LATVIA UNIVERSITY OF AGRICULTURE

RESEARCH FOR RURAL DEVELOPMENT 2005

International Scientific Conference Proceedings

LATVIA UNIVERSITY OF AGRICULTURE

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FOR RURAL DEVELOPMENT
2005

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EDITORIAL

With this issue of 2005, we bring 48 proceedings of the 56, which started life as presentations at the 11 International Scientific Conference "Research for Rural Development 2005" held at the Latvia University of Agriculture, in Jelgava, on 18th to 21st May 2005.

In the retrospect of 4 months later, we can count the Conference as a great success. The theme – Research for Rural Development – attracted participation of 303 researchers with very different backgrounds. There were 1 presentation from Cameroon, 1 from Finland, 2 from Turkey, 2 from Sweden, 9 from Lithuania and 43 from Latvia.

Four independent reviewers estimated each report.

The proceedings of the 11 International Scientific Conference "Research for Rural Development 2005" is intended for academics, students and professionals researching in the area of crop production, animal breeding, agricultural engineering, economics, food sciences, veterinary medicine, forestry, wood processing and water management.

The proceedings will also be useful for researchers in educational sciences.

CONTENTS

AGRICULTURAL SCIENCES (CROP SCIENCES, ANIMAL SCIENCES)

NITROGEN, PHOSPHORUS AND POTASSIUM INFLUENCE ON INFECTIONS BY ARBUSCULAR MYCORRHIZAL FUNGI IN *DACTYLIS GLOMERATA* ROOTS

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Abstract

The aim of this research was to compare effects of fertilization with various ratios of N, P and K (N:P:K) on arbuscular mycorrhizal fungi (AMF) infection in roots of *Dactylis glomerata* in Ca-carbonate (limed) and non-limed meadow plots at the Research Centre of Skriveri, Latvia University of Agriculture. *Dactylis glomerata* roots were excavated from variously fertilized plots, a minimum 3 root samples per plot and analysed for two consecutive years. Arbuscular mycorrhizal fungi infection rates were estimated according to accepted scoring tables used for determination of AMF colonization.

In 2003 the non-limed plots showed the highest AMF infections treated with fertilizer N:P:K (3:1:3 ratio) 8.5%, and in control 5.7%. The lowest results were with N:P:K ratio1:3:3, 0.8% and N:P:K (1:3:1), 0.9%. In the limed plots the highest AMF infection were with N:P:K (3:1:3) 6%, and N:P:K (1:3:3) 5.3%, but the lowest was in the control, 1.5%. In 2004 the non-limed plots had the highest arbuscular mycorrhiza infection with the fertilizer N:P:K ratio 3:1:1, 7.8%, and N:P:K (3:1:3) 7.1%, but the lowest with N:P:K (1:3:1) 4.1%. In the limed meadows the greatest arbuscular mycorrhiza infection rate was at N:P:K (3:1:1) 9.6% and N:P:K (1:3:3), 7.5%, but the lowest result at N:P:K (1:3:1), 3.4%, and N:P:K ratio 3:3:3, 4%. In 2003 the fertilizer N:P:K ratio3:1:3 favoured arbuscular mycorrhiza infections in limed and non-limed plots, but in 2004 plots fertilized with N:P:K ratio 3:1:1. In 2004 AMF infections in *Dactylis glomerata* roots were greater than in 2003. We conclude that fertilization with N:P:K ratio 3:1:3 markedly increased the AMF infection rates in non-Ca-carbonate amended soils, but in the Ca-carbonate amended soils the results were variable due to the increased soil pH causing apparent non-specific phosphate precipitation/dissolution processes.

Key-words: arbuscular mycorrhiza, Dactylis glomerata, nitrogen, phosphorus, potassium

Introduction

Arbuscular mycorrhizal fungi (AMF) are symbiotic with plants in their roots (Smith, Read, 1997). Eighty to 95% of all plant species having true roots form this symbiosis. AMF mycelia in the soil are "pseudo-root" extensions providing roots with increased absorption surface for nutrients and water usable for plants, whereas fungi obtain photosynthetically synthesized organics, especially carbohydrates from plants. The AMF also protect roots from pathogens and root-invading nematodes (Diedhiou, Hallmann et al., 2003). AMF infections of plants are greater in non-cultivated soil (Gloss, Varennes, 2001) and in soils with low phosphorus availability (Pankhurst, Doube et al., 1997).

High phosphorus (P) concentration in the soil may inhibit AMF colonization (Mosse, 1986, cited by Mohammad, Pan et al., 1998). Low P availability increases mycorrhizal infection. Roots with AMF has a higher availability of all phosphorus sources (organic and inorganic) in the soil than non-mycorrhizal roots (Smith, Read, 1997). AMF increases the plant capacity for P extraction from soil (Pankhurst, Doube et al., 1997). Inorganic phosphorus enters soil as fertilizer in upon cultivation of soil and increases phosphate ion concentration in the soil solution, important for P fixation processes by roots and microorganisms.

AMF commonly capture also organic and inorganic nitrogen (N) from the soil (Hodge, Robinson et al., 2000). Main nitrogen sources for plants and AMF fungi are nitrate (NO_3^-) and ammonium (NH_4^+) (Smith, Read, 1997). Nitrate dominates in agriculture soils, because ammonium is rapidly nitrified. Nitrate is mobile, not adsorbed on soil colloids. AMF can help plants to take up nitrate in low water content soil, where its mobility is limited. AMF has a slight effect in humid soils, where roots take up nitrate and water efficiently depending on the root absorbing power. Ammonium ions are relatively non-mobile and commonly adsorbed on soil constituents. Arbuscular mycorrhizal fungi, however, can increase the rate of ammonium uptake.

There is a greater potassium (K) concentration in tissues of mycorrhizal than non-mycorrhizal plants (Smith, Read, 1997). Potassium ions are relatively non-mobile similar to ammonium. The K uptake may provide mycorrhizal role in plant mineral nutrition.

The aim of this work was to compare effects of nitrogen, phosphorus and potassium fertilizers at different N:P:K ratios on AMF infections of roots of *Dactylis glomerata* in Ca-carbonate amended (limed) and non-amended (non-limed) plots, resembling meadow situations

Materials and Methods

Sampling plots, 2 x 5 m, were located in Research Centre of Skriveri, Latvia University of Agriculture. In 1974

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SCORING MYCORRHIZAL COLONIZATION
IN CLASSES FROM 0 TO 5

0	1	2	3	4	5
0%	<1%	<10%	<50%	>50%	>90%
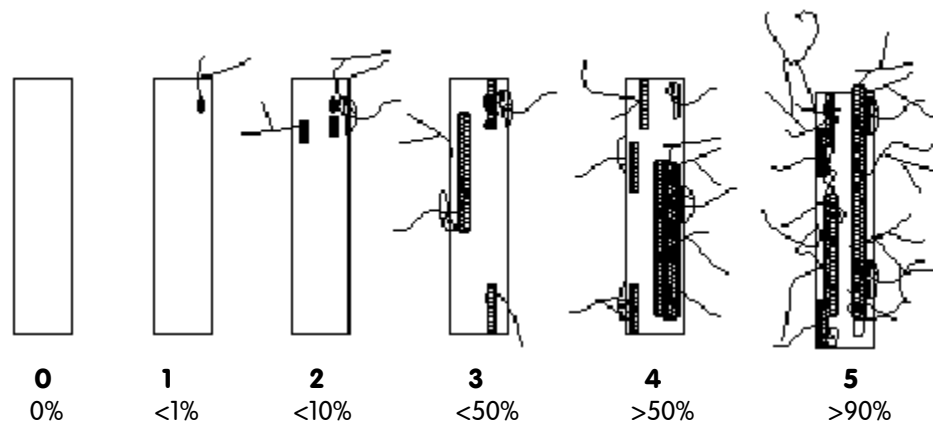
Fig. 1. Table of mycorrhizal presence % determination according to Habte and Osorio (2001).

sowed a blend of grasses – *Deschampsia caespitosa, Poa pratensis, Dactylis glomerata* and *Festuca pratensis* in plots resembling meadows. The plots were fertilized with N, P and K in different ratios annually. One half of the plots were amended with Ca-carbonate (limed), otherwise receiving the same fertilization schedule. The grass was mowed annually since 1974. Soil samples from the plots were analysed by the Laboratory of Plants Mineral Nutrition, Institute of Biology, University of Latvia.

Roots of *Dactylis glomerata* were collected in June 2003 and in July 2004. Roots were washed and cut into 1 cm long fragments. The root fragments were heated in 10% KOH for one hour, then simmered for 5 min in 0,05% Trypan blue. The dyed roots are washed and stored in lacto-glycerol (Hayman, 1970) until examined microscopically. A minimum of three sample of roots per plot were collected to obtain the mean infection values.

The infection rates of AMF were determined by a quantitative count of infection % on length unit of dyed root (Fig.1). The mean infection percentages were determined according to the accepted scoring tables for AMF infection rates (Habte, Osorio, 2001).

Results

In 2003 the AMF infection rate was the highest at 8.5% in non-limed plot with N:P:K fertilized ratio 3:1:3, but in 2004 infection was the highest at 7.8% in plot with N:P:K ratio 3:1:1 (Fig.2.). The lowest infection rate in 2003 was in non-limed plots with fertilizer N:P:K (1:3:3) = 0.8%, and (1:3:1) = 0.9%. In 2004 the lowest results were in plots with fertilizer N:P:K (1:3:1) = 4.1%. In control plots the AMF infection rate in 2003 was 5.7% and in 2004 it was 6.8%. In the plot having fertilizer N:P:K ratio 3:3:3 the infection rate in 2003 was 3.8% and 2004 it was 5.4%.
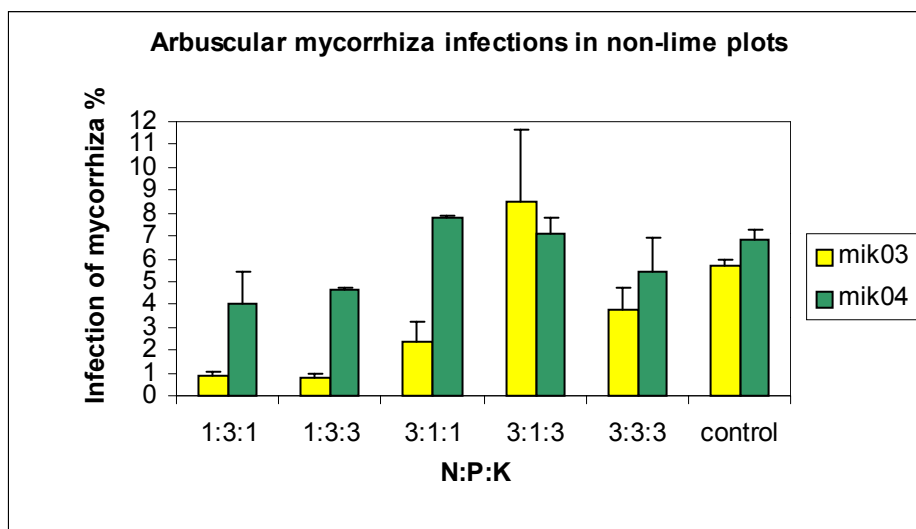
Fig. 2. AMF infections in 2003 compared with 2004 results in *Dactylis glomerata* roots. Bars indicate standard errors. In legend mik03 means AMF infection percentage in 2003, but mik04 that in 2004.
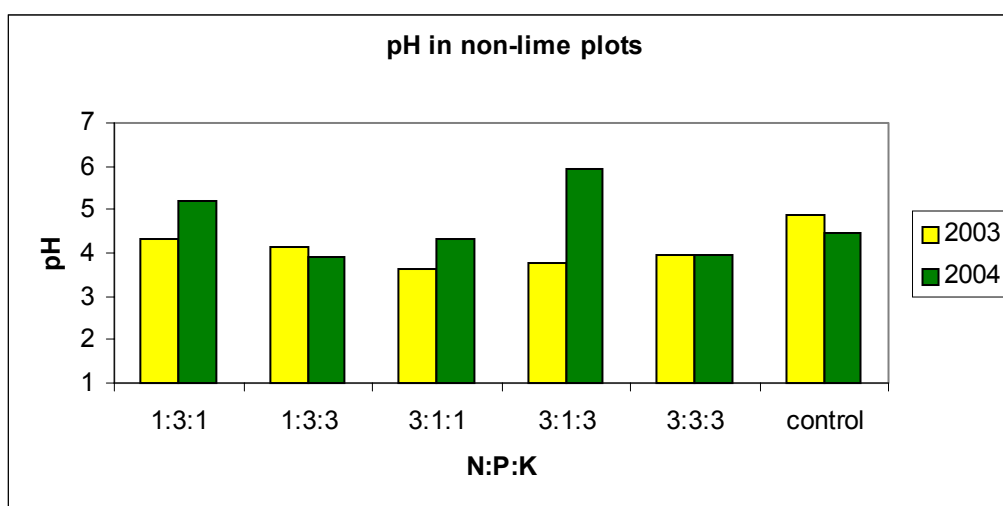
Fig. 3. Soil pH values in non-limed plots.

Arbuscular mycorrhizal fungi infections increased in 2004 as compare with 2003 root samples, except in non-limed plot with fertilizer N:P:K ratio 3:1:3. In this plot in 2003 AMF infection rate was greater than in 2004. In both years the soil pH values were different (Fig.3). Soil pH values varied markedly between plots and years. When pH was 5.93, AMF infection rate was 7.1% in 2004. When pH was acidic 3.77, the infection rate was 8.5% similar natural control soil. It is not clear why in this sampling plot there were such pronounced differences in soil pH between 2003 and 2004. There were no such differences in pH values in other non-limed plots between both years. There was a sharp difference in the plot having fertilizer N:P:K ratio 3:1:1 between AMF infection rates in 2003 (2.4%) and in 2004 (7.8%).

In the limed plots the AMF infection rate was greater in the plot with fertilizer N:P:K (3:1:1) = 9.6% in 2004, but in 2003 with fertilizer N:P:K (3:1:3) it was 6% (Fig.4). On the average in the limed plots AMF infection rates increased in 2004 similar to non-limed plots. Limited infections rates were in the control plot (1.5%) and in plots with fertilizer N:P:K ratios 1:3:1 (2.1%), and 3:3:3 (2.7%) in 2003. Low AMF infection rates in 2004 were in plots with N:P:K ratios 1:3:1 (3.4%) and 3:3:3 (4%).

Fertilization with a low P content fertilizer, such as having N:P:K ratio 3:1:3 markedly increases the AMF infection rate, exceeding or being similar to non-treated control.

In limed soils pH was equal in both years in all plots. There was a sharp difference in arbuscular mycorrhizal infection rates in the plot with fertilizer N:P:K (3:1:1) (Fig. 4). In 2003 infection rate was slight, but in 2004 it had the highest percentage. In limed plots the pH values are elevated and phosphorus is precipitated or adsorbed in non-soluble state, for example, as $Ca_3(PO_4)_2$ and not available to plants (Mežals, 1970). In such situations the AMF mycelia may
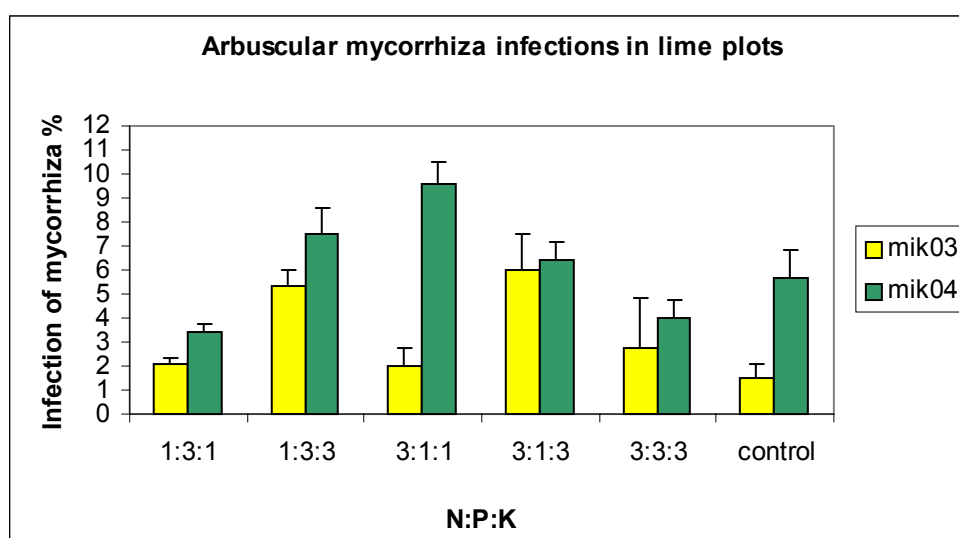
Fig. 4. Comparison of AMF infection rates in 2003 and in 2004. Bars show standard errors.

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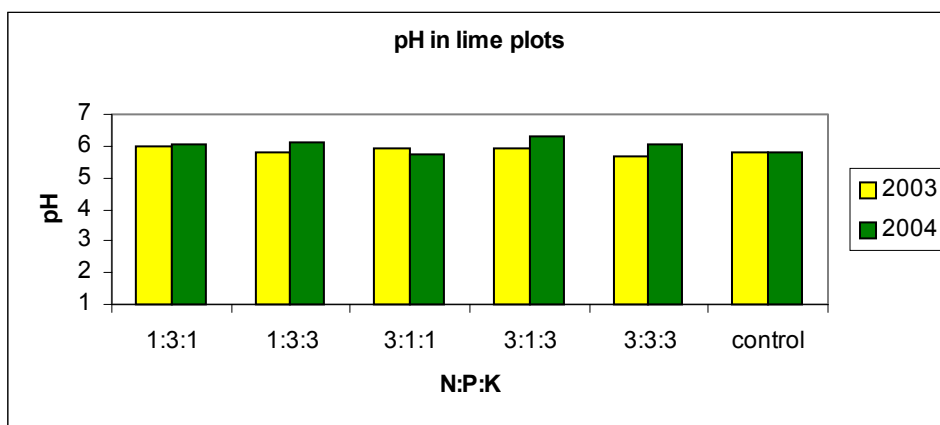
Fig. 5. Soil pH values in limed plots.

solubilize phosphates and by assimilation and transport make P available to plants. Elevated precipitations also may dissolve some phosphates. In our case July of 2004 was the rainiest month in the last 80 years (Anonym, 2004).

There were different AMF infection rates in the control plot. In 2003 it was 1.5%, but in 2004 the infection rate was 5.6%. The soil pH did not change the two years (Fig.5). This dissimilarity in rates may be caused by the increased soil water content in 2004, with increased presence of germinating AMF spores.

Ferilization is not effective for increasing AMF colonization rates in limed meadows, whereas in non-limed situations the fertilization is effective, especially with fertilizers having low P content. Although we have not tested fertilizers with no P content, we presume that fertilization only with N and K would further support the AMF infection rates.

Conclusions

1. Arbuscular mycorrhizal fungi infection increased in 2004 as compared with 2003 root samples, except non-lime meadow with fertilizer N:P:K (3:1:3). This has been attributed mainly to markedly increased precipitations, providing increased soil moisture.

2. In limed and in non-limed plots the maximal and minimal AMF infection rates were different in both years.

3. In 2003 Ca-carbonate (lime) amendment had a negative effect on AMF infection process in *Dactylis glomerata* roots.

4. The 2004 results did not show marked negative influence of lime amendment on arbuscular mycorrhizal fungi infection rates. This has been attributed to the markedly increase moisture availability over the year 2003.

5. Advisable fertilisation for meadows to increase AMF infection rates is to avoid Ca-carbonate amendments and to use low P content fertilizers.

6. Our results support the results by previous worldwide research, that fertilization with excessive P content materials limit the rates of AMF infections of plant roots.

Acknowledgment

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THE EFFECT OF HARROWING ON THE WEEDINESS AND YIELD OF SPRING BARLEY IN ORGANIC FARMING

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Abstract

Field trials were carried out on organic farming fields at the Research Institute of Agriculture of the Latvia University of Agriculture (LLU). The influence of harrowing (without harrowing, before emergence, at the stage of tillering, before emergence and at the stage of tillering) depending of pre-crop (red clover, winter rye for grain, bare fallow, bare fallow and green manure,) and use of stable manure (60 t ha^{-1} or without) on the weediness and yield of spring barley 'Sencis' was tested during 2003 – 2004. In spring barley, 18 species of weeds were established at the stage of earing during 2003 – 2004. The most widespread of perennial weeds were *Elytrigia repens* (L.) Nevski and *Sonchus arvense* L. The dominant annual weeds were *Chenopodium album* L, *Stellaria media* L., *Capsella bursa-pastoris* L., *Polygonum* spp., and *Matricaria inodorum* L. The number of annual weeds at the stage of earing differed during the years 50–160 (in 2003) and 33 –118 (in 2004) annual weeds per m^{-2}. The influence of harrowing on the number of annual weeds was different during the testing years. The influence of harrowing on the grain yield was negligible during 2003 and 2004.
Key words: organic farming, spring barley, stable manure, harrowing, previous plants.

Introduction

The aim of weed management strategies in organic farming systems is to maintain weeds at a manageable level by structural measures (rotation design, variety choice, sowing date) (Millington et al., 1990).

It is stated that influence of weeds on grain yields is different at the different growth stages of cereals. The increasing of number of weeds in the period from tillering to earing influence significantly the grain yields (Терещук, 1997).

Weed harrowing before and after crop emergence is used widely in arable crops. Timing of harrowing is critical and determines whether weed or crop dominates the system (Petraitis, 1994). In cereals, plug harrow may be used for 'blind harrowing', which is carried out after drilling but before crop emergence to kill the first flush of small emerging weeds. The aim is to give the crop an early advantage over the weeds and to aid selectivity in subsequent weeding operations. Post-emergence harrowing may cause crop injury (Bond W., Grundy AC., 2001).

The aim of field trial was to investigate the influence of harrowing on the weediness and yield of spring barley in organic farming.

Methods

The three-factorial field trials were carried out on certified organic fields during 2003 and 2004.

The influence of harrowing (without harrowing, before emergence, at the stage of tillering, before emergence and at the stage of tillering) depending of pre-crop (red clover, winter rye for grain, bare fallow, bare fallow and green manure,) and use of stable manure (60 t ha^{-1} or without) on the weediness and yield of spring barley 'Sencis' was tested.

The field trials were studied on turf podsolic soil: pH$_{KCl}$ – 6.75, P$_2$O$_5$ – 162 mg kg^{-1}, K$_2$O – 158 mg kg^{-1}, organic matter content – 32.5 g kg^{-1} and N$_{total}$ – 1.1 g kg^{-1}. The content of nitrogen was determinated before sowing of barley in spring.

The object of research: spring barley 'Sencis'. Seed rate was 500 germinating seeds per m^{-2}. Before sowing, grains were treated with 1.5 kg of ashes of foliage trees and 1.5 l of water per 100 kg of grain. Sowing date was 19.05.2003. and 30.04.2004. The number of replications was four, random plot layout, plot size 42 m^2 and testing plot size – 26.18 m^2. The harvest was done on 11.08.2004. and 10.08.2004., adjusted to 14 % moisture content and 100% purity.

After previous plant bare fallow + green manure, 15 t ha^{-1} (2004) and 17 t ha^{-1} (2003) of biomass of winter rye were incorporated into soil. The chemical content of winter rye biomass: dry matter – 169.3 (2003) and 178.3 (2004) g kg^{-1}, P$_2$O$_5$ – 60 and 65 mg kg^{-1}, K$_2$O –254 and 302 mg kg^{-1} and total content of nitrogen – 277 and 287 mg kg^{-1}. Winter rye was sown in autumn (10.09.2002. and 15.09.2003.) but was incorporated in spring at the stage of tillering. In the trial, variants with stable manure were included (60 t ha^{-1}). The chemical content of stable manure: dry matter – 169.7 (2003) and 387.7 (2004) g kg^{-1}, P$_2$O$_5$ – 64 and 88 mg kg^{-1}, K$_2$O 97and 183 mg kg^{-1} and total content of nitrogen – 238 and 377 mg kg^{-1}.

Weed assessment was done 3 weeks after harrowing using a 0.20 m^2 big frame.

Meteorological conditions are summarised in Figures 1–2.

The year 2003 was very favourable for growth and development of spring barley. April was rainy and cold, which hampered the time of sowing. In May, the air was getting warmer gradually, at nights the temperature was under 10 °C, and frosts were frequent on the soil surface. Barley germinated and tillered quickly. In June, the average air temperature was 0.7 degrees lower than the long-term average, but the amount of precipitation made 75 % of the norm. July with average air temperature 19 °C was the second warmest middle-summer month during the last 80 years in Latvia.
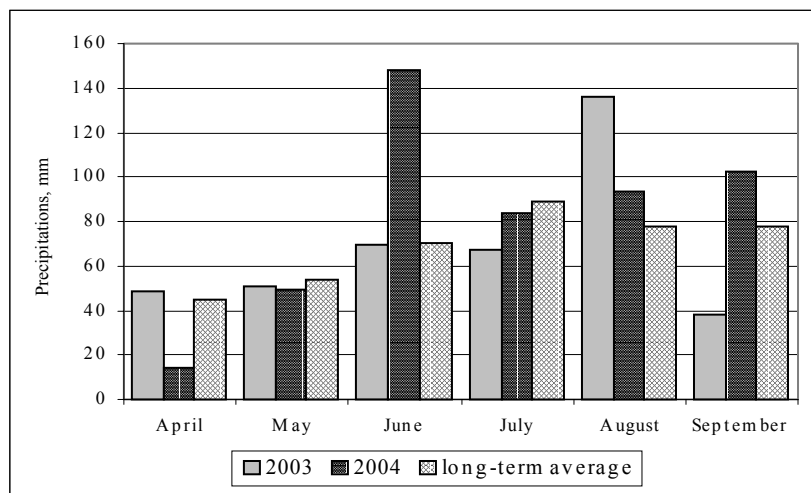
Fig. 1. The amount of precipitation during the vegetation period, mm, 2003-2004.
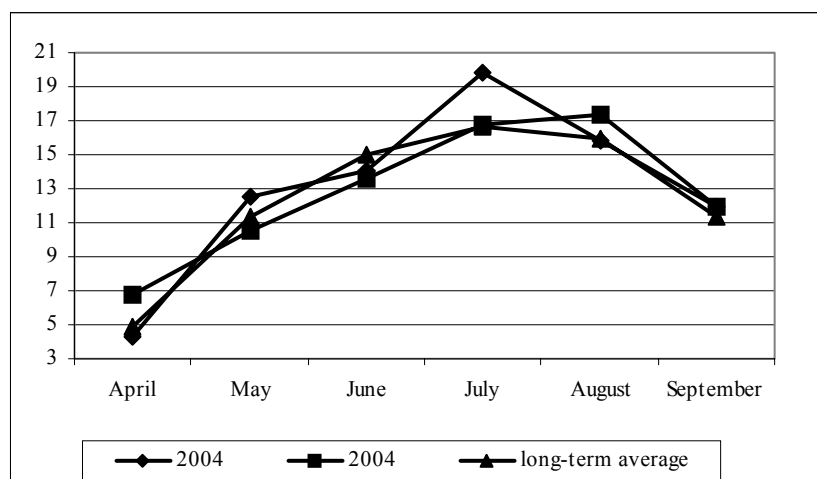
Fig. 2. The average air temperature during the vegetation period, °C, 2003-2004.

In April of 2004, the average air temperature was 1.7 degrees higher than the norm. The first decade of May was one of the warmest decades during the last 80 years in Latvia. The second decade of May was 3.1 degrees lower but the third decade – 3.6 degrees lower than the norm. In this time, frosts were frequent on the soil surface. In May, the amount of precipitations made 80% of the norm. In June, the average air temperature was 1.3 degrees lower than the norm, but the amount of precipitation made 152% of the norm. Very wet conditions were observed in the third decade of June (223% of the norm). In August, the average air temperature was 1.7 degrees higher than the norm. Barley grew and developed well and produced good and qualitative grain yields.

ANOVA (two factor with replication) was used for data analysis.

Results

For establishment of effectivity of harrowing on the weediness of barley, the weeds were ascertained at the stage of earing (3 weeks after harrowing). Altogether 18 species of weeds were established in the sowings during 2003 -2004. In 2003, six perennial weed species were established in spring sowings, the most widespread of which were *Elytrigia repens* (L.) Nevski and *Sonchus arvense* L. After red clover, a higher number of weeds was established compared to other previous plants. Sowings of previous plant red clover were sparse, which favoured fast spread of perennial weeds. In 2004, the number of perennial weeds was negligible.

From annual weeds, *Chenopodium album* L, *Stellaria media* L., *Capsella bursa-pastoris* L., *Polygonum* spp. and *Matricaria inodorum* L. were ascertained in all variants. In some variants, *Spergula arvensis* L., *Viola* spp., *Galeopsis speciosa* Mill., *Raphanus raphanistrum* L. and *Thlaspi arvense* L. were established, though the number of these weeds was negligible.

The number of annual weeds depending of pre-plants, time of harrowing and use of stable manure is presented in Figures 3 and 4.
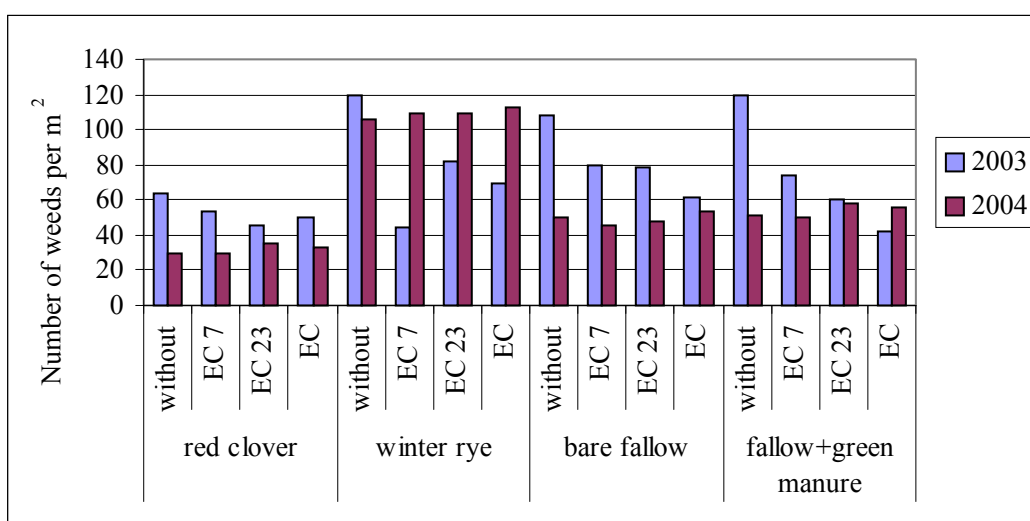
Fig 3. The number of annual weeds at the stage of earing, depending on pre-crop and harrowing variant and without use of stable manure during 2003 – 2004.
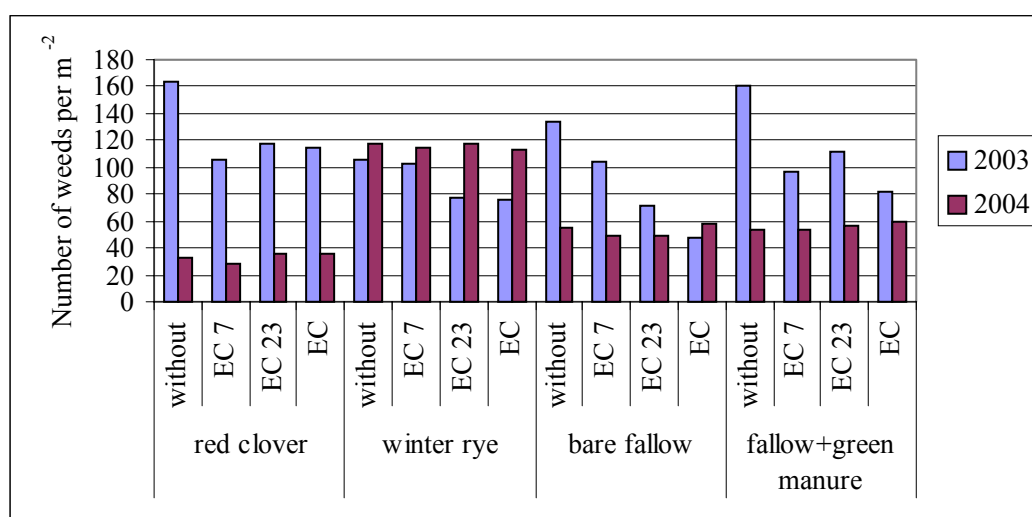
Fig 4. The number of annual weeds at the stage of earing, depending on pre-crop and harrowing variant and with use of stable manure 60 t ha^{-1}, during 2003 – 2004.

The number of annual weeds at the stage of earing differed during the years (p-value < 0.05). In 2003, in sowings 50 – 160 annual weeds per m^2 were established, but in 2004 the number of annual weeds was significantly lower – only 33 – 118 annual weeds per m^2.

The influence of stable manure on the number of annual weeds was significant during the testing year (p-value < 0.05). A significantly higher number of annual weeds was ascertained in variants with stable manure on average 104 weeds per m^2 in 2003 and 64 weeds per m^2 in 2004).

The influence of pre-plants on the number of annual weeds was different during testing years (p-value < 0.05). In 2003, the previous plant did not influence the total number of weeds if spring barley was grown without stable manure. After use of stable manure the number of weeds in-

creased significantly when barley was grown after red clover (on average + 65 weeds m^2) and after winter rye for green manure (+ 39 weeds m^2).

In 2004, in barley after bare fallow and bare fallow + green manure, the number of annual weeds was similar – 49 – 50 weeds per m^2. A significantly higher number of annual weeds was ascertained in barley after winter rye – 109 weeds per m^2. In barley after bare fallow, the number of annual weeds was low – 32 weeds per m^2.

The influence of harrowing on annual weeds was different during the testing years (p-value < 0.05).

In 2003, harrowing significantly decreased the number of weeds after all previous plants. After bare fallow without stable manure, double harrowing decreased the number of weeds significantly but only in variants without harrowing. In variants with stable manure, harrowing decreased

the number of weeds significantly at the stage of tillering (EC 23) and if barley was harrowed twice before germination (EC 7) and at the stage of tillering (EC 23). After winter rye for green manure, the time of harrowing had no influence on the number of weeds. After winter rye without stable manure harrowing at the stage of tillering and double harrowing decreased the number of weeds, but in variants with stable manure the time of harrowing did not influence the number of weeds.

In 2003, the harrowing decreased the number of *Chenopodium album* L. significantly, but the time of harrowing influenced the number of *Chenopodium album L.* insignificantly.

In 2004, harrowing did not significantly decrease the number of weeds. At the time of second harrowing (at the stage of tillering, (EC 23)) there was high amount of precipitation and harrowing only loosened the soil but did not kill the weeds. Excess precipitation and warm weather at the

stage of tillering favoured fast development of barley and suppression of weeds.

The data in figure 5 shows that the influence of harrowing on the grain yield was negligible both years. In 2003, the pre-plants and use of stable manure influenced the grain yield similarly. In 2004, the main factor, which influenced grain yields, was pre-crops.

Depending on the variants, the yields in the field trial varied from 1.56 to 3.85 t ha^{-1} (Fig. 6).

The influence of stable manure on spring barley yield was significant (p-value < 0.0001). Grain yields increased by 0.47–0.99 t ha^{-1} (2003) and 0.33–0.87 t ha^{-1} (2004) on average. Use of stable manure for barley after winter rye provided the highest yield increase on average by 0.92 t ha^{-1} during 2003–2004.

The influence of previous plants on spring barley yield was significant (p-value < 0.0001) and differed during years (p-value < 0.0001). In 2003, the highest yields were
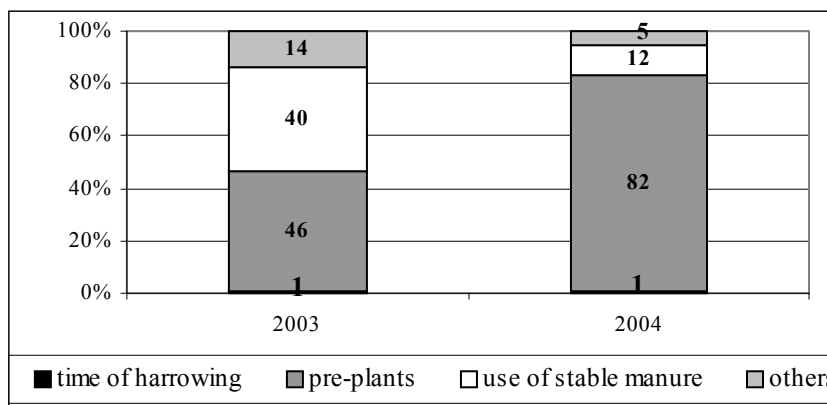
Fig 5. The effects of pre-plants, use of stable manure and time of harrowing on the grain yield of spring barley 'Sencis' during 2003–2004,h %.
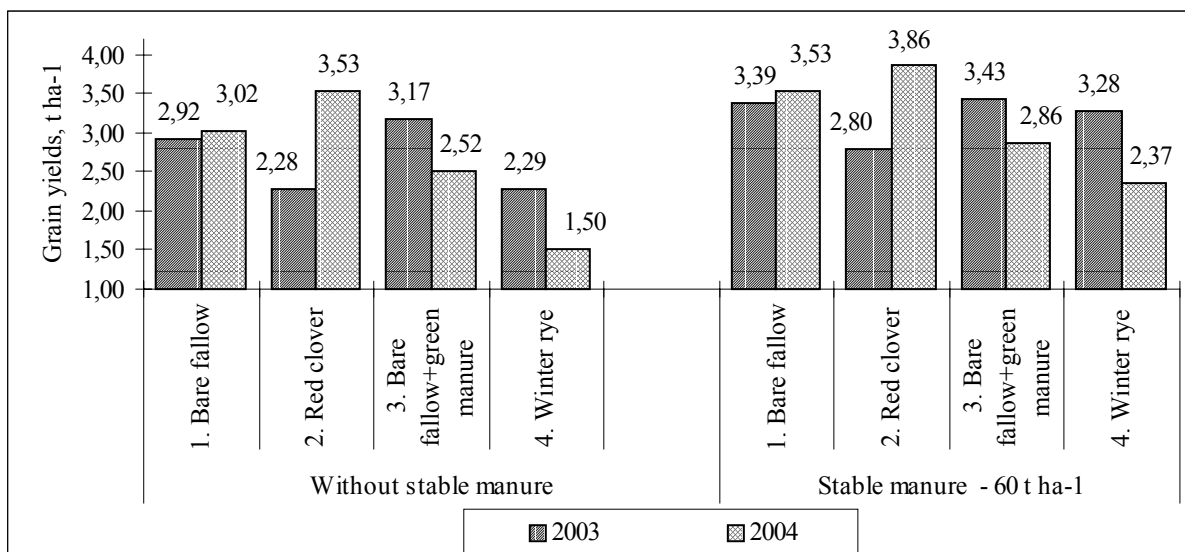
Fig. 6. The grain yield of spring barley 'Sencis' depending on the use of stable manure and pre-plants.

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obtained after winter rye for green manure and after bare fallow in both variants, with stable manure and without it.

In 2004, the highest yields were obtained after red clover and bare fallow in both variants, with stable manure and without it.

Harrowing increased the grain yields significantly only after winter rye for green manure with stable manure, whereas time of harrowing had no significant influence on the grain yield.

In 2003, the number of annual weeds had a positive strong and statistically significant correlation with the spring barley grain yield only after red clover without stable manure (r = 0.86).

In 2004, there was a strong negative correlation between the number of annual weeds and spring barley grain yield (r= −0.84) only after winter rye in variants without stable manure (equation of relationship $y = −0.0281x + +4.5765$, $R^2 = 0.71$) and in variants with stable manure after bare fallow + green manure (r= −0.83, equation of relationship $y = −0.0733 x + 6.9057$, $R^2 = 0.69$).

Conclusions

1. In spring barley, 18 species of weeds were established at the stage of earing during 2003–2004. The most widespread of perennial weeds were *Elytrigia repens* (L.) Nevski and *Sonchus arvense* L.

2. The dominant annual weeds were *Chenopodium album* L, *Stellaria media* L., *Capsella bursa-pastoris* L., *Polygonum* spp., and *Matricaria inodorum* L. The number of annual weeds at the stage of earing differed during the years 50–160 (in 2003) and 33-118 (in 2004) annual weeds per m^2.

3. The influence of harrowing on the number of annual weeds was different during the testing years. In 2003, harrowing significantly decreased the number of weeds after all pre-plants. In 2004, harrowing did not significantly influence the number of weeds.

4. The influence of harrowing on the grain yield was negligible during 2003 and 2004. In 2003, harrowing increased the grain yields significantly only after winter rye for green manure with stable manure, whereas time of harrowing had no significant influence on the grain yield.

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THE EFFECT OF NITROGEN AND SULPHUR FERTILIZATION ON TILLER FORMATION AND GRAIN YIELD OF SPRING WHEAT

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Abstract

In 2003 and 2004, field experiments with spring wheat (*Triticum aestivum* L.) were carried out at the Lithuanian Institute of Agriculture in Dotnuva, Lithuania. The aim of the study was to evalute the effect of nitrogen and sulphur fertilizers on tiller formation and grain yield of spring wheat (variety 'Munk'). N and S fertilizers were applied at 3 rates: N (0, 60 and 120 kg ha^{-1}) and (S 0, 15 and 30 kg ha^{-1}).

Both years, N fertilization had a significant effect on tiller formation. At harvest, the total number of tillers was approximately 0.5 tillers higher in the plots with the application of N_{120}. The growing season in 2003 was comparatively dryer, and a significant increase in grain yield was found – up to 60 kg ha^{-1} of N. Due to higher rainfall in 2004, grain yield was much higher and the highest effect was found with the maximum N supply – 120 kg ha^{-1}.

One thousand grain weight was influenced by the year, while fertilizers did not have any significant effect.

The impact of S fertilization on the number of tillers and final grain yield was insignificant; nevertheless S fertilization increased the concentration of S in the aboveground plant mass.

Key words: nitrogen, sulphur, tillers, yield, 1000 grain weight.

Introduction

Spring wheat (*Triticum aestivum* L.) has a potential to become a much more important crop in Lithuania, although in 2003 – 2004 the area under spring wheat accounted for 3.6-3.9% of the total crop area. Spring wheat has received less attention, because of relatively smaller grain yield compared with other cereals, especially winter wheat. Over the last decade the attention to spring wheat has increased simultaneously with the introduction of new varieties yielding more than 6 kg ha^{-1} of grain (Baniūnas and Petraitis, 1994).

The available soil water and nitrogen are the primary factors limiting wheat yield (Nielsen, 1991; Brown, 1971; Masle, 1985). As much as 44–45% of grain yield depends on the weather conditions during the growing season Goldberg, 1988). Under Lithuanian climatic conditions, the highest effectiveness of nitrogen fertilizers in winter wheat was found in humid seasons. In semi-humid seasons the grain yield declined by 30–46%, and in dry seasons - by 35-62% (Janušauskaite, Šidlauskas, 2004).

During the last 2–3 decades the sulphur deficiency has been reported throughout the world (McGrath et al., 1996; Zhao, 2003). Some researches suggest that by using sulphur fertilizers, the grain yield increased between 5 and 40% (Withers, 1997; Zhao et al., 2003; McGrath, 1996). Sulphur fertilizers affected the yield of cereals mainly through increasing the number of tillers and number of spikes per unit area in some experiments (Taureau et al., 1987; Garcia et. al., 1998).

Tillers are important structures for wheat because they contribute to the increase in the number of spikes per area, enhancing the grain yield. Stresses during plant growth exert a sizeable effect on tiller production. Tiller initiation and survival depend on the intensity of competition among plants in the community (Almeida et al., 2004).

In Lithuania, research efforts were focused on nitrogen fertilization and main grain yield characteristics of major cereals winter wheat and spring barley. Only a few experimental data have been published on spring wheat yield formation, and patterns of tiller initiation and survival have been seldom discussed.

The task of this study was to investigate the influence of nitrogen and sulphur on tiller production and yield of spring wheat in two seasons differing in weather conditions.

Materials and Methods

Field experiments were carried out at the Lithuanian Institute of Agriculture in Dotnuva, Lithuania in 2003 and 2004. The soil of the experimental site is sod gleyic (Endocalcari-Endohypogleyic Cambisol) light loam. The arable layer of soil had pH$_{KCl}$ 5.5–6.1 (2003) and 6.7 (2004), content of total N (Kjeldahl method) – 0.105–0.110% (2003) and 0.163% (2004). K$_2$O (A-L method) – 0.117–0.142 g kg^{-1} (2003) and 0.146 g kg^{-1} (2004), P$_2$O$_5$ (A-L method) – 0.137–0.196 g kg^{-1} (2003) and 0.102 (2004), organic C – 0.71–0.76% (2003) and 1.08% (2004). The 0–40 cm layer contained N-NO$_3$ – 0.00112–0.00626 g kg^{-1} (2003) and 0.00496 g kg^{-1} (2004), N-NH$_4$ (calorimetrically) – 0.00293–0.00327 g kg^{-1} (2003) and 0.00286 g kg^{-1} (2004), total S (turbidimetrically) – 0.108-0.120 g kg^{-1} (2003) and 0.019–0.024 g kg^{-1} (2004), available S – 0.00005–0.00065 g kg^{-1} (2003) and 0.0002–0.00036 g kg^{-1} (2004).

The experiment was arranged according to two-factor (3 N levels and 3 S levels) randomized complete block design with four applications. The levels of N were 0, 60, and 120 kg ha^{-1} and S – 0, 15 and 30 kg ha^{-1}. The size of harvested area was 20.37m^2. Phosphorus (P$_2$O$_5$ 40 kg ha^{-1}) and potassium (K$_2$O 100 kg ha^{-1}) were applied to each plot. The main doze of N was applied as ammonium nitrate, and S - as potassium sulphate. P was applied as ammo-

nium phosphate, and rate of K was adjusted using potassium chloride. All the fertilizers were broadcast manually just before drilling. Both years the spring wheat ('Munk' variety) was drilled on the 26th of April. The seed rate was 5.5 million germinable seeds ha⁻¹.

During growth, plants were sampled from 4 treatments (N_0S_0, N_0S_{15}, $N_{120}S_0$ and $N_{120}S_{30}$) to assess the number of plants⁻² and number of tillers per plant. The samplings were done eight times at different growth stages (3–4 leaves stage (DK 14–15), beginning of tillering (DK 21–22) (only in 2004), end of tillering (DK 23–25), end of shooting (DK 37–39), booting (DK 41–43), head emergence (DK 53–55), flowering (DK 67–69), bud maturity (DK 73–75).

The crop was harvested on the 12th of August in 2003 and 7th of September in 2004. Before harvesting, samples were taken in four places per plot (total sampling size – 0.5 m⁻² per plot). The grain was harvested bny a plot combine harvester and grain samples were taken from each plot for measuring of moisture (yield adjusted to 14% of moisture) and mean 1000 kernel weight.

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Results

The growing season of spring wheat in 2003 was warmer than normal, with low amount of precipitation, especially in the second half of the season. In 2004, the temperature was lower than normal, with low rainfall during the first half and high rainfall during the second half of the season.

Plant number on the first sampling date (DK 11–13) was on average 310 plants m⁻² in 2003 and 403 plants m⁻² in 2004. The number of plants in plots without N reached the maximum level (almost the same level of 480–500 plants⁻² in 2003 and 2004) on the second sampling date (DK 23–25). Plant number in the plots with application of 120 kg ha⁻¹ N at first sampling was at the same level as in the plots without N, but was lower at second sampling. These results can be an outcome of the sampling method used – pulling out plants and sampling each time at a new place. However, it is likely that a lower plant number in plots applied with high rate of N – boosted production of tillers, which resulted in increased competition between plant or/and tillers for water and, possibly, light, as has been suggested by other authors (Petr et al., 1984). The beginning of plant number reduction was connected with the beginning of a rapid biomass growth. The decline in the number of plants was registered from the 2nd – 3rd sampling date (end of tillering – beginning of stem elongation growth stage) and, notwithstanding some differences in reduction between years, at harvest reached almost the same population density of 480–510 plants m⁻² in 2003 and 2004.

Tiller number dynamics is shown in Figure 3 and 4. Tiller initiation and reduction followed the pattern of plant number with a delay of some 7–10 days. The positive effect of nitrogen fertilizers on tillering became visible and registered on the 3rd sampling date (DK 23–25) and remained such until harvesting. At the 3rd – 4th sampling, most of the plants in the plots without N had 3 tillers (the main tiller and 2 secondary tillers), and in the plots applied with N_{120} – 4 tillers (main and 3 secondary). In the case of nitrogen shortage, the occurrence of competition for nitrogen begins very early – before the first tiller emerges (Masle, 1985).

In 2003, the number of tillers in the plots applied with N_{120} was almost on the same level during the period from DK 33–37 until DK 57–59. Later on, we observed the steady decrease in tillers until the end of growing season. This was perhaps due to the dry conditions in the second half of the growth as is also stated by other researches, that heading, flowering and grain filling are most critical growth stages in wheat for water requirement (Musick, 1963; Singh, 1981; Kirkham and Kanemasu, 1983). In 2004, the number of tillers decreased until heading, but later on they remained almost on the same level until harvest. As distinct from 2003, the second half of the growing season in 2004 was rainy; consequently water was not a limiting factor. In both years, the total number of tillers was approximately 0.5 tillers higher in the plots with the application N_{120}.

In our experiments, the content of total and available S in the soil layer 0–40 cm (according to classification recommended by Adomaitis, 1998) was relatively low. In 2003, the content of available S in the soil was 0.8 mg kg⁻¹, which resulted in a quite low level of total S (1.88–2.34 g kg⁻¹ at the second sampling) in the aboveground mass of plants in the plots without S fertilizers. In 2004, the content of available S in the soil was somewhat higher (2.0–3.6 mg kg⁻¹) and the level of total S in plants – higher (2.00–2.68 g kg⁻¹ at second sampling). Sulphur fertilizers increased the content of total S in plants, but the effect of S fertilizers on plant number and tillering was not significant in treatments selected for sampling in our experiments. This might indicate that plants are able to redistribute part of sulphur and ensure minimal requirements for tiller formation on heavy-textured soils.

There was a significant difference in grain production between two seasons, and treatment differences varied between the seasons. The effect of S rate was nonsignificant. In the drier year 2003, spring wheat produced an average yield of 4.67 t ha⁻¹ and in 2004, with more favourable conditions – 5.65 t ha⁻¹. Larger grains were also produced in 2004. These results are consistent with the results of other investigators (Goldberg, 1988; Lopez-Bellido, 2000).

The effect of nitrogen rate was highly significant in both experimental years, but a much higher yield increase was in 2004 with more adequate moisture supply. The yield was increasing up to the highest rate of nitrogen 120 kg ha⁻¹. In 2003, a significant increase in yield was found – up to 60 kg ha⁻¹ N. The effect of sulphur was nonsignificant, but some
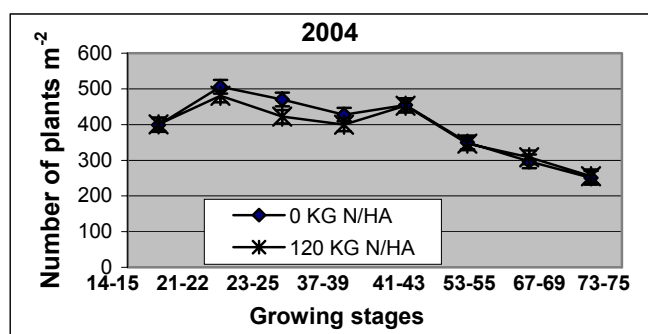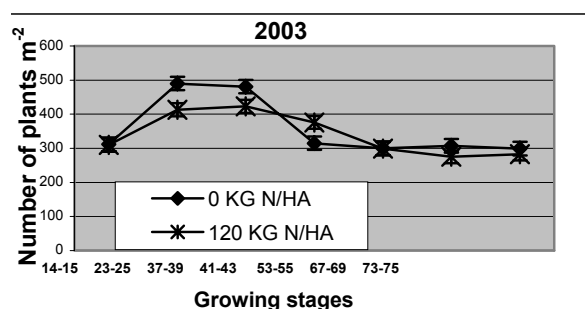
Fig. 1, 2. Dynamics of the number of plants during growing seasons (2003 and 2004).
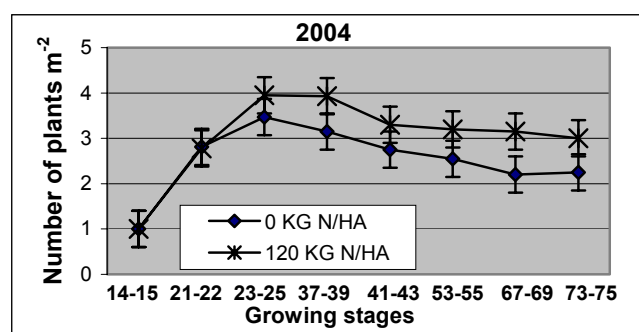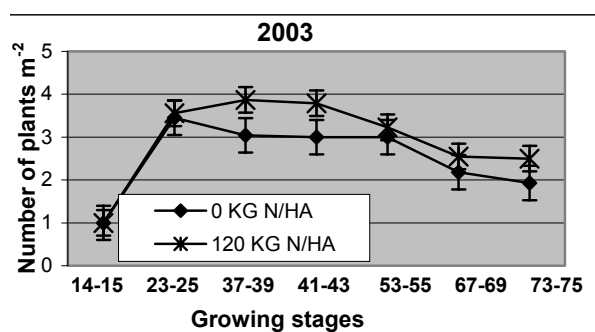
Fig. 3, 4. Dynamics of tillering during growing seasons (2003 and 2004).

tendency of increase in grain yield (by 0.92 t ha^{-1}) with the level of significance 90% was recorded in 2003.

The effect of N and S fertilizers on 1000 kernel weight was nonsignificant in both experimental years.

S inputs with ground water and capillary rise can also have significant effect on S nutrition of spring wheat. This issue will be addressed in the next year's experiment.

Conclusions

1. The positive effect of nitrogen fertilizers on tillering became significant at DK 23-25 stage and remained such until harvesting. At this stage, most of the plants in the plots without N had 3 tillers (the main tiller and 2 secondary), and in the plots applied with N_{120} 4 tillers (the main tiller and 3 secondary). Sulphur fertilizers increased the content of

Table 1

Effect of N and S fertilizers on grain yield in 2003 and 2004

	2003				2004			
	S0	S15	S30	Average	S0	S15	S30	Average
N0	3.94	3.95	4.06	3.98	4.36	4.30	4.19	4.28
N60	4.80	5.06	5.06	4.97	5.70	5.86	6.03	5.86
N120	5.11	4.99	5.02	5.04	6.99	6.60	6.84	6.81
Average	4.62	4.67	4.71	4.67	5.68	5.59	5.69	5.65

LSD$_{05}$ for main N and S effects 0.13 and 0.20; for NxS interaction 0.27 and 0.40 respectively in 2003 and 2004.

Table 2

Effect of N and S fertilizers on 1000 grain weight in 2003 and 2004

	2003				2004			
	S0	S15	S30	Average	S0	S15	S30	Average
N0	45.42	46.02	45.51	45.65	46.71	46.56	46.50	46.59
N60	46.09	46.05	45.70	45.95	47.20	47.09	46.49	46.93
N120	46.40	46.47	45.85	46.24	46.68	46.65	46.64	46.66
Average	45.97	46.18	45.69	45.95	46.86	46.77	46.54	46.72

LSD$_{05}$ for main N and S effects 0.35 and 0.72; for NxS interaction 0.70 and 1.44 respectively in 2003 and 2004.

total S in plants, but the effect of S fertilizers on plant number and tillering was nonsignificant.

2. The effect of nitrogen rate was highly significant in both experimental years, but a much higher yield increase and higher optimum rate of N (120 kg ha^{-1}) was in 2004 with more adequate moisture supply. The effect of sulphur on the yield of grain was nonsignificant in contrast to the low level of S content in soil.

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THE DEVELOPMENT OF AQUACULTURE IN TURKEY

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Abstract

Turkey has rich inland water sources, about 200 natural lakes, about 750 artificial lakes or ponds, about 193 reservoirs, 33 rivers and streams of 177714 km length and 8333 km of coastal strips. Some lagoons covering of 70000 ha in Aegean and Mediterranean coastal strips are very suitable for aquaculture. The main fish species cultured in Turkey are Carp (*Cyprinus carpio*), Rainbow trout (*Oncorhynchus mykiss*), Atlantic salmon (*Salmo salar*), Gilthead sea bream (*Sparus aurata*), European sea bass (*Dicentrarchus labrax*), Bluefin tuna (*Thunnus thynnus*), Black sea turbot (*Psetta maxima*), Mediterranean mussel (*Mytilus galloprovincialis*) and Shrimp (*Penaeidae spp*). Aquaculture production of Turkey has grown steadily over the years from 5782 t in 1990 to 63000 t in 1999 and to 79031 t in 2000. There are 1309 farms in inland water producing approximately 32466 t of fresh water fish species and 352 farms at sea producing 40119 t of sea fish species, mainly Gilthead sea bream and European sea bass.

Key words: Turkey, aquaculture, fish farming.

Introduction

The history of aquaculture is very old. The first records of aquaculture activities in 2500 BC can be found in the tomb of Aktihep during the ancient Egyptian civilisation. In the Etruscan Culture in Italy, the earliest marine farms date back to 6th century BC. The China is the first country in Asia where aquaculture has been started during the dynasty of When Fang (1135-1122 BC). Fan Li wrote classic of fish farming in the 460s BC in China.

Marine and inland water resources provide an important source of protein for human nutrition. Because of this reason, fish farming has become a growing industry in the world in recent years. According to the FAO statistics the world aquaculture production by inland and marine waters has grown from 24456561 t in 1993 to 51385912 t in 2002. The total world fisheries production (capture and aquaculture) was 132.989.225 t and aquatic plant production was 12929323 t in 2002 (FAO, 2002).

Development of Aquaculture in Turkey

Turkey is situated between the Black Sea in the north, the Mediterranean in the south and the Aegean Sea in the west. The Marmara Sea divides the country into two parts called Anatolia and Thrace. The country has an important geo-political status because its location serves as a natural bridge linking Asia and Europe and has a total area of 779452 km². Turkey is a highland country with an average altitude of over 1.000 meters. The climate in eastern and inland Anatolia is cold in winter and hot in summer, while the coastal regions have rather mild climatic conditions. The annual average precipitation is 643 mm, but it varies

Fig. 1. Geographical Status of Turkey.

Water Capacity of Turkey for Aquaculture

Production fields	Number	Surface Area, ha	Length, km
Natural Lakes	200	906118	-
Dam Lakes	193	342377	-
Ponds (Artificial Lakes)	750	15500	-
Rivers and streams	33	-	177714
Seas (Coastal Strips)	-	24607200	8333
TOTAL		25871195	

from 250 mm in the central part to 3000 mm in the eastern Black Sea region (Figure 1) (Tekinel, 1988).

Turkey has rich inland water sources, about 200 natural lakes, about 750 artificial lakes or ponds, about 193 reservoirs, 33 rivers and streams of 177714 km length, and 8333 km of coastal strips (Table 1). Some lagoons covering of 70000 hectares in Aegean and Mediterranean coastal strips are very suitable for aquaculture. Another aquaculture potential will be obtained with the South East Anatolia Project (GAP) in the lower Euphrates River and Tigris River basins. This project is the largest regional development project in Turkey, and one of the largest in the world, integrating development of irrigated agriculture and agro-industry, supporting services, including communications, health and education (Canyurt, 1997, Min. Agr., 2003).

The project area covers 74000 km^2 that correspond to 9.2% of the total surface area of Turkey. About 224000 ha of water surface will be obtained at the end of this project; this will be a big aquaculture production potential for the country.

Situation of Aquaculture in Turkey
Aquaculture production, exportation, importation and consumption:

According to FAO data (2002), Turkey produces 604725 t, exports 51746 t and imports 33961 t of fish and fisheries products. The amount of non-food usage is 101852 t that is used for food industry. The population of the country is 68279000 and consumption per capita is 7.1 kg.

All activities in fisheries and aquaculture in Turkey are based on the Water Products Law No. 1380, enacted in 1971. The Ministry of Agriculture and Rural Affairs is responsible for all kinds of aquaculture activities and fisheries in the country. The Ministry undertakes its duties in aquaculture and fisheries management through four General Directorates and as well as 81 Provincial Directorates. During 1980s, significant effort was devoted to preparing laws related to the management of coastal and inland water sources (Kiliē, 2000; Knudsen, 1995).

Aquaculture has been included in the encouragement
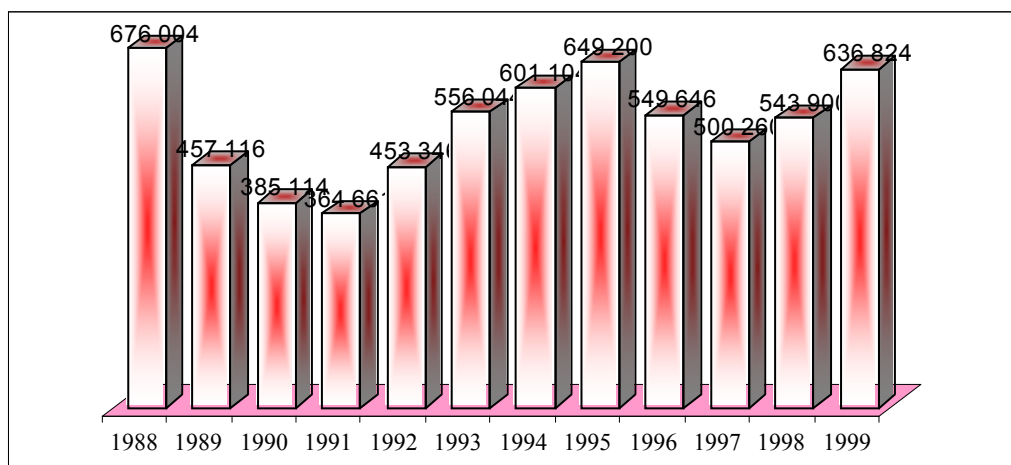
Fig. 2. Fish Production in Turkey.

Aquaculture Production in Turkey (t)

Year/Sp.	Carp	Trout	Gilthead sea bream	Sea bass	Salmon	Other Sp.	Total
1990	1025	3212	1031	102	300	112	5782
1992	251	6396	930	808	680	133	9212
1994	288	9997	6070	2229	430	-	15998
1995	424	12689	4847	2773	654	40	21607
1996	780	18420	6320	5210	193	2188	33201
1997	800	28500	7500	6300	50	2300	45450
1998	950	34630	10150	8660	40	2310	56700
1999	900	38570	11000	12000	-	530	63000

decree published by governments, and the Agriculture Bank of Turkey applied interest rates to support and encourage investments in aquaculture. In addition to encouragement measures and financial support of the Governments, the Universities attach great importance to the research activities and education of engineers and technicians in 16 Faculties of Fish Products and Professional Colleges.

The main fish species cultured in Turkey are Carp (*Cyprinus carpio*), Rainbow trout (*Oncorhynchus mykiss*), Atlantic salmon (*Salmo salar*), Gilthead sea bream (*Sparus aurata*), European sea bass (*Dicentrarchus labrax*), Bluefin tuna (*Thunnus thynnus*), Black sea turbot (*Psetta maxima*), Mediterranean mussel (*Mytilus galloprovincialis*), and Shrimp (*Penaeidae spp*) (Table 2).

Aquaculture production of Turkey has grown steadily over the years (Min. Agr., 2003) from 5782 t in 1990 to 63000 t in 1999 and to 79031 t in 2000 (Figure 3).

The numbers of aquatic farms are shown in Table 3. There are 1.309 farms in inland waters producing approximately 32.466 tonnes of fresh water fish species, and 352 farms at sea producing 40.119 tonnes of sea fish species, mainly Gilthead sea bream and European sea bass (Min. Agr., 2003).

Constraints of Aquaculture in Turkey

Especially marine aquaculture systems are criticised for their environmental and ecological impacts. The extensive and semi-intensive farming methods have less environmental impacts than intensive aquaculture. It is necessary to support the development of sustainable aquaculture. For this purpose, in 2002 European Commission designed a strategy document for a sustainable development of aquaculture in Europe (C.E.C., 2002; Basurco and Lovatelli, 2004). As a candidate country to the European Community, Turkey takes all the measures to respect and adopt the rules designed by the European Commission. Fisheries and Aquaculture file is one of the 31 files to be discussed with the Commission from 3 October 2005. The importance of aquaculture has been recognized by the Ministry of Agriculture and Rural Affairs and by the private sector in collaboration with the Universities (Canyurt at all., 2003). The
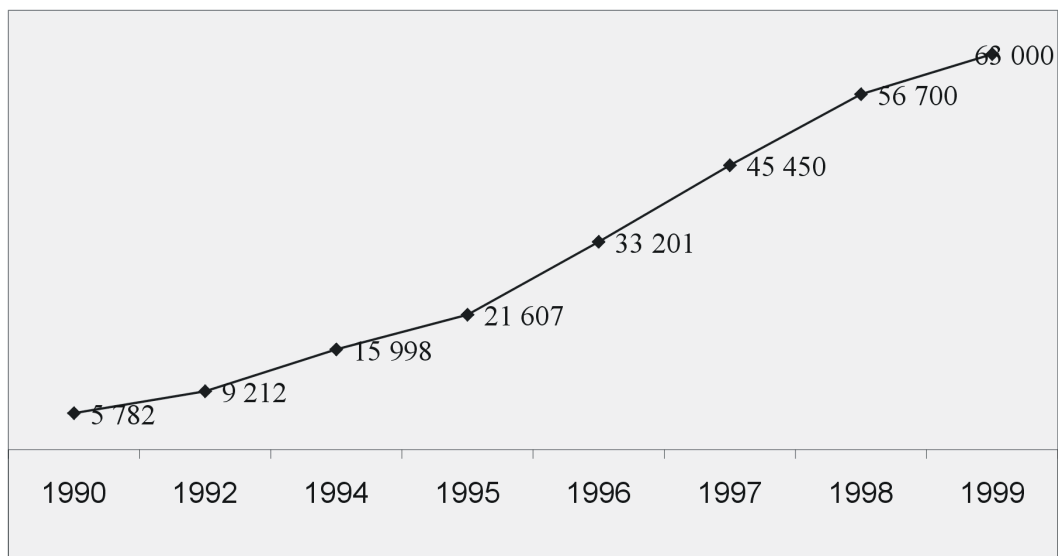
Fig. 3. Development of Aquaculture in Turkey.

Table 3

Number of Licensed Aquaculture Farms and Capacities by 2002

Area	Number	Capacity, t year^{-1}	Number	Capacity, t year^{-1}	Total number	Total Capacity, t year^{-1}
Fresh water Farms	1022	23970	287	8496	1309	32466
Sea Farms	247	22912	105	17207	352	40119
Total	1269	46882	392	25703	1661	72585

Table 4

Aquaculture Production by Years at Fresh Water and the Sea (t)
(Ministry of Agriculture and Rural Affairs)

Year	Fresh water	%	Sea	%	Total	%
1988	3965	96,7	135	3,3	4100	100
1990	4237	73,3	1545	26,7	5782	100
1992	6522	70,8	2688	29,2	9210	100
1994	7265	45,4	8733	54,6	15998	100
1996	17960	54,1	15241	45,9	33201	100
1998	33290	58,7	23410	41,3	56700	100
2000	43385	54,9	35646	45,1	79031	100

development of aquaculture is very important in Turkey because it provides jobs.

Conclusions

In the conclusion of this work we can say that the aquaculture sector in Turkey is facing some constraints, such as (Canyurt, 1996; Kiliē, 2000; Min.Agr. 2003):
- the complexity of licensing procedures;
- site selection problems;
- the complexity of project preparation and application;
- problems with some other sectors, like tourism, protected areas and navigation;
- high prices of inputs and difficulties in supplying;
- disease risk with imported eggs and fry;
- marketing and quality control problems;
- non-organization of the sector can be cited as a major constraint of aquaculture in Turkey to be solved.

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ACIDIFIERS ADDITIVE PROJECTION ON PIGS METABOLIC PROCESSES AND DIGESTIVE TRACT MICROFLORA

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Abstract

A study was conducted to determine efficiency of an organic acids additive on pigs metabolic processes and digestive tract microflora. The pigs of control group were fed without an organic acids additive. The feed of the trial group piglets contained 6 kg of organic acids additive per tonne feed, for starter pigs – 4 kg per tonne feed, for finished pigs – 3 kg per tonne feed. The study indicated that at the age of 130 days, pig mass in the trial group was 54.08 kg on average, but in the control group – 51.06 kg, which showed that pigs from the trial group had by 6% higher average mass than in the control group (p <0.05). At the age of 160 days, pig mass in the trial group was on average 94.3 kg, in the control group – 90.63 kg; pigs from the trial group had by 4% higher mass than in the control group (p<0.05). Feed consumption for the trial group was by 1% less than in the control group. Average daily gain for the trial group was 0.663 kg, which was by 6% more than for the control group pigs (p<0.05). Feed conversion in the trial group was 3.06 kg, but in the control group – 3.275 kg, i.e. 6.4% higher than in the trial group. Analyses of Jejunum microflora showed that use of acidifier additive reduced Mould colony formed units – CFU amount in 1 g of the trial group sample by 6%. Staphylococcus species amount in the trial group was 500 CFU in 1 g of sample, but in the control group – 40000 CFU, i.e. 80 times more. In the trial group, Lactic acid bacteria CFU amount in 1 g of sample was by 6% higher than in the control group. The results of Rectum microflora analyses showed that Staphylococcus species amount in the trial group was 12000 CFU in 1 g of sample, but in the control group it was by 34% higher.
Key words: pigs, organic acids, guts microflora.

Introduction

Diarrhoea is a common problem in animal production, affecting mostly the young growing animal. High average frequency (6–7%) of all litters born are affected with diarrhoea pre-weaning (Svensmark et al., 1989a). Further the risk for developing diarrhoea post-weaning increased if the piglets had gastrointestinal disorders during the suckling period (Svensmark et al., 1989b).

Organic acids and some of their salts are added into starter feeds and fattening feeds for piglets in order to improve the performance and stabilize the general health of the animals (Hyden, 1995).

Microbial activity in raw materials and feeds can be eliminated by the use of antimicrobial substances, which either inhibit the growth of the organism (bacteriostatic or fungistatic action) or kill it (bacteriocidal or fungicidal action). Growth of an organism is a consequence of several processes. Inhibition of one or more of those processes results in growth inhibition and possibly kills.

The survival and growth of microorganisms are governed by many parameters, such as temperature, moisture, nutrient availability, and pH. In most cases, enteropathogens have a low tolerance to low (acid) pH whilst commensal microflora tend to prefer a more acid environment. Within the framework of using organic acids, pH is an important criteria. Each microorganism has its own response to acidity: minimum, maximum and optimal pH level for growth. Altering the ion concentration influences the growth or inhibition of an organism. Bacteria are generally more fastidious and prefer a nearly neutral pH (6.5–7.5), but can tolerate a pH range of 4–9. Yeasts tolerate lower pH values than bacteria. Moulds are to the widest pH range (Axford et al., 2000).

The major disease causing bacteria in animal production are the Gram negative enteric bacteria. These species will colonise the gut and result in either subclinical infections which lower performance or cause clinical scours and enteritis problems that can, in severe cases, lead to

Table 1

Acidifier additive projection on pig mass dynamics

Traits	Control group n=50		Trial group n=50	
	$\bar{x} \pm s_{\bar{x}}$	S	$\bar{x} \pm s_{\bar{x}}$	S
Mass on 30th day, kg	9.24±0.24	1.72	8.09±0.14	1.03
Mass on 130th day, kg	51.06±1.17	8.29	54.08±1.19	8.44
Mass on 130th day, % to control	100		106	
Mass on 160th day, kg	90.63±0.76	5.39	94.30±0.83	5.87
Mass on 160th day, % to control	100		104	

Table 2

Acidifier additive projection on pigs productivity

Traits	Control group	Trial group
	n=50	n=50
Daily gain, kg	0.626±0.005	0.663±0.006
Daily gain, % to control	100	106
Feed consumption, kg	266.5	264.3
Feed conversion, kg	3.275	3.066
Feed conversion, % to control	100	93.6

death. In case of salmonellae, these organisms can relocate through the mucouse membranes of the gut wall and enter the blood stream. Once in the blood, these organisms can colonise various organs such as liver, spleen, ovary, etc. (Malmquist et al., 1995).

Lactic acid, fumaric acid, propionic acid, citric acid and theirs salts have been shown to improve growth rate and feed efficiency in pigs (Peris, Asensio, 2002). Other benefits associated with acidification include improvements in digestive enzyme activity, microbial phytase activity, and increased pancreatic secretion (Dibner, 2004).

The aim of the research was to detect organic acids additive projection on pigs metabolic processes and guts microflora.

Methods

The studies were carried in the pig breeding Association Ltd "Cirma", Biochemistry laboratory of the Research Institute of Biotechnology and Veterinary Medicine "Sigra" and meat processing plant "Ruks". With the aim to carry out the studies, two groups of pigs were formed. The control group did not contain the organic acids additive. The feed of the trial group contained 6 kg of organic acids additive per tonne feed for pigs after weaning, 4 kg per tonne feed for grower pigs, and 3 kg per tonne feed for finished pigs.

Organic acids additive contains formic acid, acetic acid, citric acid, phosphoric acid, and calcium. Investigation was made with 100 pigs from 30 days of age till slaughtering at the age of 160 days. Pig mass was detected on the 30th day, 130th day after birth, and before slaughtering. During the feeding experiment, consumed feed and feed conversion was analysed. Small intestine and rectum substances were taken for microbial tests after slaughtering. Microbial tests was made by standard methods.

The data were processed with MS Excel program, t - test.

Results

At the beginning of the investigations, when the piglets start mass was compared (Table 1), in both groups indices of mass did not show an essential difference (p>0.05). At the age of 130 days, pigs mass in the trial group was 54.08 kg on average, but in the control group – 51.06 kg, which demonstrated that pigs from the trial group had by 6% higher mass. An essential difference between both groups was found (p<0.05). At the age of 160 days, pig mass for the trial group was on average 94.3 kg, for the control group – 90.63 kg, which showed that pigs from the trial group had by 4% higher mass compared to the control. An essential difference between the groups was found (p<0.05).

Table 3

The results of pigs' Jejunum microflora analyses

Traits	Control group	Trial group
Total thermophilic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	150000	20125500
Lactic acid bacteria CFU amount in 1 g of sample	23800	25250
Mould CFU amount in 1 g of sample	800	750
Yeasts CFU amount in 1 g of sample	1000	500
Escherichia coli mesophilic forms CFU amount in 1 g of sample	128000	246500
Escherichia coli termophilic forms CFU amount in 1 g of sample	142400	282500
Staphylococcus species CFU amount in 1 g of sample	40000	500
Enterococcus species bacteria CFU amount in 1 g of sample	2540000	167500

Table 4

The results of pigs' Rectum microflora analyses

Traits	Control group	Trial group
Total thermophilic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	9500000	1473800
Lactic acid bacteria CFU amount in 1 g of sample	12833	58000
Escherichia coli mesophilic forms CFU amount in 1 g of sample	165666	255600
Escherichia coli termphilic forms CFU amount in 1 g of sample	120000	1288000
Enterobacter aerogenes CFU amount in 1 g of sample	13333	80000
Staphylococcus species CFU amount in 1 g of sample	34333	12000
Enterococcus species bacteria CFU amount in 1 g of sample	4766666	2240000

Pigs from the trial group consumed 264.3 kg of feed, from the control group – 266.5 kg, thus feed consumption in the trial group was by 1% less than in the control. The highest daily gain indices for pigs from the trial group was 0.663 kg, which was by 6% higher than for pigs in the control group (Table 2). An essential difference between both groups was found (p<0.05).

The bests results of feed conversion were found in the trial group, because 3.06 kg of feed ration were necessary to obtain 1 kg of body mass, but in the control group 3.27 kg were necessary which was by 6.4% more.

The results of Jejunum microflora analyses (Table 3) showed that use of acidifier additive reduced Mould colony formed units - CFU amount in 1 g of sample. In the control group, CFU amount was 800 in 1 g of sample, in the trial group –6% less. A significant decrease was observed to Staphylococcus species: in the trial group – 500 CFU in 1 g of sample, but in the control group – 40 000 CFU, i.e. 80 times higher than in the trial group. Lactic acid bacteria CFU amount in 1 g of sample in the trial group was by 6% higher compared to the control.

The results of Rectum microflora analyses (Table 4) showed that use of acidifiers additive reduced the Staphylococcus species amount: 12000 CFU in 1g of sample in trial group, but in the control group – 34333 CFU in 1 g of sample, i.e. by 34% more compared to the trial group.

Lactic acid bacteria CFU amount in 1 g of sample was by 4.5 times higher in the trial group compared to the control group.

Conclusions

1. The acidifiers additive improved pigs' growth rate: pigs daily gain in the trial group was by 6% higher than in the control group.

2. Pigs from the trial group consumed by 1% less feed than pigs in the control group.

3. The best results of feed conversion were in the trial group – 3.06 kg, which was by 6.4% less than in the control group.

4. Jejunum microflora analyses showed that use of acidifiers additive reduced Mould CFU amount by 6% in the trial group. Staphylococcus species amount in the trial group decreased by 80 times. Lactic acid bacteria CFU amount in 1 g of the trial group sample was by 6% higher compared to the control group.

5. Rectum microflora analyses showed that use of acidifier additive reduced Staphylococcus species amount in the trial group by 34% compared to the control. Lactic acid bacteria CFU amount in 1 g of sample in the trial group was 4.5 times higher compared to the control group.

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AGRICULTURAL ENGINEERING SCIENCES

INSURANCE OF THE MILKING EQUIPMENT WASHING REGIME IN LOWERED ENVIRONMENTAL TEMPERATURE

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Abstract

In Latvia, use of unheated cow sheds with lowered environmental temperature is growing. In such circumstances, cooling of the milking equipment washing liquid is more rapid and quality of the washing equipment decreases. However, it may be eliminated by coating the milk and washing liquid piping with heat insulation.

A mathematical model of the milking equipment washing liquid by which the end temperature of the washing liquid cooling can be determined is developed. Two types of heat insulation materials are under the trial. Laboratory experiments on cooling of the washing liquid are carried out and the experimental coefficients of the mathematical model are determined.

Key words: cow shed, milking equipment, washing liquid, temperature.

Introduction

In Latvia, use of the unheated cow sheds is growing where in the cold season the environmental temperature is lowered. For instance, in the milking parlours this temperature exceeds 0 °C only a little in winter [1]. In turn, the advised temperature is lower than 12 °C [2]. Therefore, in such circumstances more rapid cooling of the milking equipment washing liquid occurs and it is under the threshold of the maximum limit which for more widely used washing liquids is set as +40 °C [2]. But it worsens washing quality of the milking equipment.

To eliminate this drawback, supplementary heating of the washing liquid is done in modern milking equipment. However, it is related to an increased consumption of electricity.

As our former experiments indicate [3], in milking equipment with the milk piping envisaged for 100 cows, approximately 60% of the heat of the washing liquid is lost when it is flowing in the milk and washing liquid piping. Therefore, the washing liquid cooling can be decreased by heat insulation of piping. This method is particularly suitable in modern milking equipment, because it does not have glass, but stainless steel piping. Currently, it is also possible to purchase different heat insulation coatings which are suitable for cow shed conditions. Therefore, the aim of our research was to develop heating solution for the milk and washing liquid piping in milking equipment, develop its mathematical basis and carry out testing in laboratory conditions.

Materials and methods

In general, cooling of the washing liquid is characterized by the equation [4]:

$$T_b = T_g + \left(T_i - T_g\right)\cdot e^{-\frac{t}{\tau}}, \qquad (1)$$

where:

T_b – the end temperature of the washing liquid, °C;
T_g – the environmental temperature, °C;
T_i – the start temperature of the washing liquid, °C;
t – time of measurement, s;
τ – time constant where temperature change of the washing liquid happens e times (i.e., 2,718 times), s.

Applying this equation, we have developed a mathematical model of cooling the washing liquid for a cow milking equipment with milk piping [3]:

$$T_b = T_g + \left(T_i - T_g\right)\cdot e^{-\frac{t\cdot\left(k_I\cdot L_I + K_{II} + k_{III}\cdot n_{III} + k_{IV}\cdot L_{IV}\right)}{c_u\cdot M_u + c_I\cdot m_I\cdot L_I + c_{II}\cdot M_{II} + c_{III}\cdot m_{III}\cdot n_{III} + c_{IV}\cdot m_{IV}\cdot L_{IV}}}, \quad (2)$$

where:

c_u – the peculiar thermal capacity of the washing liquid, kJ kg^{-1} K^{-1};
M_u – mass of the washing liquid
c_I – the peculiar thermal capacity of the milk piping, kJ kg^{-1} K^{-1};
m_I – mass of one meter of the milk piping, kg m^{-1};
c_I – the total peculiar thermal capacity of the milk collecting unit and the washing liquid tank, kJ kg^{-1} K^{-1};
M_{II} – the total mass of the milk collecting unit and the washing liquid tank, kg;
c_{III} – the peculiar thermal capacity of the milking equipment, kJ kg^{-1} K^{-1};
m_{III} – mass of one milking equipment, kg;
c_{IV} – the peculiar thermal capacity of the washing liquid piping, kJ kg^{-1} K^{-1};
m_{IV} – mass of one meter of the washing liquid piping, kg m^{-1};
k_I – heat transition coefficient of the milk piping, W m^{-1} K^{-1};
L_I – length of the milk piping, m;
K_{II} – the total heat transition coefficient of the milk collecting piping and the washing liquid tank, W piece^{-1} K^{-1};
k_{III} – the heat transition coefficient of the milking equipment, W piece^{-1} K^{-1};

n_{III} – number of the milking equipment, pieces;

k_{IV} – the heat transition coefficient of the washing liquid piping, W m^{-1} K^{-1};

L_{IV} – length of the washing liquid piping, m.

Developing the given model, it is taken into account that flow of the washing liquid in the milking equipment is insured via four different sections (Fig.1) which are made of different materials and which are with different heat accumulating and leakage properties. In addition, this model is universal, because it can be used in milking equipment which differs in length both in milk and washing piping and in the numerical amount of the washing equipment.
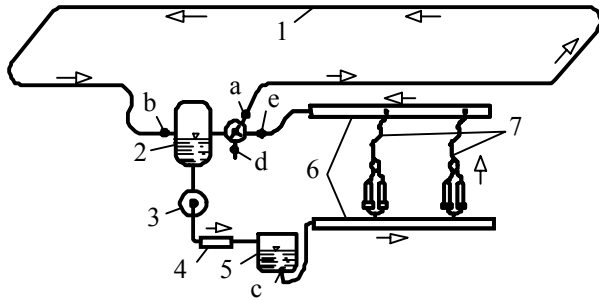
Fig.1. Division of the washing liquid flow according to separate sections of the washing equipment: 1 – the milk piping; 2– the milk collector; 3 – the milk pump; 4 – the milk filter; 5– the washing liquid tank; 6 – the washing liquid piping; 7– the milking equipment; a–b– Section 1 (the milk piping); b–c– Section 2 (the milk collecting unit and the washing liquid tank); Section 3 (the milking equipment); c–a– section 4 (the milking liquid piping excluding the milking equipment).

If the milk and washing liquid piping in the milking equipment is covered by heat insulation, then the mathematical model (2) looks as follows:

$$(3)$$

$$T_b' = T_g + \left(T_i' - T_g\right) \cdot e^{\frac{t \cdot \left(k_I' \cdot L_I + K_{II} + k_{III} \cdot n_{III} + k_{IV}' \cdot L_{IV}\right)}{c_u \cdot M_u + c_I \cdot m_I \cdot L_I + c_I' \cdot m_I' \cdot L_I + c_{II} \cdot M_{II} + c_{III} \cdot m_{III} \cdot n_{III} + c_{IV} \cdot m_{IV} \cdot L_{IV} + c_{IV}' \cdot m_{IV}' \cdot L_{IV}}},$$

where:

T_b' – the end temperature of the washing liquid using milk and washing liquid piping with heat insulation, °C;

T_i – the start temperature of the washing liquid, °C;

k_I' – heat transition coefficient of the heat insulation material for the milk piping, W m^{-1} K^{-1};

k_{IV}' – heat transition coefficient of the piping insulation material for the washing liquid, W m^{-1} K^{-1};

c_I' – the peculiar heat capacity of the heat insulation material for the milk piping, kJ kg^{-1} K^{-1};

m_I' – mass of one meter of heat insulation for the milk piping, kg m^{-1};

c_{IV}' – the peculiar heat capacity of the heat insulating material for the washing liquid piping, kJ kg^{-1}K^{-1};

m_{IV}' – mass of one meter of the heat insulating material for the washing liquid piping, kg m^{-1}.

Taking into account that by letting the hot washing liquid into the washing system of the milking equipment, at first heating of the elements which form the given system occurs, at first temperature of the fluid rapidly decreases. It levels out only in 3–5 minutes [3]. Therefore, the start temperature of the washing liquid (after levelling out) is calculated according to the formula [3]:

$$T_i' = \frac{c_u \cdot M_u \cdot T_0 + \left(\sum c_i \cdot m_i + c_i' \cdot m_i' \cdot L_i\right) \cdot T_g}{\sum c_i \cdot m_i + c_u \cdot M_u + c_i' \cdot m_i' \cdot L_i}, \quad (4)$$

where:

T_0 – the start temperature of the washing liquid, °C;

c_i – the peculiar heat capacity of the singled out section in the milking system, kJ kg^{-1} K^{-1};

c_i' – the peculiar heat capacity of the heat insulation for the singled out section in the milking equipment, kJ kg^{-1} K^{-1};

m_i – mass of the singled out section in the milking equipment, kg m^{-1};

m_i' – heat insulation mass for the singled out section in the milking equipment, kg m^{-1};

L_i – length of piping, m.

In turn, the heat transition coefficient of the heat insulation material for the milk piping is found using the following equation [3]:

$$k_I' = \frac{\left(c_u \cdot M_u + c_I \cdot m_I \cdot L_I\right) \cdot \ln\left(\frac{T_i' - T_g}{T_b' - T_g}\right)}{L_I \cdot t}. \quad (5)$$

To experimentally evaluate cooling rapid ness of the washing liquid in the washing equipment piping, it is possible to use the time constant τ getting it from the formula (1):

$$\tau = \frac{t}{\ln\dfrac{T_i - T_g}{T_b - T_g}} \quad \text{and} \quad \tau' = \frac{t}{\ln\dfrac{T_i - T_g}{T_b' - T_g}}. \quad (6) \text{ and } (7)$$

Where formula (6) is good for the milking equipment without heat insulation of the corresponding piping, but formula (7) – is good using the milk and washing liquid piping which is coated by the heat insulation.

Relating one constant against the other, it is possible to determine the coefficient δ, which characterizes the effect of the heat insulation:

$$\delta = \frac{\tau}{\tau'} = \frac{\ln\dfrac{T_i - T_g}{T_b' - T_g}}{\ln\dfrac{T_i - T_g}{T_b - T_g}}. \quad (8)$$

From formula (8) expressing T_b' coherence is obtained:

$$T_b' = T_g + \left(T_b - T_g\right) \cdot \left(\frac{T_b - T_g}{T_i - T_g}\right)^{\delta - 1}, \quad (9)$$

Thus, knowing value of the experimentally determined coefficient δ, it is possible to calculate the end temperature T'_b for the washing liquid, i.e., temperature of this liquid after its discharge through such sections of the milking equipment which are coated by the heat insulating material.

Methods of research

To determine effect of the heat insulation coefficient δ, a milk piping segment made of stainless steel was used which is used by the firm *Larta1* for its equipment. Length of piping – 1.2 m, outer diameter – 42 mm, thickness of the wall – 1.2 mm. The experiments were carried out in several successions. In the first succession of the experiment, the milk piping section was without heat insulation, in the second succession- it was covered by the heat insulating material made of foam polythene, but in the third succession- by rock cotton and aluminium foil coating.

Heat insulation coating for piping was put on its outside part, supplementary wrapping (strengthening) them by water-proof stick-type tape. One end of piping was locked by a tight stopper, but during the experiment piping was placed with the open end upwards.

For the experiments water was applied which substituted the washing liquid. As it is known from specialist literature [2], concentration of the washing liquid in the milking equipment is only 0.3–0.8%. Therefore, its physical heating properties can be accepted to be the same as for water.

In the start of every experiment, piping was filled (full) with hot water the temperature being 90 °C. Taking into account that at first material of piping heats up, measurement registration was started when water temperature decreased to 80 °C. The experiments lasted for two hours, every 15 minutes changes in temperature of the washing liquid were. In turn, it was tried to maintain the environmental temperature constant at 16.5 °C.

As a result of the experiments, data were obtained about dynamics of changes in water temperature in the given period of time. To evaluate the cooling tempo of the fluid, the time constant τ was estimated using formulas (6) and (7). After that, coefficient δ of the heat insulation effect was calculated using the formula (8). For estimations subsequent computing programs were developed.

Using the mathematical model (3), mathematical equations for estimating the end temperature were developed for every section in the milking equipment.

$$T_{II} = T_g + \left(T_i - T_g\right) \cdot e^{-\frac{t \cdot K_{II}}{c_u \cdot M_u + c_{II} \cdot M_{II}}}. \tag{10}$$

$$T'_I = T_g + \left(T'_i - T_g\right) \cdot e^{-\frac{t \cdot k'_I \cdot L_I}{c_u \cdot M_u + c_I \cdot m_I \cdot L_I + c'_I \cdot M'_I \cdot L'_I}}. \tag{11}$$

$$T_{III} = T_g + \left(T_i - T_g\right) \cdot e^{-\frac{t \cdot k_{III} \cdot n_{III}}{c_u \cdot M_u + c_{III} \cdot m_{III} \cdot n_{III}}}. \tag{12}$$

$$T'_{IV} = T_g + \left(T'_i - T_g\right) \cdot e^{-\frac{t \cdot k'_{IV} \cdot L_{IV}}{c_u \cdot M_u + c_{IV} \cdot m_{IV} \cdot L_{IV} + c'_{IV} \cdot m'_{IV} \cdot L'_{IV}}}. \tag{13}$$

The entities T'_i; k'_i; δ of the formulae were estimated using the formulae (4); (5); (8).

To determine temperature T_b, the heat transition coefficient k [3] which was determined in our laboratory trials and the constructive parameters of the milking equipment available in our laboratory were used.

The physical heat parameters of the separate sections in the milking equipment were taken from a source of literature [6].

Results of the theoretical research were tested practically applying the milking equipment of the firm *Larta1* available at the laboratory of the agricultural machinery of the Latvia University of Agriculture for which the cooling dynamics of the washing liquid was determined in two different situations: both when the milk and washing liquid piping is coated by heating insulation and also when it is not applied.
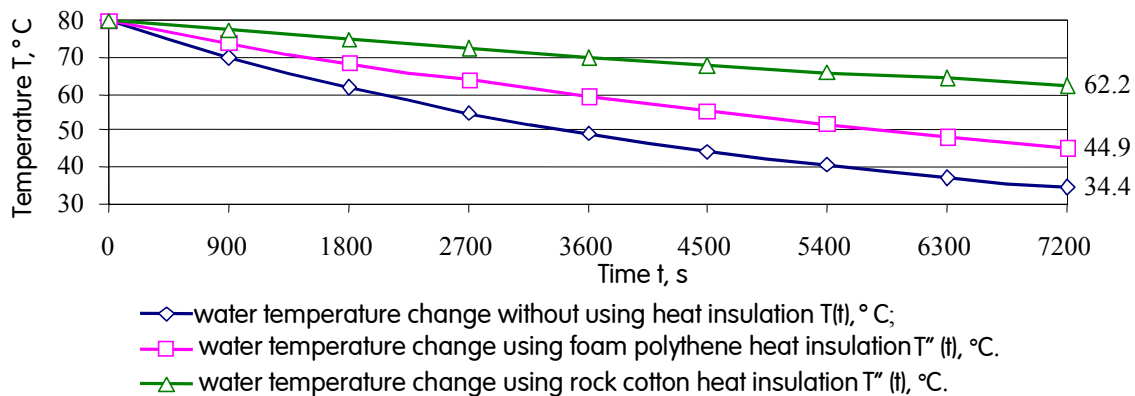
Fig. 2. Dynamics of water cooling in the piping section without heat insulation and using heat insulation.

Table1

Results of heat insulation effect

Parameters to be stated	Without heat insulation	Research variants		Formula used in estimations
		With polythene insulation ($''$)	With rock cotton and aluminium foil insulation ($'$)	
τ, s	5690			(6)
τ'' un τ', s		8953	22081	(7)
δ'' un δ'		0.636	0.261	(8)
T_b	34.4			(1)
T''_b un T'_b		44.9	62.2	(9)

Results

In the experiments, water cooling dynamics was determined for the piping without heat insulation and for one with foam polythene and rock cotton heat insulation coating. The water cooling characteristic obtained in the experiments is shown in Fig. 2.

Results of the research including the estimated parameters are presented in Table1.

If heat insulation is not used then temperature of the liquid during the experiment decreased from 80.0 to 34.4 °C, but applying piping covered by heat insulation the end temperatures of the fluid were 44.9 and 62.2 °C, respectively, on 10.5 and 27.8 °C higher. In turn, the time constants τ' for fluid cooling were 5690, 8953 and 22081 s, respectively. Thus, using foam polythene heat insulation, the time constant τ' for fluid cooling increased on 36.4%, but using rock cotton heat insulation which is also coated by aluminium foil, the time constants τ' increased on 74.2%. The respective coefficient δ of the heat insulation effect in these instances was 0.636 and 0.261, respectively.

Basing on the formulae (2) and (3), a computing program was developed (Table 2) by the aid of which it is possible to estimate the end temperature of the washing liquid.

This computing program is universal because it is used both when the milk and the washing liquid piping is without heat insulation and when they are with heat insulating coating. As the starting parameters, the constructive numbers of particular milking equipment and the characterizing indices of its washing regimes can be used.

Table 2

Estimation program of the washing liquid end temperature

(Numbers refer to the milking equipment with the milk piping manufactured by the firm *Larta1* available at the Technical Faculty of the Latvia University of Agriculture)

Heat transition coefficients		The applied formula	Changeable parameters		The applied formula	Intermediate results		The applied formula
k_I	0.66		T_0, °C	80		c_u, kJ kg^{-1} K^{-1}	4180	
k''_I	0.42	(5)	T_i, °C	67.62		c_I	461	
k'_I	0.15	(5)	T''_{i1}, °C	67.60	(4)	$L_I \cdot m_I$	13.4	
K_{II}	22.68		T'_{i2}, °C	67.52	(4)	$c_{II} \cdot M_{II}$	15705.8	
k_{III}	11.96		T_g	11.9		c_{III}	1400	
k_{IV}	0.77		t, s	3600		m_{III}	1.15	
k''_{IV}	0.22	(5)	L_I, m	12.4		c_{IV}	461	
k'_{IV}	0.14	(5)	M_u, kg	30		$L_{IV} \cdot m_{IV}$	6.0	
Heat insulation coefficients			n_{III}, gab	2		$\Sigma c_i \cdot M_i$	27868.1	
$\delta'' =$	0.636	(7)	L_{da}, m	5.6		$c_u \cdot M_u$	125400	
$\delta' =$	0.216	(7)	M''_{iz1}, kg	0.05		c''_{iz1}	1030	
			M'_{iz2}, kg	0.2		c'_{iz2}	1400	
T_I	56.4	(2)	T''_I	60.2	(10)	T_b, °C	25.8	(2)
T_{II}	43.1	(11)	T'_I	64.9		T''_b, °C	27.9	(3)
T_{III}	40.4	(12)	T''_{IV}	63.5	(13)	T'_b, °C	29.4	(3)
T_{IV}	61.2	(2)	T'_{IV}	66.1				

Comparing the end temperatures T_b and T'_b of the washing liquid which are obtained in the laboratory trials and by estimations, difference is only 0.25% (without heat insulation) and 3.21% with heat insulation. It shows that method of estimation for the end temperature of the washing liquid cooling in the milking equipment is sufficiently high in its accuracy.

Conclusions

1. If the environmental temperature is lowered in the milking place and is below the recommended 12 °C then cooling of the washing liquid is increased which can exceed the permitted limits.

2. Cooling of the washing liquid in the milking equipment can be decreased if the milk and washing liquid piping is coated by heat insulation. Applying foam polythene heat insulation, the time constants τ for washing fluid cooling is on 36.4% higher, but applying rock cotton insulation coated by aluminium foil, the time constant τ increases on 74.2% in comparison with piping without heat insulation coating.

3. For estimating the end temperature of the washing liquid cooling in the milking equipment, the developed mathematical model is applicable (Table 2).

4. Comparing the estimated and experimentally obtained end temperature for the washing liquid, difference amounts only to 0.25% (without heat insulation) and 3.21% (using piping with heat insulation) which indicates that the mathematical model is with sufficiently high accuracy.

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LOADING ANALYSIS OF DISC BRAKE'S FRICTION CLUTCH

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Abstract

The article discusses investigations in a flat rectangular shape contact area of two elastic solids (brake friction lining and disc) using a theoretical method. The solids are in free as well as in forced movement. The investigations have resulted in correlations describing deformation and stiffness parameters of solid flat joint in different loads: transference of the center of cross section δ_0, the angle of turning φ of one solid in relation to the other (as a result of friction lining deformation), and tension σ_x in any cross section of the contact area. The results of the investigations make it possible to analyze the stiffness of the contact of solids, test the strength of the contact areas, optimize the contact area of solids, and prognosticate even wear out of friction lining.

Key words: stiffness, tension, friction, joint.

Introduction

The aim of this study is to realize even wear on friction lining surface. Wear depends on such factors as: a kind of material, specific surface pressure, friction coefficient, slipping velocity, and surface temperature (Соколовский, 1955). During braking process, friction lining wears out and grows hot intensively. Braking force causes the friction force. Friction force causes the bending moment. As a result, loading distribution and wear out are uneven. It is possible to achieve even loading and wear out applying braking force P with eccentricity l.

Stiffness criterion of machine assemblies mounting characterises preciosity, oscillation resistance, conditions in contact (for example, pressure concentration, butt firmness and firmness of loaded joints), and longevity of parts during exploitation.

Stiffness of machines depends on stiffness and deformation of mounted surfaces. About 40…90% from all elastic deformation consists of contact elastic deformation. Contact deformation of mounted parts surfaces can induce either positive (reduce frequency of self resonance oscillation, impact load absorption) or negative influence (loading density, decrease preciosity of motion and increase wear out). In joints loaded with bending moment parts tend to curve. It influences parts motion preciosity and induces vibrations.

Elastic transference in contact of area depends on the following factors: roughness of surface, deflection of accurate geometry, pressure distribution on surface, loading character, material, movable or immovable contact surface, lubrication and other factors (Штаерман,1949; Рыжов1966; Демкин, 1970, 1980; Островский 1965).

The authors carried out a theoretical study of two flat surface contact for a brake of single disc.

Friction lining wear out mainly depends on specific surface pressure $p\ (x,z,t)$ and slipping velocity $v\ (x,z,t)$ between disc and its lining (Fig. 1, c). Usually velocity of wear out dw/dt is proportional to specific surface pressure and function of exponent (Крагельский, 1977).

$$\frac{dw}{dt} = K'_W p^{\alpha}(x,z,t)v^{\beta}(x,z,t). \tag{1}$$

$$w(x,z,t) = K_W \int_0^t p^{\alpha}(x,z,\widetilde{t})v^{\beta}(x,z,\widetilde{\tau})d\tau, \tag{2}$$

where

K_w – coefficient characterizes resistance of wear and working conditions;

τ – time moment;

α and b – exponents ($\alpha \geq 1 ; b \approx 1$).

Uneven wear out of friction lining in radial direction depends on the length of friction way. Length of friction way depends on friction radius r (Fig. 1, a). Wear out of friction lining will be nearly even in all points of friction surface if linear intensity (or velocity) of wear out is equal in these points. It is possible to realize such conditions if distribution of specific surface pressure is uneven. Specific surface pressure should be reduced in points on friction surface in which the friction way is longer. During braking process, distribution of specific surface pressure p is uneven. Friction force causes $F_f(F'_f)$ the bending moment $M = F_f \cdot h$ (Fig. 1, c). Because of the bending moment friction lining tends to rotate on one side of lining load more than on the other. It means that friction lining wear out uneven in radial and axial direction. One of the aims of the study is to develop a theory to analyse tension distribution, deformation and angle of rotation as functions of force P applying point (x, z) and bending moment $\pm M$. By changing eccentricity it is necessary to find the desirable distribution of specific surface pressure on friction lining.

Resistance of lining wear increases if wear out in all surface points is equal. It will preserve flatness of friction lining, too. As a result, longevity of disc brake will increase.

The results of this study is contribution to the design of α disc brake with single a disc.

Methods

The authors have investigated a flat rectangular shape contact area of two elastic solids using a theoretical method.
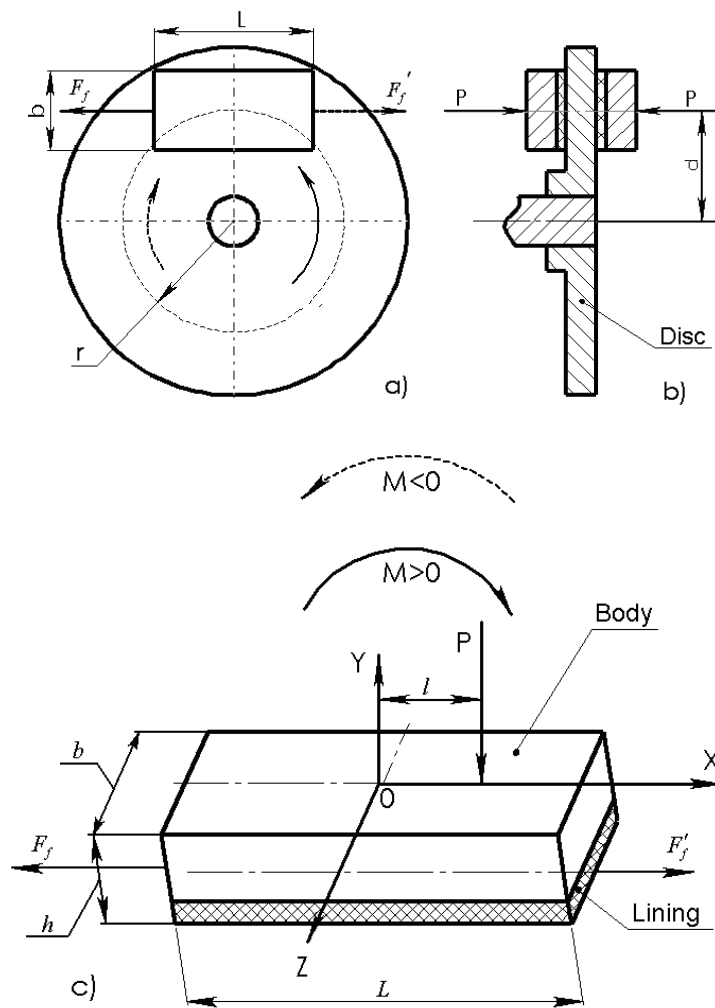
Fig. 1. Schemes of single disc friction elements (body with friction lining) loading:

a) load with friction force $F_f(F_f')$; b) load with force P;

c) brake friction clutch loaded eccentrically with force P and bending moment caused by friction force $F_f(F_f')$.

In this aspect parameters have been experimentally detected and statistically generalized by other authors (Левина, Решетов, 1971).

Such a method allowed to include more parameters in a constructive research compared with theoretical modeling. The study has been carried out with solids in free movement.

Two solids, loaded with forces, are translated regarding each other in contact area because of local solids deformation.

The task was to solve a free movement contact provided solids can move freely regarding each other.

The authors characterize stiffness of elastic solid closed joint contact with such parameters:

- transference of the center of cross section δ_0;
- angle of turning φ of one solid in relation to the other one;
- tension σ_X in any cross section of the contact area.

It is assumed that only friction lining is deformed under load. These parameters are analysed as a function of force $P > 0$, bending moment $M > 0$ (or $M < 0$) caused by friction force F_f (or F_f'), and eccentricity l. It is assumed that $z = 0$.

Results

Free motion of two solids loaded with force and bending moment if flat joint contact area is closed

Relative deformation of two solids, moving flatly and paralelly, (the elastic displacement being in the middle of the flat closed joint) and the relative turning angle depend on the part whose stiffness is lower (Fig. 2).

Condition of solid flat closed joint contact balance (Левина, Решетов, 1971):
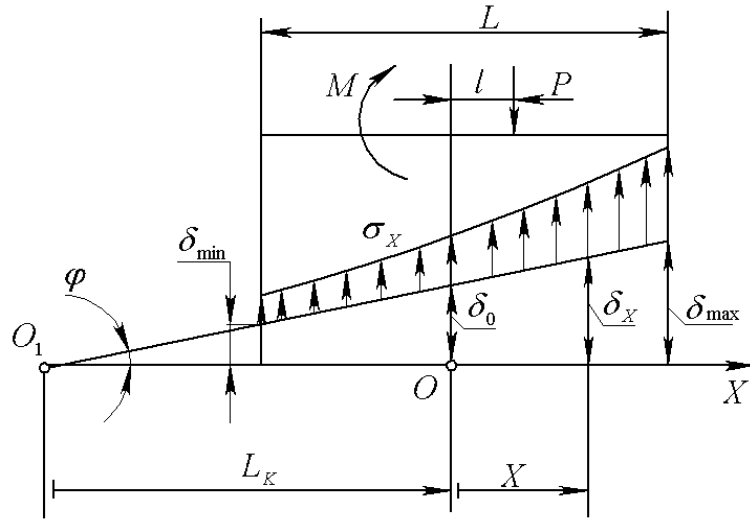
Fig. 2. Scheme of calculation of solid flat closed joint contact area stiffness parameters.

$$0{,}1b \int_{-0{,}05L}^{0{,}05L} \sigma_X \, dx = P; \qquad (3)$$

$$b \int_{-0{,}05L}^{0{,}05L} \sigma_X x \, dx = M + Pl, \qquad (4)$$

where

b – width of joint, mm;

σ_X – tension in any cross – section of the contact area, MPa;

M – bending moment, Nmm;

l – coordinate of force P applying point, mm;

L – joint length, mm.

Tension σ_X can be calculated using empirical formula (Левина, Решетов, 1971):

$$\sigma_X = \left(\frac{\delta_X}{10c}\right)^n = \left[\frac{\varphi(x - L_K)}{10c}\right]^n, MPa, \qquad (5)$$

where

n – degree exponent, n = 1 ... 3 [Левина, Решетов, 1971];

c – coefficient, it depends on geometry of material (Левина, Решетов, 1971);

δ_X – elastic transference of the center of cross – section at distance x, μm;

x – coordinate of contact area cross-section, mm;

L_k – coordinate of part's rotation center, mm.

After integrating (3) and (4), nonelinear equation regarding parameters L_k and φ has to be solved:

$$\begin{cases} \dfrac{(0{,}05L - L_K)^{n+1} - (-0{,}05L - L_K)^{n+1}}{n+1} = \dfrac{10P}{b} \cdot \dfrac{10^{-4n} c^n}{\varphi^n} & (6) \\[2mm] \dfrac{(0{,}05L - L_K)^{n+2} - (-0{,}05L - L_K)^{n+2}}{n+2} + L_K \dfrac{(0{,}05L - L_K)^{n+1} - (-0{,}05L - L_K)^{n+1}}{n+1} = \\[2mm] = \dfrac{M + Pl}{b} \cdot \dfrac{10^{-4n} c^n}{\varphi^n}. \end{cases}$$

It is impossible to solve the equation system (4) directly regarding parameters L_k and φ. At the beginning it is necessary to solve the equation:

$$\frac{(0{,}05L - L_K)^{n+2} - (-0{,}05L - L_K)^{n+2}}{(0{,}05L - L_K)^{n+1} - (-0{,}05L - L_K)^{n+1}} = \frac{(n+2)}{(n+1)} \cdot \left(\frac{M + Pl}{10P} - L_K\right). \quad (7)$$

Firstly $L_k \leq 0$ is established, afterwards rotation angle φ can be calculated:

$$\varphi = 10^{-4} c \sqrt[n]{\frac{10P(n+1)}{b\left[(0{,}05L - L_K)^{n+1} - (-0{,}05L - L_K)^{n+1}\right]}}. \qquad (8)$$

The joint will open, if $L_k = -0{,}05\,L$ (9)

$$0{,}1L = \frac{n+2}{n+1}\left(\frac{M + Pl}{10P} + 0{,}05L\right); \qquad (10)$$

or

$$\frac{M + Pl}{Pl} = \frac{n}{2(n+2)}. \qquad (11)$$

if

$$\frac{M + Pl}{Pl} \leq \frac{n}{2(n+2)}, \qquad (12)$$

than the joint will be closed, but if

$$\frac{M + Pl}{Pl} > \frac{n}{2(n+2)}, \qquad (13)$$

the joint will be open.

Maximal tension in joint contact area (MPa) is:

$$\sigma_{\max} = \left[\frac{\varphi(0,05L - L_K)}{10^{-4}c} \right]^n \tag{14}$$

Elastic displacement (μm):

$$\delta_0 = -10^3\,\varphi \cdot L_K. \tag{15}$$

Free motion of two solids loaded with force and bending moment if flat joint contact area is open

The condition of solid flat closed joint contact balance (Fig. 3) are:
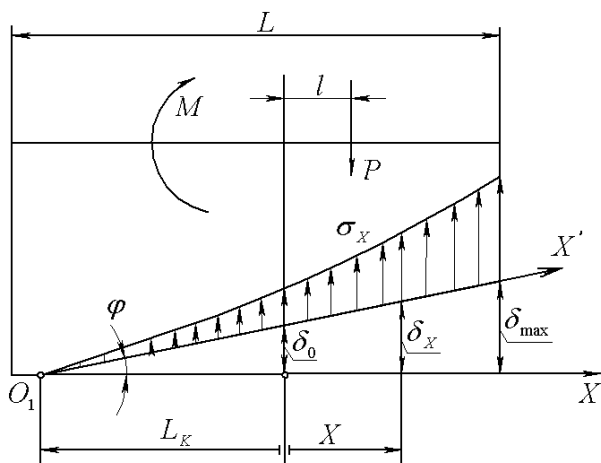
Fig. 3. Scheme of calculation of solid flat open joint contact area stiffness parameters.

$$0,1b \int_{L_K}^{0,05L} \sigma_X\,dx = P; \tag{16}$$

$$b \int_{L_K}^{0,05L} x\sigma_X\,dx = M + Pl, \tag{17}$$

$$\sigma_x = \frac{[\varphi(x - L_K)]^n}{10^{-4n}c^n},\,kG/cm^2. \tag{18}$$

After integrating of (14) and (15) such equation regarding parameters L_k and φ should be solved:

$$\begin{cases} \dfrac{(0,05L - L_K)^{n+1}}{n+1} = \dfrac{10P}{b} \cdot \dfrac{10^{-4n}c^n}{\varphi^n} & (19) \\[4mm] \dfrac{(0,05L - L_K)^{n+2}}{n+2} + L_K \dfrac{(0,05L - L_K)^{n+1}}{n+1} = \dfrac{M + Pl}{b} \cdot \dfrac{10^{-4n}c^n}{\varphi^n}. \end{cases}$$

Equation (19) can be directly solved regarding parameters L_k and φ:

$$L_K = (n + 2)\frac{M + Pl}{10P} - 0,05(n + 1)L; \tag{20}$$

$$\varphi = 10^{-4}c\sqrt[n]{\frac{M + Pl}{b\left[\dfrac{(0,05L - L_K)^{n+2}}{n+2} + L_K\dfrac{(0,05L - L_K)}{n+1}\right]}}. \tag{21}$$

If $L_k = -0.05$ L, the joint will close. If $L_k = -0.05$ L is put into (18), the joint opening conditions (9) will be described.

Maximal tension $\sigma_{\max}$ and elastic displacement δ_0 are:

$$\sigma_{\max} = \left[\frac{10^4\varphi(0,05L - L_K)}{c} \right]^n; \tag{22}$$

$$\delta_0 = -10^3|\varphi|L_K. \tag{23}$$

The algorithm for estimation has been worked out to estimate the load of solids when they are moving in both possible ways of motion.

The friction lining is attached to the body. Force P and the bending moment $M = F_b \cdot h = P \cdot f \cdot h$ caused by friction force F_f acts on friction lining.

Using computer software "Solidworks" and "Cosmosworks" optimal eccentricity $l = 27$ mm was determined. Such eccentricity provides the desirable distribution of specific surface pressure on friction area.

Three graphs illustrate the results of computing (Figs. 4, 5, 6). Such input parameters were admitted: a = 180 mm; b = 80 mm, $l = 27$ mm , n = 3, and c = 5.
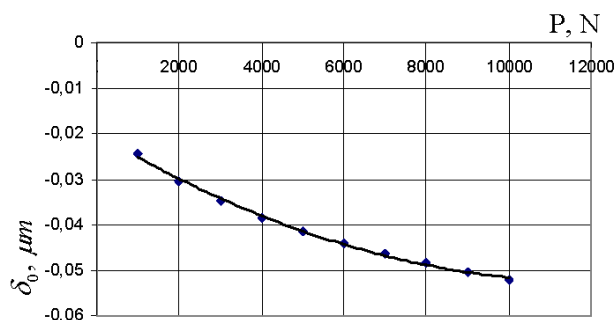
Fig. 4. Interface centre displacement δ_0 depending on force P and moment M caused by friction force.
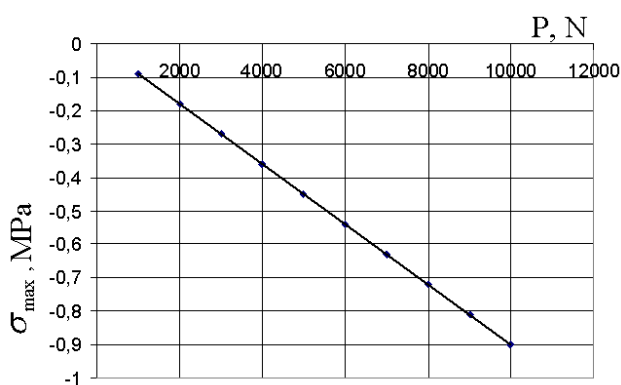
Fig. 5. Maximal normal tension σ_{max} depending on force P and moment M caused by friction force.
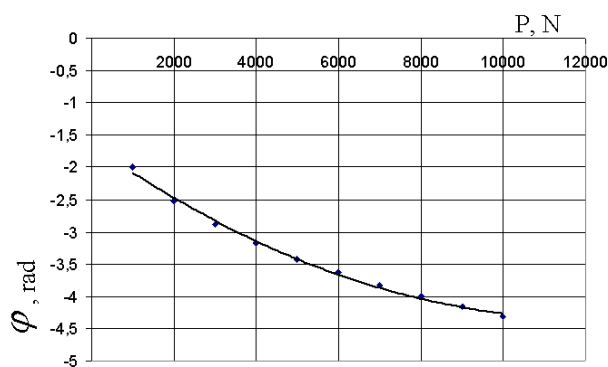
Fig. 6. Angle of solid flat rotation φ depending on force P and moment M caused by friction force.

Discussion

The investigations have revealed correlations between deformation and stiffness parameters of a solid flat joint in different loads.

When investigating the motion (movement) of two flat and parallel solids, whwn the concentrated force P and the bending moment M (positive or negative) act on one of the solids, the tension σ_X in any cross section of the contact area and the displacement δ_0 of the joint , located in the cross section, running through the middle of the joint, can be computed using formulas 14 and 15.

There are three cases:

• if bending moments are equal (M = P · *l*), the joint will not open and the angle of loaded parts regarding each other will be φ = 0, maximal tension $\sigma_{max} = P / bL$, and transference of the center of cross section $\delta_0 = 10 c \sigma_{max}^{1/h}$, which means, that there is proportionality between contact deformation and tension;

• if the joint is closed (12) or open (13), stiffness parameters of joint φ, δ_0 , and maximal tension σ_{max} should be calculated.

When designing the joint, it must be closed. It is possible to reduce maximal tension σ_{max}, and the angle of solid contact area rotation changing dimensions of b and L.

If $\sigma_{max} \leq [\sigma]$, resistance in contact area will be provided ([σ] – allowable tension of material surface).

Conclusions

The investigations have resulted in revealing correlations between deformation and stiffness parameters of a solid flat joint under different loads: transference of the center of cross section δ_0, the angle of turning of one solid in relation to the other, and tension σ_x in any cross section of the contact area. The results of the investigations make it possible to analyze the stiffness of the contact of solids, to test the strength of the contact areas, and to optimize the contact area of solids.

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IMPACT OF THE WORKING WIDTH OF THE PLOUGH BODY ON THE TILLAGE EFFICIENCY

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Abstract

Theoretical and experimental investigations are carried out to estimating the impact of the plough body working width on its specific draft resistance, as well as the ploughing efficiency.

By using analytical correlations derived as a result of theoretical research, a computer algorithm has been worked out for simulating the functions of the plough body and the forces exerted by soil upon the operating parts, as well as its draft resistance. Specific draft resistance of the plough body, energy consumption, as well as labour efficiency and ploughing costs depend considerably on the working width of the body. By increasing it, the energy capacity, specific fuel consumption and expenditure decrease, but labour efficiency increases.

Key words: plough body width, specific draft resistance, optimisation of parameters.

Introduction

It is known from our previous investigation (Vilde, 1999, 2001) that draft resistance of ploughs depends on the body parameters and on such soil properties as its hardness, density, friction and adhesion, as well as on working regime. By using analytical correlations derived as a result of theoretical research, a computer algorithm has been worked out for simulating the functions of the plough body and the forces exerted by soil upon the operating parts, as well as its draft resistance. These correlations allow to determine the forces acting on the plough body and its draft resistance depending on the body parameters, as well as to evaluate the impact of physical and mechanical properties of soil upon it (Rucins, Vilde, 2004). However, there are no analytical correlations that would enable to determine the specific draft resistance of the share-mouldboard surface and the plough body as a whole, depending on the working width of the body.

In the literature, there is difference of opinions on the impact of plough body working width on its specific draft resistance. F. P. Ciganov in his dissertation had written that decreasing of the body width decreases specific draft resistance of ploughing (Ciganov, 1969). W. R. Gill and G. E. Vanden Berg have opposite views, their data show that "specific draft generally tended to decrease as size of cut increased" (Gill, Vanden Berg, 1967, p. 262). In the Kverneland plough prospect it is written that by increasing the furrow width from 35 cm to 45 cm (14" to 18") the consumption of diesel fuel is reduced by as much 18% and working capacity is increased by up to 30% (Kverneland prosp. Nr. 1, 2002).

The purpose of the investigation is to estimate the specific draft resistance of the plough body and ploughing efficiency depending on its working width.

Materials and methods

The object of the research is the specific draft resistance of the plough body depending on the body design parameters, as well as the physical and mechanical properties of soil. On the basis of previous investigations (Vilde, 1999), theoretical and experimental studies are carried out to determine the impact of body working width on its specific draft resistance and ploughing efficiency.

Results

Theoretical studies

By using analytical correlations derived as a result of theoretical research, and a computer algorithm worked out for simulating the functions of the plough body and the forces exerted by soil upon the operating parts of the plough body, the draft resistance caused by these forces, as well as the specific resistance depending on the working width are determined (Fig. 1).

According to our previous investigations (Vilde, 1999), the draft resistance R_x of the plough body is determined by the share cutting resistance R_{Px}. The resistance caused by weight R_{Gx} of the strip lifted, by the inertia forces R_{Jx}, by soil adhesion R_{Ax} and by weight R_{Qx} of the plough body itself (including a part of the weight of the plough). However, the latter is not dependent on the plough parameters.

$$R_x = \sum R_{ix} = R_{Px} + R_{Gx} + R_{Jx} + R_{Ax} + R_{Qx} \qquad (1)$$

The vertical reaction R_z and the lateral reaction R_y of the operating part are defined by corresponding partial reactions:

$$R_z = \sum R_{iz} \; ; \; R_y = \sum R_{iy} \; . \qquad (2; 3)$$

The total draft resistance R_x of the operating part is composed of the resistance of the working (share-mouldboard) surface R'_x and the resistance of the supporting (lower and lateral) surfaces R''_x :

$$R_x = R'_x + R''_x = \sum R'_{ix} + f_0 \left(\sum R_{iz} + \sum R_{iy} + p_{Axy} S_{xy} + p_{Axz} S_{xz} \right), \qquad (4)$$
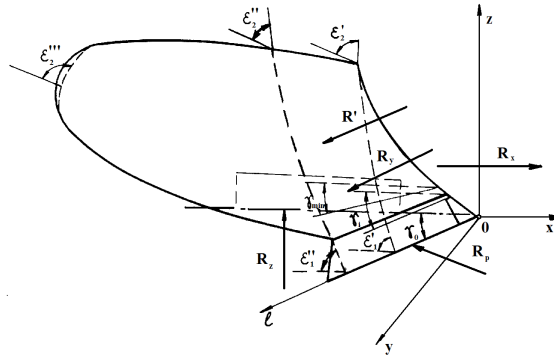
Fig. 1. Scheme of the plough body, its parameters and acting forces.

where

f_0 – coefficient of soil friction along the working and supporting surfaces of the operating part;

p_{Axy} and p_{Axz} – specific adhesion force, respectively, to the lower and the lateral supporting surfaces of the operating part;

S_{xy} and S_{xz} – surface area of the lower and lateral supporting surfaces of the operating part.

The specific draft resistance related to the unit of the area q of the cross section of the lifting soil strip:

$$K_0 = R_x q^{-1} = (R'_x + R''_x)q^{-1} = (R_{Px} + R_{Gx} + R_{Ix} + R_{Ax} +$$

$$+ R_{Qx})q^{-1} = k' = k'' = k_P + k_G + k_I + k_A + k_Q, \tag{5}$$

where:

k' – specific draft resistance of the working (lifting) surface;

k'' – specific draft resistance of the supporting surfaces;

kp – specific draft resistance caused by the share cutting resistance;

k_G – specific draft resistance caused by the weight of the soil strip lifted;

k_J – specific draft resistance caused by the inertia forces of the soil strip lifted;

k_A – specific draft resistance caused by the soil adhesion;

k_Q – specific draft resistance caused by the weight of the plough body itself (including a part of the weight of plough).

$$q = ab, \tag{6}$$

where:
a - depth of ploughing (thickness of soil strip);
b - working width of plough body (width of soil strip).

From our previous investigations (Rucins, Vilde, 2004) it follows:

– specific draft resistance caused by the weight of the lifting soil strip:

$$k_G = k'_G + k''_G \approx q\,\delta g k_y r \sin^{-1}\gamma *$$

$$* \{ [(\sin\gamma\cos\varepsilon_1 + \cos^2\gamma\sin^{-1}\gamma)e^{f_0\sin\gamma(\varepsilon_1 - \varepsilon_2)} -$$

$$- (\sin\gamma\cos\varepsilon_2 + \cos^2\gamma\sin^{-1}\gamma)]\cos\varepsilon_1 + \tag{7}$$

$$+ (\cos\varepsilon_1 e^{f_0\sin\gamma(\varepsilon_2 - \varepsilon_1)} - \cos\varepsilon_2)(\cos\varepsilon_1 - f_0\sin\varepsilon_1\sin\gamma)^{-1} *$$

$$* \sin\varepsilon_1 [\sin\varepsilon_1\sin\gamma + f_0(\sin^2\gamma\cos\varepsilon_1 + \cos^2\gamma)] \} +$$

$$+ \delta g r\sin^{-1}\gamma(\varepsilon_2 - \varepsilon_1) + \delta g r\sin^{-1}\gamma(\varepsilon_2 - \varepsilon_1)\ (\varepsilon_1 + 0.52)\mathrm{ctg}\,\gamma$$

– specific resistance caused by soil inertia:

$$k_J = k'_J + k''_J = \delta v^2 k_y^{-1}\sin\gamma\{ (\sin\gamma\cos\varepsilon_1 + \cos^2\gamma\sin^{-1}\gamma) *$$

$$* e^{f_0\sin\gamma(\varepsilon_1 - \varepsilon_2)} - (\sin\gamma\cos\varepsilon_2 + \cos^2\gamma\sin^{-1}\gamma) +$$

$$+ (\cos\varepsilon_1 - f_0\sin\varepsilon_1\sin\gamma)^{-1}e^{f_0\sin\gamma(\varepsilon_2 - \varepsilon_1)}$$

$$\sin\varepsilon_1 [\sin\varepsilon_1\sin\gamma + f_0(\sin^2\gamma\cos\varepsilon_1 + \cos^2\gamma)] \} + \tag{8}$$

$$+ \delta v^2 k_y^{-1}\sin\gamma\sin\varepsilon_2 e^{f_0\sin\gamma(\varepsilon_2 - \varepsilon_1)} + \delta v^2 k_y^{-1}\sin\gamma\cos\gamma(1 - \cos^2\varepsilon_2)$$

– specific resistance caused by soil adhesion:

$$k_A = k'_A + k''_A = p_A\,r\sin^{-1}\gamma\,(e^{f_0\sin\gamma(\varepsilon_2 - \varepsilon_1)} - 1) *$$

$$* \{ \sin\gamma\cos\varepsilon_1 + \cos^2\gamma\sin^{-1}\gamma + (\cos\varepsilon_1 - f_0\sin\varepsilon_1\sin\gamma)^{-1} *$$

$$* \sin\varepsilon_1 [\sin\varepsilon_1\sin\gamma + f_0(\sin^2\gamma\cos\varepsilon_1 + \cos^2\gamma)] \}a^{-1} + \tag{9}$$

$$+ f_0(p_{Axy}S_{xy} + p_{Axz}S_{xz})(ab)^{-1}$$

– specific resistance caused by the weight of the plough body:

$$k_Q = Q_1(ab)^{-1} \tag{10}$$

– specific resistance caused by cutting off the soil strip:

$$k_p = R_{px}(ab)^{-1} = [k_s\rho_{0s}i_s b_s ctg(\gamma + \varphi_0) + k_n\rho_{0n}i_n a_n](ab)^{-1}, \tag{11}$$

where

q – the cross section area of the strip to be lifted;
δ – the density of soil;
k_y – the soil compaction coefficient in front of the operating part;
f_0 – the soil friction coefficient against the surface of the operating element;

ν – the speed of the movement of the plough body;

p_A – the specific force of soil adhesion to the operating surface;

b – the surface width of the soil strip;

ε_1 and ε_2 – correspondingly the initial and the final angles of the lifting (share- mouldboard) surface;

g – acceleration caused by gravity ($g = 9.81$).

k_s and k_n – coefficients involving the impact of the shape of the frontal surface of the ploughshare edge and knife;

ρ_{0s} and ρ_{0n} – soil hardness in the working zone of the share and knife;

i_s and b_s – thickness and width of the share edge;

i_n and a_n – thickness and working depth of the knife;

γ – the inclination angle of the share edge towards the direction of movement (the wall of the furrow);

φ_0 – the angle of friction.

That is proportional to soil hardness and the share edge, as well as the knife surface area (Rucins, Vilde, 2004).

From our previous investigations (Rucins, Vilde, 2004) and formulas (7) – (11) conclusions follow.

- Because draft resistance of the plough body caused by weight and inertia forces of the lifting soil strip is directly proportional to it cross section area, the changes in working width cause no influence on the specific draft resistance.

- Resistance of the lifting (share-mouldboard) surface caused by soil adhesion is proportional to the body working width (width of the lifting strip), and changes in working width cause no influence on the specific draft resistance. On the contrary, the specific draft resistance of supporting surfaces caused by soil adhesion is inversely proportional of the cross section area of the soil strip.

- The specific draft resistance caused by the weight of the body itself is inversely proportional to cross section area of the soil strip. It means that by increasing the working width, the partial specific resistance decreases.

- The specific draft resistance caused by cutting off the soil strip can be or cannot be dependent on body working width. By constant increasing of the share width, working width decreases the specific draft resistance because resistance caused by break off the soil slice is insignificant in comparison with cutting resistance. If the share width is equal to working width of the body and varied identical with the variation of the body's working width, the specific draft resistance caused by cutting is not dependent on its working width.

The soil friction coefficient and the specific force of soil adhesion are not constant values. Their values decrease with the increase in speed (Rucins, Vilde, 2003 a). This is considered in calculations.

The resistance of the supporting surfaces of the plough body depends on the values of the reacting forces.

Yet their value is dependent, in many respects, on the manner of unification and perfection of the hydraulically mounted implements of the tractor. The vertical reaction of the plough with modern tractors having power regulation is transferred to the body of the tractor, and it affects the plough resistance to a considerably lesser degree.

The presented work discusses, as an example, theoretical research results of forces acting on the plough body and the specific draft resistance of the plough body at its various working widths when ploughing loamy soils that predominate in Latvia.

The calculations were carried out with the computer according to the foregoing formulae.

The following values of the basic factors were taken into consideration, which affect the resistance of the share-mouldboard surface and the plough body.

Parameters of the plough body

Thickness of the share blade and knife $\quad i_s = i_n = 0.004\,m$

Width of the plough share $\quad b_s = 0.35\,m$

Initial angle of the lifting strip of soil $\quad \varepsilon_1 = 30°$

Final angle of the lifting strip of soil $\quad \varepsilon_2 = 100°$

Angle between the horizontal generatrix of the operating surface and the vertical longitudinal plane $\quad \gamma = 40°$

Radius of the curvature of the lifting surface $\quad r = 0.5\,m$

Area of the lower supporting surface $\quad S_{xy} = 0.0157\,m^2$

Area of the lateral supporting surface $\quad S_{xz} = 0.068\,m^2$

Weight of the plough body $\quad Q = 200\,kg$

Physical and mechanical properties of soil

Hardness of soil $\quad \rho_0 = 4.1\,MPa$

Coefficients involving the impact of the shape of the of the plough share edge and knife $\quad k_s = k_n = 0.8$

Density of soil $\quad \delta = 1600\,kg\,m^{-3}$

Coefficient of soil friction against the surface of the operating element $\quad f_0 = 0.4$

Adhesion force $\quad p_{A0} = 2.5\,kPa$

The mode and status of work

Ploughing depth $\quad a = 0.20\,m$

Working width of the plough body $\quad b = 0.30...0.50\,m$

Working depth of the knife $\quad a_n = 0.20\,m$

Cross section area of the lifted soil strip $\quad q = 0.06...0.1\,m^2$

Soil compaction coefficient in front of the operating part $\quad k_y = 1.1$

Working speed $\quad v = 1...5\,m\,s^{-1}.$

Calculation results of the specific draft resistance of the plough body and its components are presented in Table 1 and Figs. 2 4.
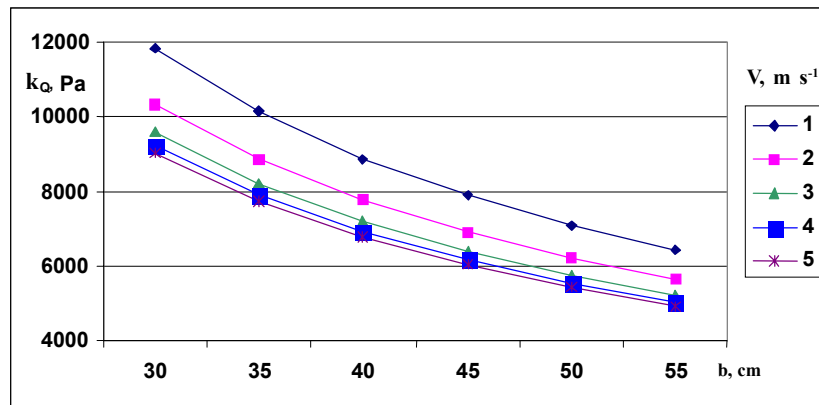
Fig. 2. Specific draft resistance k_Q of the plough body caused by its weight Q depending on the body's working width b at various speeds v.
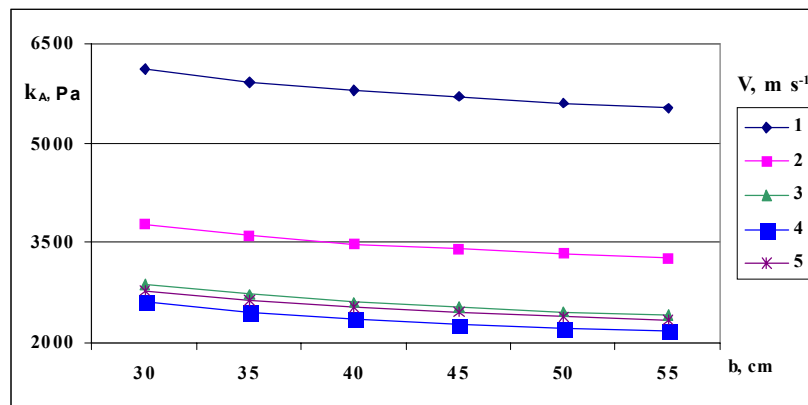
Fig. 3. The specific draft resistance k_A of the plough body caused by soil adhesion depending on the body's working width b at various speeds v.
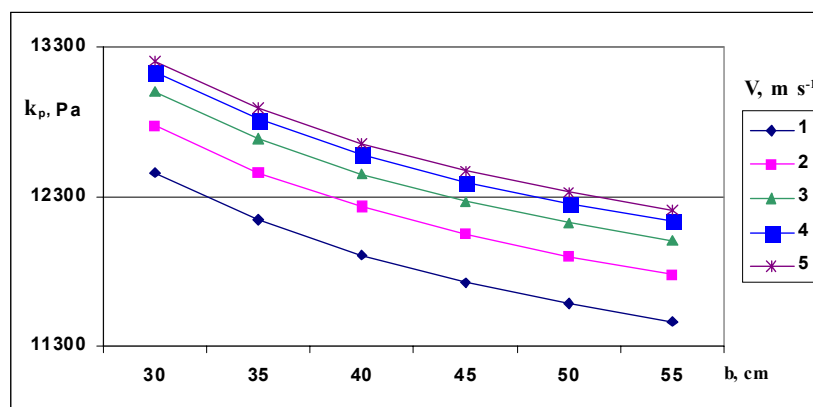
Fig. 4. The specific draft resistance of the plough body k_P caused by cutting resistance R_{Px} depending on the body's working width b by various speeds v.
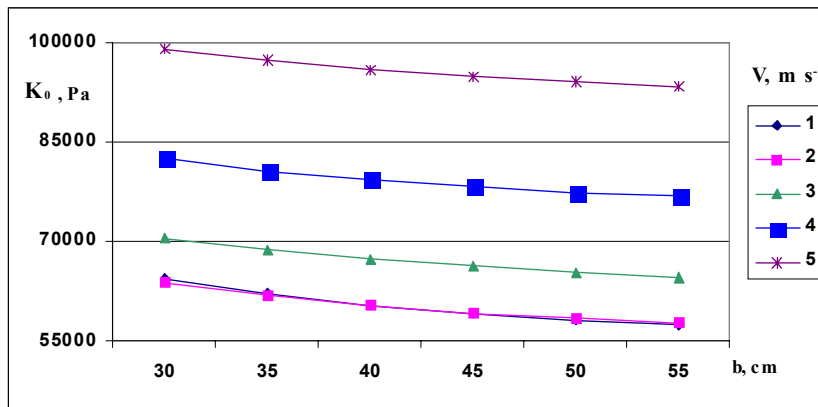
Fig. 5. Total specific draft resistance of the plough body K_0 depending
on the body's working width b by various speeds v.

Table 1

Specific draft resistance caused by soil weight k_G and inertia forces k_I

V, m s^{-1}	1	2	3	4	5
k_G, Pa	31616.91	28575.36	27100.36	26390.86	26013.65
k_I, Pa	2311.29	8386.87	17933.71	31080.75	47897.78
$k_G + k_I$, Pa	33928.21	36962.24	45034.07	57471.60	73911.43

Experimental studies

Experimental studies are carried out on the "Kverne-lands Vary Width" plough, having bodie's working width from 30 cm to 50 cm (Valsts Baltijas MIS,1996). Conditions of the study are shown in Table 1 and the results – in the graph (Figure 5).

The graph (Fig. 6) shows how specific draft resistance and energy consumption in ploughing depends on the working width of each body. By increasing it, the energy capacity and specific fuel consumption in ploughing decreases by 10-16%. The greater is the ploughing depth, the greater is the effect due to the increased working width of

the body. This phenomenon is caused by higher soil hardness and density of the deeper soil layers (see Table 1).

In loamy soil, increase in working width of the bodies at the ploughing depth of 18…19 cm decreases specific fuel consumption by 2…3 kg ha^{-1}, but at the depth of – 24 cm – by 4…5 kg ha^{-1}. Correspondingly, there is a rise in labour efficiency, and the ploughing costs fall by 2…4 LVL ha^{-1}. Therefore, when ploughs are used that have a possibility to vary the working width, it is recommended to work at the maximum width and, if necessary (insufficient power of the tractor), to reduced number of bodies.

Thus, for example, in the aggregate with the MTZ-82

Table 2

Testing conditions of the plough

Characteristics	Unit of measurement	Value of indice
Field kind		grassland
Soil kind		loam
Relief		even
Micro-relief	cm	2
Soil humidity in layers: 0-10 cm	%	18.2
10-20 cm		17.4
20-30 cm		17.5
Soil hardness in layers: 0-10 cm	MPa	1.50
10-20 cm		2.85
20-30 cm		3.33
Mass of remnants	g m^{-2}	180
High of remnants	cm	14
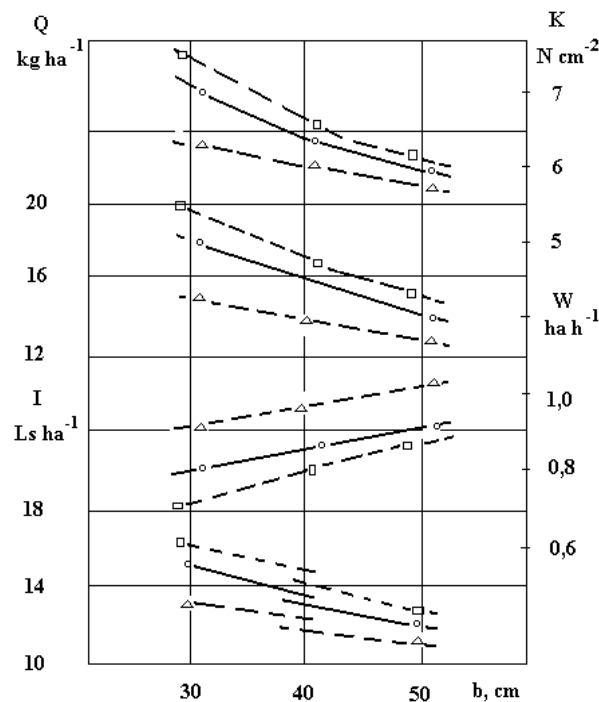
Fig. 6. Variations of energetic and economic characteristics of the Kverneland AB-85 plough body with semihelicoidal bodies No. 8 depending on the body with in ploughing grassland on a loamy soil at the speed of 8.7–9 km h^{-1}; b – the body width, cm; K_0 – the specific draft resistance, N cm^{-2}; Q_0 – the specific fuel consumption, kg ha^{-1}; W_0 – the direct labour productivity, ha h^{-1}; I – ploughing costs LVL ha^{-1} (LVL 1 = USD 1.85).
- - - ploughing depth of: 24 cm; ———— ploughing depth of: 22 cm; ——— ploughing depth of: 19 cm;

tractor it is more purposeful to work with the Kverneland AB-85 two-body plough with the working width of each body 50 cm (the total width 1 m) than with three bodies having the width of 33 cm each and the same working width.

Conclusions

1. The deduced analytical correlations and the developed computer algorithm allow simulation of the soil coercion forces upon the operating surfaces of the plough body and determine its specific draft resistance depending on the body design, working parameters and soil properties.

2. Presentation of the plough body specific draft resistance as the sum of components cutting resistance of the strip, resistance caused by its weight, the soil inertia forces and adhesion allows analysing the forces acting upon the share-mouldboard surface, finding out the character of their changes depending on the parameters of the surface and working mode, as well as the assessment of their ratio in the total specific resistance.

3. Specific draft resistance of the plough body, energy consumption, as well as labour efficiency and ploughing costs considerably depend on the working width of the body.

By increasing it, the energy capacity, specific fuel consumption and expenditure decrease, but labour efficiency increases.

4. In loamy soil, increase in the working width of the bodies at the ploughing depth of 18…19 cm decreases the specific fuel consumption by 2…3 kg ha^{-1}, but at the depth of 24 cm – by 4…5 kg ha^{-1}. Correspondingly, there is a rise in labour efficiency, and the ploughing costs fall by 2…4 LVL ha^{-1}.

5. When ploughs are used that have a possibility to vary the working width, it is recommended to work at the maximum width and, if necessary (insufficient power of the tractor), to reduced number of bodies.

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SYSTEM MODELING OF THE GRAIN DYING PROCESS

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Abstract

One of the prior trends of research is the problem studies of power economy of technological processes and quality of automatic control. Though the theory of grain drying process has been developed profoundly, still there are problems in its implementation. The developed analytical and simulation models of grain drying are difficult to implement into practice because they do not contain all the factors, which influence the real grain drying process or they cannot be solved. The developed models enable to assess only the essentiality of factors and/or the fundamental basics of the process. In order to ensure the effective and user-friendly grain drying process, it is indispensable to develop the control methodology using system modeling approach.

The present paper deals with the system approach to heat and mass transfer problem and the testing of the basic hypothesis of the diffusion theory about the normal distribution of particles in the diffusive environment.

Key words: grain drying, diffusion, system modeling, class diagram, state chart diagram.

Introduction to system modeling methodology

The central concept in the system analysis is the concept of system. The system is a set of objects, components or autonomic elements that forms the entirety. Some sets become systems, if the new features and characteristics appear which are not attributed to the elements of the component system.

The main characteristics of system are its structure and functioning process. The structure of system is a set of the elements, which is stable within its interrelation. The structure unites all elements and facilitates the split of the system into separate components. The structure reflects different interrelations, including putting the elements of one system into another. In this case, the put in system is called a subsystem, but a superior system is called a metasystem (Steve McConnell, 2004).

The system functioning process is connected with the changes of its features within a period of time. The significant characteristic of the system is the state of the system. It is a set of features that reflects in each moment the significant peculiarities of the system. System functioning process is reflected as the sequential change of its states. The system functioning process is a set of transition from one state to another. The methodology of system analysis and modeling is a conceptual basis for the decomposition of the field of objects. The model is some conception of system that reflects the most essential regularities of its structure and process functioning. The common feature of all models is their similarity to the original system. The building of models enables to obtain the additional information about the features or behaviour of the original system. The process of model building and their further application in the obtaining of new information about the system is called modeling.

The problems of the system and its models are viewed from different positions. The number of the system elements causes the problems of the system structure. On the other hand, the process of system functioning might bring the unpredictable nature that forbids to provide the laws on transformation from the input action to the output result formally.

The analysis of the system structure is the method of system exploration that starts with its general description and proceeds with detailed examination of separate aspects. The general model of system is built as the hierarchical structure, where different levels reflect different levels of abstraction. One of the tasks of the structural analysis is to determine the most significant elements or components of a system in each abstraction level.

The development of the logical model of system in the form of class diagram is the basis for the methodology of system analysis. The class diagram reflects the statical structure of the system models. The class diagram shows different interrelations among the elements, components and subsystems of systems. In the given diagram there are types of relations and inner structure of the structure described. The class diagram plots the structural relations, which do not depend on time. The class is the abstract description of the set of objects. These objects have identical structure, behaviour and interrelation with objects from other classes. The class has a name, the set of attributes and operations. The attribute of the class is the reflection of a separate feature. The class operation is a function that processes the data.

The diagram of classes reflects both the inner structure of the class and the relations among classes. These relations are called associations. There are two kinds of associations: aggregation and generalization. The aggregation association shows the "whole – part" type relation, but the generalization association shows the "successor – predecessor" relation.

The statistical aspects of the system are modeled using such elements as the class diagrams and the object diagrams. They enable to visualize, specify and document everything that is situated in the system, including classes, interfaces, components, instances and their interrelations. The dynamic aspects of the system are modeled by means of automats and interrelations.

The main aim of this diagram is to describe the possible sequences of states and transitions, which characterize the behaviour of the modeled system (Элиенс А., 2002). The diagram of states describes the dynamic behaviour of the essence on the basis of their responses to particular events. The diagram of states is a special chart type that reflects the complete automat. The tops of the chart are states, which are connected with arcs, indicating transition between the states. The automat has the starting and ending state.

During all life-time the object faces different events, such as signal, demand to perform an operation, formation or destruction of the object. By responding to an event, the object performs some calculation activity that changes the state of the object. The object can receive an event, respond to it, performing an action, and then it can change its state. If after this it receives another event, the response of the object will differ depending on the previous state.

The automat models the life-cycle of a separate object. During its life-cycle, the object goes through the sequence of states. The state describes the period of time of the object's life-cycle. The state has a name. The states are interrelated with the transitions. In the diagram, the state is shown as a rectangle with rounded corners.

The transfer of energy and humidity in the drying process – methodology explanation

The drying theory is based on the laws on heat and humidity transfer in humid materials during their interaction with the heated gas, hot surfaces and electromagnetic waves. One of the basic tasks of drying analytical theory is the solution of differential equation systems. These are heat and mass transfer equations, the solution of which enables to describe the fields – potential distribution of transfer. The analytical distribution of the material's temperature and humidity is obtained in the cases, when the environmental potentials have linear, exponential and harmonic time type. The task becomes more complicated, if we take into account that the kinetic coefficients are not constant during all the process, but they depend on the current potentials of temperature and humidity. This brings to the nonlinear transfer equations.

The process of material drying consists of three stages: the inner transfer of humidity closer to surface, formation of humidity vapour, and the transfer of humidity from the surface of the material into the environment. In the case of the interaction between the humid material and heated air, the liquid from the surface through diffusion leaves the surface of the material and is transferred into the environment. The vaporization from the surface of the material creates the difference of humidity capacity between the inner layers and the surface layer. This causes the diffusion of humidity from the inner to the surface layers. The presence of humidity gradient in the material causes the decrease of temperature between the inner layers and the surface layer, and under the influence of thermodiffusion the humidity tends to move into the material.

The description of the drying process is defined by the humidity movement mechanism in the material, vaporization energetics, and the humidity movement mechanism from the material surface into the environment.

The fundamental law of substance transfer can be expressed as $q = -\lambda \nabla \theta$, where q – density of the humidity flow (quantity of humidity, transferred within a time unit through the surface unit), $\nabla \theta$ – gradient of the substance potential, which characterizes the potential speed of change athwart the surface, and λ – coefficient of proportionality, which is called the coefficient of the humidity conductivity.

Diffusion theory and the incidental movement of particles

The phenomenon of the heat and humidity transfer is described by means of the diffusion model. The system of particles that forms the substance is indeterminate. We look at the system that consists of particles, which move chaotically (Зельдович Я.Б.,1973). The system is indeterminate in a sense that, knowing the initial state of a particle in a space, we are not allowed to indicate directly its coordinates at any coming moment. It is the class of the particle movement tasks, where the particles implement their movement under the influence of incidental impulses. For instance, the movement of the diffusive substance molecules is performed under the influence of the incidental shocks of molecular environment. It is impossible to anticipate the movement of every particle, but only to forcast with a certain probability. However, it is excellent that, if the particles, which move chaotically and independently from each other, are in great number, it is possible to determine unequivocally the behaviour of the particle system in general.

Two types of environment take part in the diffusion process. One of them diffuses, but the other one serves as a base, where the diffusion takes place (Гинзбург А.С., 1973). Such division does not have a complete characteristic: it is possible when the concentration of the diffusive environment is low.

Let us assume that the particles of substance are situated in squares, each of which is located in some distance from others. All squares are situated on one line and form discreet points on the infinite straight line. Every space of time each of the particles that occupies one of the cells on the straight line moves to the one of the two neighboring squares. In every square there can be one, several or none of the particles. The particles move to another square irrespectively of the behaviour of other particles and regardless of their own previous behaviour. In this case it is impossible to anticipate the behaviour of every particle, but it is possible to forecast the system with a great number of particles. This moving system models the diffusion process of particles: the flow of the diffusive mass is directly proportional to the density gradient and is directed contrary to this gradient, i.e. towards the decrease of density.

This law has consequences. Although initially all particles are situated in one point, there might be some parti-
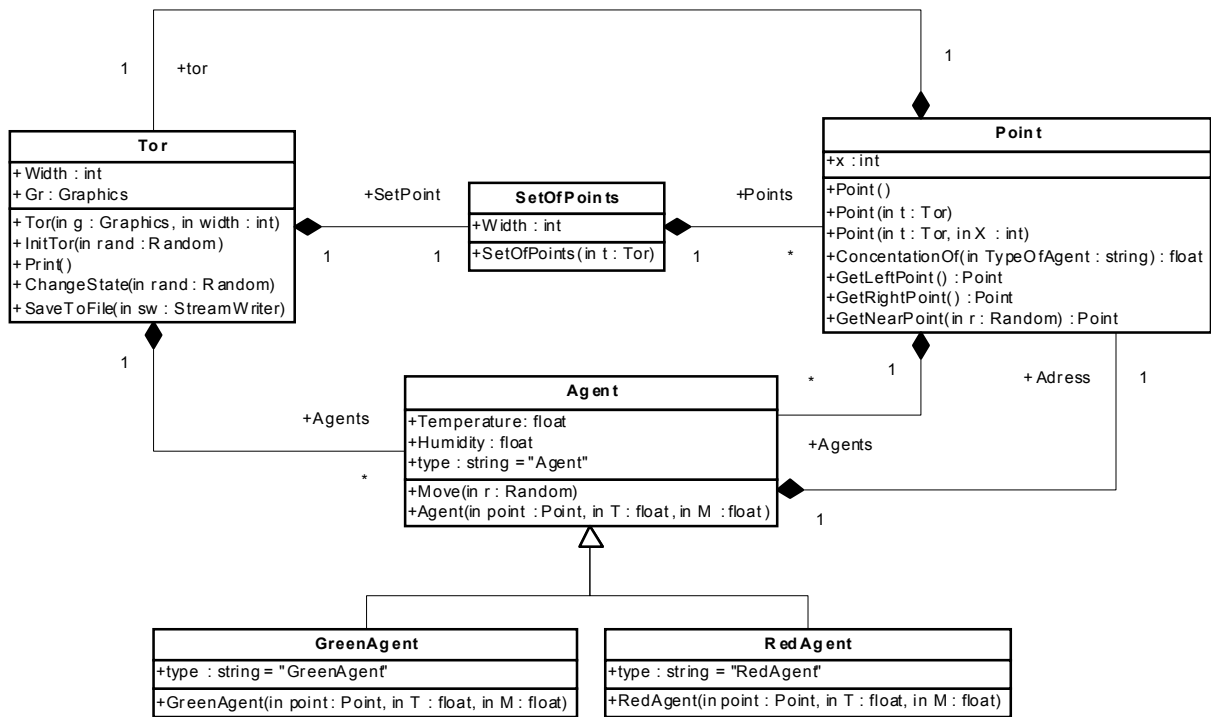
Fig. 1. The diagram of one-dimension diffusion system classes.

cles that within the time unit will move far away. The diffusion equation has a significant role in physics of maths, it describes the expansion of heat and mass in the material.

The class Agent models the diffusive particles (Fig. 1). There are two types of agents: green and red. The red agents perform the role of moving particles, but the green ones – the role of the immobile obstacles. The class Tor models the environment in which the agents are situated. Tor consists of the Point type points. Every agent knows its location. Every point comprises the information about its neighbouring points.

One particle can have three states (Fig. 2). At the beginning it is situated in the point and with the probability 1/3 it may be there in the next moment. With the same prob-

ability 1/3 it can reach one of its neighbouring points. The process continues until the experiment is stopped.

Diffusion in the plane

The linear movement model of particles can be expanded in the plane and space. The discreet system of squares is viewed. This system consists of focal points in the quadratic network of plane. The particles can be situated in one of the points of this set of squares, and they can move in every discreet time moment with the probability 1/5 to the right, to the left, upwards, downwards, or to stay where they are. This model is expressed by the diffusion equation in the plane.

The behaviour of the point is supplemented with the functions (Fig. 3), which determine their own upper and
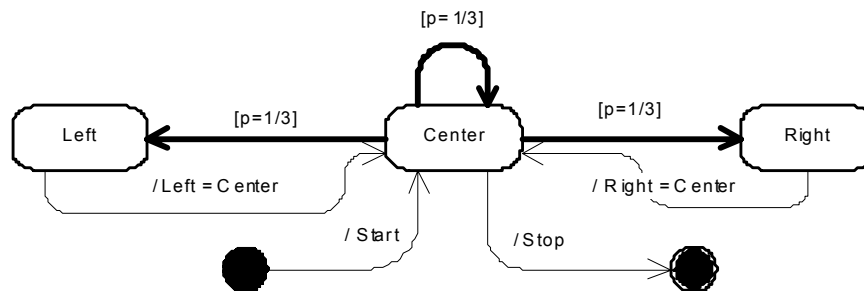
Fig. 2. The diagram of one particle states.
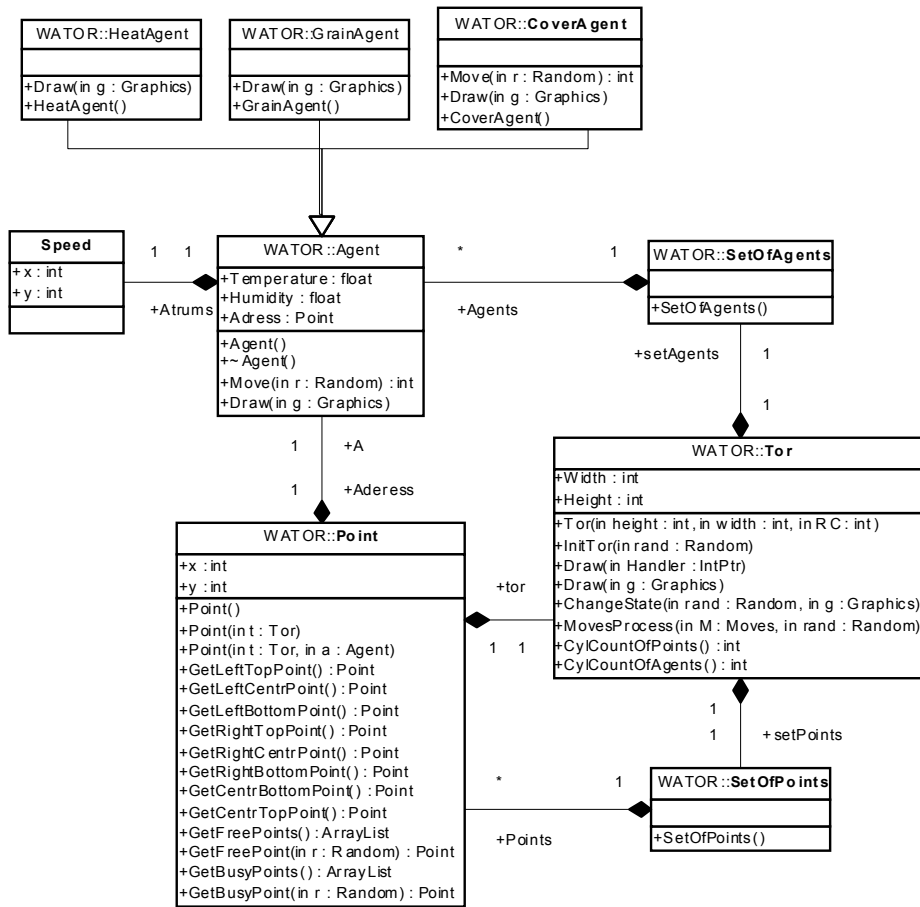
Fig. 3. The diagram of two-dimensional diffusive system classes.

lower points. The agents have new features: temperature and humidity. Now the system can register the comparison of two parameters: humidity and temperature.

The number of the state (Fig. 4) is supplemented with the upper and lower point. The probability can get to the one of neighboring points or stay where it is 1/5.

The methodology and results of experiments

The essence of research is the modeling of two types of environment. The first type of environment is the base space, where the diffusion processes take place. The second type of environment is the mass of particles that moves chaotically from one point to another. It is necessary: to
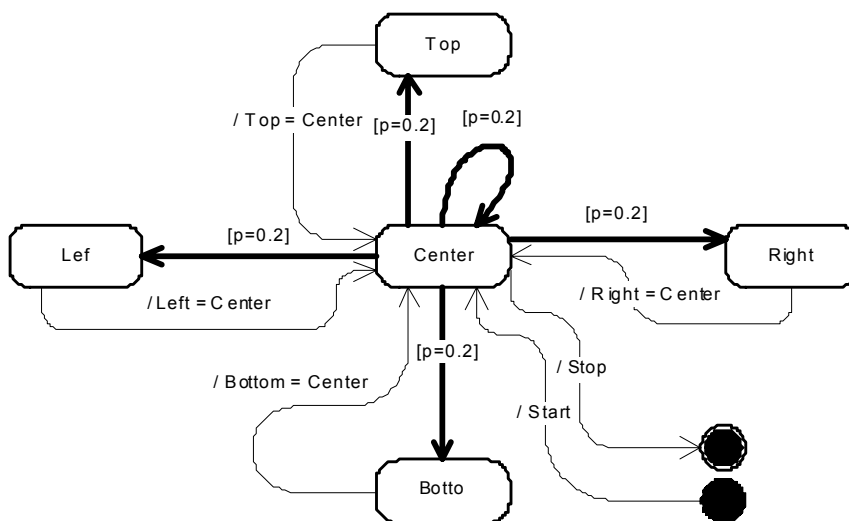
Fig. 4. The diagram of one particle states in the plane.
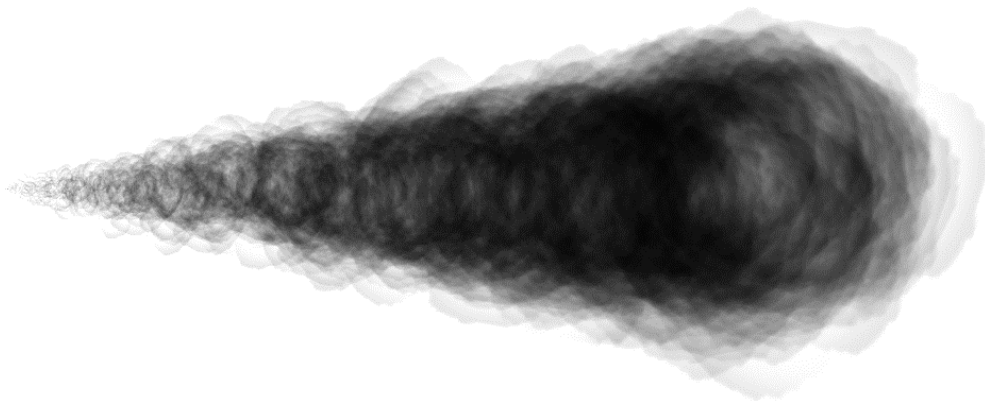
Fig. 5. Diffusion process of particles.

model the experiment in one-dimension and two-dimension space, to describe models using the system approach, to implement the computer model, and to analyze the obtained results.

Modeling of the diffusion process

The diffusive particles are concentrated in the middle of line segment. In Figure 5 the high concentration of particles is showed in black. Where the concentration is low or equal to zero, it is showed in white. The black color indicates the substance concentration between the high and low value. Every particle moves into one of its two neighbouring points or stays where it is.

The time axis is showed horizontally, but vertically we can observe the distribution of particles depending on time. There were performed about 1000 iterations. We can see that in the course of time the particles become as a cloud with dim sides. The particles tend to be positioned along all

the length of line segment, but at the same time we can see that the concentration of particles is higher in the place, where they were generated initially.

The experiment (Fig. 6) with the diffusion of the drying agents was repeated. The heat is inside the body, where there is a hole. The body coat is showed in grey. The body coat consists of the particles, which cannot move and which are the obstacle for the other particles. The black colour indicates the high concentration of particles. The experiment shows how the concentration of squares inside the body decreases and their concentration in the environment increases. This process can be interpreted as the transfer of humidity and heat from the inside of the body into the environment.

The experiment (Fig. 7) shows the location of the immobile body in the diffusive flow of particles. The particles to be modeled are able to escape obstacles. We can ob-
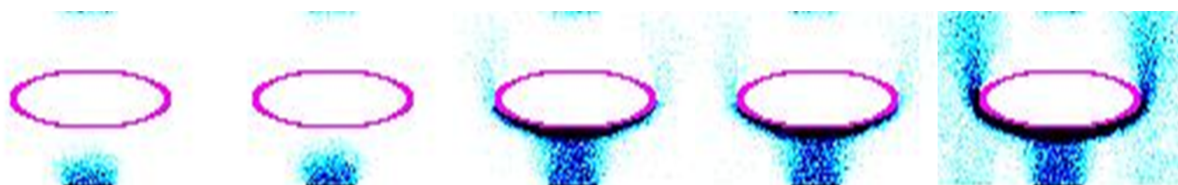
Fig. 6. Interaction of the diffusion process of particles with the coat.
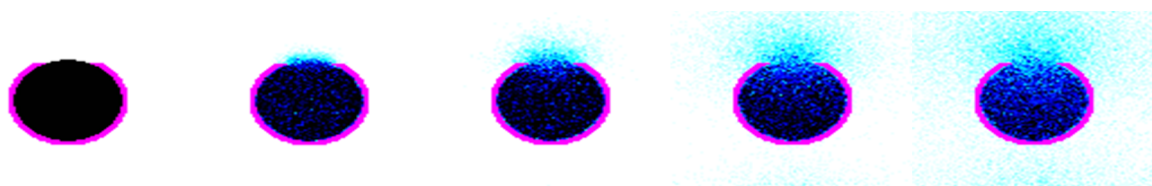
Fig. 7. The diffusion of the particles from the body into the environment.

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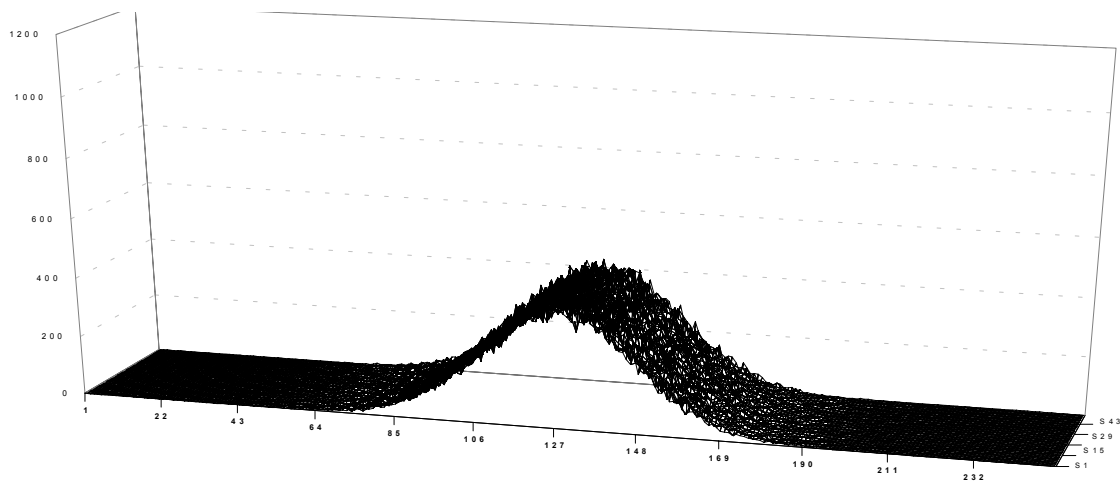
Fig. 8. Distribution of particles in the 500th iteration as a result of 50 experiments.

serve the high concentration of particles in the lower part of the body and the low concentration – in the upper part of the body. This experiment shows the modeling of limits within the diffusion process.

The computer implementation of the error system

The solutions of the diffusion equation are functions, which are described by Gauss distribution law. These solutions describe the mass evolution of units that initially were concentrated in one point. With a certain probability the point can reach the infinity, at the same time the basic mass of particles is concentrated around its starting position.

The offered system model fulfils the task, when the particles in the beginning are concentrated in one cell, and as a result of chaotic movement the particles form the cloud. It is necessary to test the hypothesis that the location of particles on the axis corresponds to the normal distribution at any time.

The data processing of the experiment

For carrying out the experiment there were 250 squares generated, which were arranged lineary and numbered from 0 to 249. In the square that was situated in the middle there was generated 1000 particles type drying agent that can, with the same probability, move to one of the two neigbouring squares or to stay where it is. Within one experiment there were 50 tests carried out, each of them consisting from 1000 quanta of time. The aim of the experiment was to obtain information about the distribution of particles on the line segment within the particular quantum of time in each of 50 tests, to assess χ^2 criteria, and to answer, whether the particular system describes the diffusion process or does not, and, in particular, whether as the result of 50 tests the empirical distribution corresponds to the normal distribution or does not correspond to it.

There were 10 time experiments with 50 repetitions

carried out. As a result of each experiment there were 20000 data obtained, but in one experiment there were 1000000 data obtained. The data, obtained during the experiment, were tested concerning the correspondence to normal distribution with χ^2 criterion. In order to test the hypothesis about the correspondence of the empirical distribution to normal in the space of time t = 500 units, the table was worked out to calculate the frequency normal distribution, where the normal value and standard deviation are equal to $\overline{X}$ = 126.5219 and s = 16.3705, respectively. Besides, the length of the interval c = 1 and n = 1000000.

χ^2 criterion was calculated according to formula

$$\chi^2 = \sum_{i=1}^{250} \frac{(n_{oi} - n_{ei})^2}{n_{ei}} = 222$$ (Liepa I, 1974). The number of intervals k = 250. Therefore the number of freedom degrees is ν = 250–1–2 = 247 and critical χ^2 value with the significance level 0.05 is 284.66.

Since the actual test value is less than the critical χ^2 = 222 < $\chi^2_{0.05;\,247}$= 284.66, we cannot reject with the probability of 95% the hypothesis that the empirical distribution corresponds to the normal.

The corresponding χ^2 test *p-value* is equal to 0.8718 that tends towards 1, therefore we can consider that the obtained empirical results correspond to the normal distribution.

The results of the experiment

As a result of the experiment, the actual χ^2 values for 10-time (t = 100, 200, … 1000 units) experiments were calculated. All experiments, except one at the space of time t = 600, proved the hypothesis about the correspondence of the empirical distribution to the normal distribution because the corresponding p-values are more than 0.4.

Conclusions

The developed model is adequate to the real process and corresponds to the analytical solutions of the diffusion equation, when the diffusive mass is focused in one point.

The computer model of the diffusive mass has the equalization feature. All particles are evenly distributed in the space. In the case of infinity the statical balance is established, when the mass flow in each point of the space is equal to zero.

The results of the experiment showed that even if distribution of the separate elements of the system is even, the system distribution corresponds to the normal. This proves a great number of laws that the sum of the case values corresponds to the normal distribution irrespective of the distribution the separate case value.

Thus, when modeling the evolution of one particle, it is possible to substitute the even movement model of a particle with the normal movement model of a particle.

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EFFECT OF USING BIODIESEL IN COMPRESSION IGNITION ENGINES

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Abstract

Biodiesel is renewable and environmentally friendly fuel, which can be used as a substitute for diesel in compression ignition (CI) engines. Nowadays it is also successfully used not only in transport sector, but also in commercial construction equipment and space heating. As the production of biodiesel (rapeseed methyl ester RME) is started now and is planned to grow rapidly, it is necessary to investigate biodiesel impact on engine performance and exhaust gas composition.

This paper describes the results of the investigation the aim of which was to find out the impact of biodiesel and its blends on an engine's dynamical, economical and ecological parameters in laboratory conditions on an engine test bench. The experimental work was done with an *XD2P* diesel engine in the Motor testing and biofuels laboratory of the Motor Vehicle Institute of LLU. The engine was fueled on fossil diesel, rapeseed methyl ester (RME) and on blends of 5 (5RME) and 35 (35RME) percent RME/diesel fuel. The results indicated that power for biodiesel and blends was lower than with ordinary petrol diesel on average: 7.9% on 100RME and 3.6% on 35RME. The reduction in torque and increase in fuel consumption was observed. Experimental results showed that the addition of RME to diesel can significantly reduce oxides of nitrogen (NO_x), carbon monoxide (CO), and absorption coefficient.

Key words: rapeseed methyl ester, engine performance, biodiesel.

Introduction

The widespread use of diesel powered vehicles and machines not only in Latvia, but also in all world, has caused many different environmental problems (acid rains, smog) and human health problems. Diesel exhaust is a complex mixture of gaseous constituents (including CO, NO_x, NO_2, CO_2) and particles, which have been classified as probable human carcinogens by International Agency for Research on Cancer (IARC, 1989).

One of the possibilities to reduce environmental, economical and social problems caused by usage of fossil diesel fuel is to introduce biodiesel instead of fossil diesel fuel in diesel engines. Biodiesel can be made of such renewable resources as rapeseed oil, palm oil, waste cooking oil and others. These fuels have many characteristics, which make them attractive for use in compression ignition engines, and the main advantage of biodiesel is that it can be used in existing diesel engines without any modifications. Biodiesel also has some other essential advantages, which make it more competitive to diesel. Biodiesel has a higher flash point, which make it safer for transport and storage; it reduces not only carbon dioxide, carbon monoxide, carcinogenic aromatic hydrocarbons (PAH) and others, but also sulfur dioxide emissions due to very low sulfur content in fuel.

Now biodiesel is applied in different areas: transport, commercial construction equipment and space heating. The use of biodiesel in automotive industry has been increasing very fast in the last years. It could be due to the fact that many manufacturers (e.g. Audi, Volkswagen, Mercedes-Benz and others) guarantee their engines for biodiesel use. In Europe, U.S.A. and other countries, biodiesel and its blends are used in diesel cars, light trucks and heavy trucks with few or no modifications. In some countries, such as U.S.A., biodiesel is used in different off-road equipment (bulldozers, excavators and cranes) and as a heating oil for boilers operation or house heating. These application areas could be primary candidates for substitution of biodiesel due to a wide usage of high sulfur diesel fuel in these application areas.

Biodiesel is also successfully used in boats in many countries. For this application area there could also be some advantages noted. Firstly, the biodegradation rate of biodiesel is about twice as high as for diesel fuel; it degrades by 98.3% in 21 days (Williams, 2002). Secondly, the toxicity of biodiesel to plants and animals is lower compared to conventional diesel fuel. For example, tests with larval forms of fish and shellfish showed that the toxicity of biodiesel is 20–40 times less than that of fossil diesel fuels (Zhou et al., 2003).

As the production of biodiesel (rapeseed methyl ester RME) is started now and is planned to grow rapidly, it is necessary to investigate the impacts of biodiesel and fossil diesel fuel blends on engine running and exhaust parameters. In this paper the results of biodiesel engine tests, which were carried out in the Engine testing and biofuels laboratory of the LLU Motor Vehicle Institute, are discussed.

Materials and methods

In the Engine testing and biofuels laboratory of the Latvia University of Agriculture investigations of a commercial direct injection diesel engine *XD2P (YTT)* were carried out. It was a four-cylinder, four stroke, water cooled, 22:1 compression ratio engine with industrial application. The maximum torque was 139 Nm at 2000 rpm, and the maximum engine power was 49 kW at 4200 rpm.

The experimental setup consists of a diesel engine, an engine test bench *VEM-100*, microscales and gas analysers. The schematic of the experimental setup is shown in Fig. 1.

Fuel consumption was determined by mass (gravimetric) method: an closed flask was previously filled with fuel and, while the engine was operated in determined conditions, the flask was opened and a record of consumed
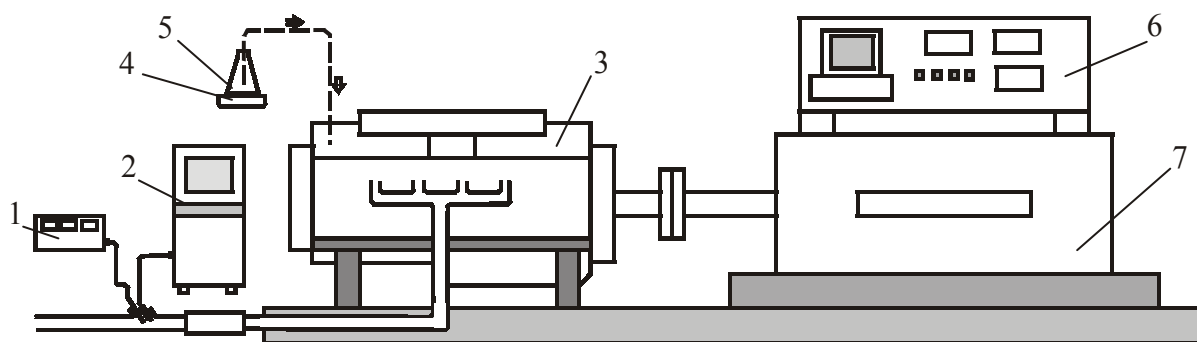
Fig. 1. Schematic diagram of the experimental setup

1 – gas analyser *KM9104*; 2 – gas analyser *BOCSH BEA-350*; 3 – engine; 4 – electronic scales; 5 – inlet fuel flask; 6 – control unit; 7 – dynamometer.

fuel on the required time was obtained. Power, torque, fuel mass consumption and specific fuel consumption were calculated later.

The exhaust emissions of NO_x, NO, CO, CO_2, and O_2 were measured using the *KM9104* exhaust gas analyser, but the PM related exhaust gas opacity (smoke) was measured using the gas analyzer *BOSCH BEA-350* with opacimeter *RTM 430*.

The engine was operated on diesel fuel (DD), rapeseed methyl ester (RME) and on its blends: 35% (350 ml L^{-1}) RME with 65% (650 ml L^{-1}) diesel (35RME), and 5% (50 ml L^{-1}) RME with 95% (950 ml L^{-1}) diesel (5RME). Biodiesel blends were prepared just before the experiments.

Each of the fuels and blends were tested on full open throttle position at a variety steady engine running points: 800, 1000, 1200, 1600, 2000, 2400, 2800, 3200, 3600, and 4000 rpm. The general testing procedure was as follows – after completion of a warm-up procedure, data collection was performed at different engine speeds (firstly, engine was stabilized for some time and only then measurement parametrs were recorded).

The engine was tested with all the fuels in random order and each reading was repeated three times. The results of these three replications were averaged and reported. The results (power, torque, and fuel consumption) for 5RME in this work are not reported due to technical problems with experimental setup during the experimental work with this blend.

Table 1

Physical and chemical properties of the 100RME, 35RME, and 5RME

No.	Parameter	Method	100RME		35RME		5RME	
			Standard LVS EN 14214	Values	Standard pr35Bio DD	Values	Standard LVS EN 590	Values
1.	Density at 15 °C, kg m^{-3}	LVS EN ISO 3675	860-900	877	830-870	848	820-845	800
2.	Viscosity at 40 °C, mm^2 s^{-1}	LVS EN ISO 3104	3.50-5.00	4.5	3.00-4.70	3.97	2.00-4.50	2.9
3.	Flash point, °C	LVS EN 22719	≥ 120	148	≥ 70	85	≥ 55	70
4.	Cetan number	LVS EN ISO 5165	≥ 51	56	≥ 51	55	≥ 46	54
5.	Ashes, %, ww^{-1}	LVS EN ISO 6245	≤ 0.02	0.02	≤ 0.01	0.01	≤ 0.01	0.01
6.	Water content, mg kg^{-1}	LVS EN ISO 12937	≤ 500	310	≤ 300	200	≤ 200	200
7.	Iodine number, g I$_2$/100 g	EN 14111	≤ 120	115.8	≤ 42	34.8	-	6.2
8.	Distillation: % evaporated at 250 °C % evaporated at 350 °C	prEN ISO 3405	-		< 65 > 85	32 100	< 65 > 85	47 95
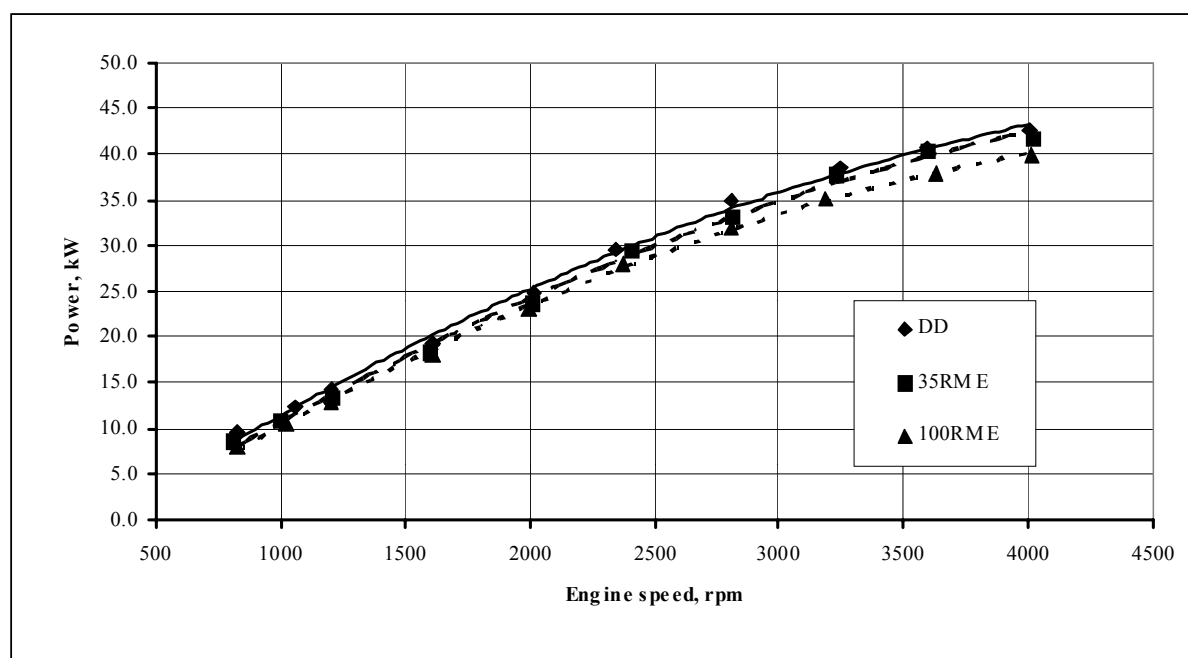
Fig. 2. Power vs. engine speed for tested fuels.

Results

The average results obtained for tests are presented in Figs 2 and 3, and Tables 2 and 3. The results show that there is a slight drop in power output, when RME is added to fossil diesel. There is only a significant difference in power between diesel and 100RME – the maximum average difference between these fuels is 16%. The engine power output for tested biodiesel and blends was lower than with ordinary petrol diesel on average: 7.9% on 100RME and 3.6% on 35RME. Largest decrease in power output was obtained, particularly at higher speeds.

As seen in Fig. 3, the differences in delivered torque are slightly more pronounced than in power output. The torque delivered with 35RME reduced by 1.1…9.5%, but with 100RME – by 6.3…15.9%. The maximum difference of the measured torques between DD and 35RME is 9.5% at 800 rpm.

Fueling the engine with 100RME and 35RME, fuel mass consumption and specific consumption was increased to a considerable extent. In these tests, fuel mass consumption for 100RME increased by 14.5% and for 35RME – by 6.7%.

The results showed that absorption coefficient levels of the engine on free acceleration regime decrease with increasing of the biodiesel blending percentage. For example, absorption coefficient for DD was 1.74 m^{-1}, for 5RME – 1.15 m^{-1}, for 35RME – 0.9 m^{-1}, and for 100RME – only 0.847 m^{-1}. As it is seen, maximum reduction of the absorption coefficient (by 51.2%) has been recorded for 100% biodiesel usage, but quite good results have been almost recorded for 35RME.

As it is seen in the Table 3, carbon monoxide (CO) emissions are reduced by 49.8% (100RME) and carbon dioxide emissions (CO_2) – by 7.8% (100RME). This reduction could be related to the fuel composition – there is less carbon and more oxygen. In summary, the reduction of these components changed on the percentage basis of biodiesel.

Monoxides of nitrogen (NO) and oxides of nitrogen (NO_x) emissions from rapeseed oil methyl ester were generally slightly lower than those from the diesel fuel. NO_x emissions were reduced by 17.5%, when the engine was fueled with clean rapeseed oil methyl ester, and only by

Table 2

Technical parameters produced by an XD2P diesel engine while fueled with 35RME and 100RME compared to conventional diesel fuel at nominal rpm

	DD	35RME		100RME	
			% +/−		% +/−
Power, kW	42.7	41.7	−2.3	39.9	−6.6
Torque, Nm	101.7	99.1	−2.6	95.0	−6.6
Fuel consumption, kg h^{-1}	14.3	15.4	+7.7	17.2	+20.3
Specific fuel consumption, g kWh^{-1}	335.7	369.7	+10.1	430.6	+28.3
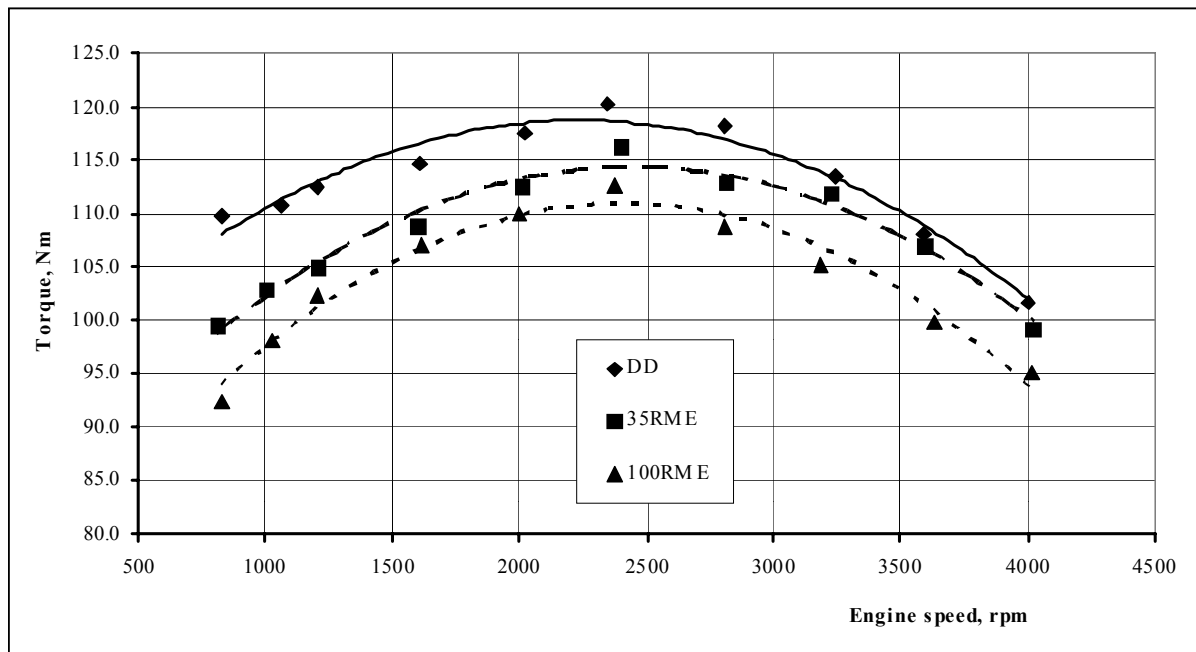
Fig. 3. Torque vs. engine speed for tested fuels.

0.3%, when the engine was fueled with 5% biodiesel blend.

The values recorded for oxygen (O_2) for biodiesel and its blends were higher than those for conventional diesel fuel. It can also be expected due to the oxygen content of biodiesel fuels.

Discussion

Many studies on the performances and emissions of CI engines are reported in the literature (Niehaus et al., 1985; Schumacher et al., 1992; Reece & Peterson, 1993). These studies observed reductions in power ranging from one to seven percent. Such reduction in power and torque can be due to a lower heating value of biodiesel (Antolin et al., 2002). Based on other studies (Graboski & McCormick, 1998), neat biodiesel and biodiesel blends exhibit a fuel economy proportional to their lower heating value. The results of the presented research also confirm other authors' (Carraretto et al., 2004) reported fact that with pure biodiesel, the maximum torque is reached at higher speeds.

In most cases, power decreased and fuel consumption increased as the percentage of biodiesel was increased in the fuel blend. For example, fuelling a *Cummins 5.9L* diesel engine, power decreased by 5% (100% RME) and 1.5% (20% RME), but fuel consumption increased by 4% (100% RME) and 1.8% (20% RME) (Peterson et al., 1999). Some studies reported that biodiesel can cause a slightly higher engine power than diesel fuel due to a complete combustion with the fuel oxygen in the fuel rich flame zone (Gonzalez Gomez et al., 2000), and therefore it can reduce smoke and CO (Chang & Van Gerpen, 1997).

Reece (Reece et al., 1993) noted reductions in smoke density when fueled the engine with a 20% rapeseed derived biodiesel and 80% No. 2 diesel blend. This agrees with other researcher studies, where a reduction on smoke with the use of biodiesel in vehicles was reported (Graboski et al., 1998). Smoke opacity reduction by 71% was noted fueling a *5.9L Cummins* direct injection diesel engine (Peterson et al., 1995). Researchers from the University of

Table 3

Exhaust emissions produced by an XD2P direct injection diesel engine

Exhaust emission variables	Emissions						
	DD	5RME		35RME		100RME	
			% +/-		% +/-		% +/-
CO, ppm	2203	*ND	*ND	1205	-45.3	1105	-49.8
CO_2, %	12.9	12.6	-2.3	12.5	-3.1	11.9	-7.8
NO, ppm	332	325	-2.1	317	-4.5	271	-18.4
NO_x, ppm	337	336	-0.3	318	-5.6	278	-17.5
O_2, %	3.1	3.8	+22.6	3.8	+22.6	4.8	+54.8

*ND–not detected

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Limerick (Gonzalez Gomez et al., 2000) noted reduction in smoke density approximately by 48% when fueled with a WCOME (waste cooking oil methyl ester) as compared to conventional diesel. Researchers (Sams, 1997) found out that carbon from fuel combustion can be reduced in the order of 60-70% using biodiesel with the oxygen content 10-12%. The presence of oxygen in biodiesel blends leads to more complete combustion processes, resulting in not only lower smoke, but also in lower emissions of CO and particles (Carraretto et al., 2004).

The main part of the experiments in the world has shown that biodiesel fuels can significantly reduce exhaust emissions, including carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), and particulate matter (PM). Fueling a 5.9 turbocharged direct injection diesel engine with RME (Peterson & Reece, 1996), hydrocarbons reduced by 52.4%, carbon monoxide – by 47.6%, and nitrogen oxide – by 10.0% compared to diesel fuel. In other research work (Hansen & Jensen, 1997) was noted that the use of RME in *VOLVO THD 103KF* leads to a decrease in CO emissions, but an increase in NO_x and particulate emissions. Some researchers (Niehaus, 1985) noted increases in carbon monoxide and hydrocarbon exhaust emissions, but decreases in oxides of nitrogen exhaust emissions. In other research work (Krahl et al., 1998) decreases in carbon monoxide, hydrocarbon, particulate matter and soot emissions were noted, but increases in oxides of nitrogen exhaust emissions fueling engine with rapeseed oil methyl ester (RME) compared to conventional diesel; Schäfer (Schäfer, 1996) also reported decreases in hydrocarbon and smoke emissions fueling the engine with rapeseed oil methyl ester compared to conventional diesel.

The research results confirmed reduction in power, torque, smoke opacity, CO, CO_2, NO, and NO_x emissions, but it is not similar to the results of those researchers who fuelled diesel engines with rapeseed oil, waste cooking oil or soybean oil methyl esters. Most of the reported studies show a difference in the results, which mostly depends on the employed engine technology and the type of the used emission test. These factors mainly have a significant effect not only on the difference of the emission composition, but also on dynamical and economical parameters reported by some authors and researchers. Therefore this confirms that is necessary to turn attention to further research in this area.

Conclusions

1. A compression ignition engine fueled on rapeseed oil methyl ester provides slightly lower power, torque and higher fuel mass consumption and specific consumption.

2. For diesel engines running on biodiesel and its blends, exhaust emissions tend to be lower for carbon monoxide, carbon dioxide, oxides of nitrogen, and monoxides of nitrogen in comparison to fossil diesel.

3. The level of the exhaust emission components (CO, CO_2, NO_x and also smoke) decreases as the biodiesel concentration increases.

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STALK MATERIAL CUTTING ENERGY

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Abstract

Sustainable energy systems and food security can be obtained in rural areas by usage of renewable energy resources and development of agro–ecotechnologies. Substitution of fossil feedstock for energy and raw materials by biomass is important measure also for greenhouse gas (GHG) emission mitigation. The article presents investigation of reed biomass size reduction processes: flattening and cutting. Necessity to reduce the size of common reeds (*Phragmites australis*) to particles smaller than 3 mm for solid biofuel production is determined by compaction properties of biomass. It was stated that unflattened reed stem cutting energy consumption is 2 times more than flattened stem cutting energy. There are no sufficient differences in the energy consumption values for single flattened reed stalk cutting with different shaped knives. The average difference is approximately 2.4 kJ m^{-2} with knife edge angles 90° and 20°.
Key words: reed biomass, cutting.

Introduction

As the fossil fuel resources are decreasing, in future we will have to rely on renewable energy sources. The World Energy Council Committee estimates that by the year 2020 the share of renewable energy will grow to 21–30% of the total energy consumption. In a shorter term, the EU assumes that the share of renewable energy in the fuel and energy balance will rise from 6% in 1998 to 12% in 2010 [1]. In rural agro – ecotechnologies, main resources for solid biofuel are residues of cereal crops, peat and emergent vegetation as common reed etc. Solid biofuels are residues from agriculture and – still to a very limited extent – energy crops grown especially for energy purposes.

Properties of stalk materials as reeds and straw have to be investigated [2] for the design of processing and handling equipment, economical transport and storage.

In Latvia, straw resources that can be used for energy production have increased (more than 171 000 t of straw annually), because cattle breading has decreased in previous years [3]. Only one part of straw residue (20–30%) is planned to use for heat production, but another part will be used as organic fertilizer. Besides that more than 230 million tons of peat are available for biofuel production. Peat can be used as additive for manufacturing of briquettes, because it improves density of stalk material briquettes. Latvia is a country of lakes (more than 2000), which are overgrowing with common reed (*Phragmites australis*) on shorelines. There is a possibility to utilize this natural biomass. Biomass energy production can be realized only in accordance with an ecosystem approach and good understanding of agricultural ecosystem function. Straw, peat and reed materials can denominate as agricultural ecosystem biomass resources only if there are mechanization tools and technologies for collection and utilization processes.

Materials and methods

Mechanical properties of biomass are not favourable for transport, storage and usage of energy. Naturally herbaceous biomass is a material of low density (0.02–0.06 g cm^{-3})

and is not favourable for transportation over long distances, therefore new mobile equipment and technologies for mechanization of biomass flattening, comminution and densification have to be worked out. A demand for density of solid biofuel briquettes and pellets is >1.0 g cm^{-3} in the standards of European countries [4]. This value has been used for evaluation of herbaceous material densification results. Size reduction is a very important conditioning process for dry biomass densification.

From densification experiments it is stated that higher density has been obtained with a stalk material particle size smaller than 3 mm [3]. During cutting operation with counter shear, stalk flattening occurs at first. For this reason flattening of reed specimens with 10% moisture content has been investigated previously.

Reed stalk cutting experiments have been carried out by means of Zwick material testing machine TC-FR2.5TN.D09 (Fig. 1). Zwick material testing machine has force measurement accuracy – 0.1 N, displacement meas-

Fig. 1. Zwick material testing machine.

Fig. 2. Cutting device.

b)

a)
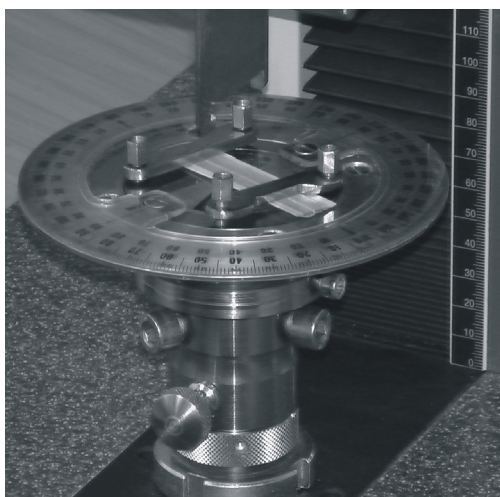
Fig. 3. Flattened reed cutting device.

urement accuracy – 0.01 mm, max force measurement – 2.5 kN. Computer controls the Zwick material testing machine. The force and displacement measurement data were collected on the computer.

Energy consumption for reed stalk cutting has been investigated using the Zwick material testing machine equipped with a cutting device (Fig. 2). Original cutting device has been designed for the Zwick material testing machine for flattened stalk material cutting.

The cutting device (Fig. 3a) consists of the die 1 with a gap and a turnable specimen fastening 4 and a rectangular prismatic punch with 5 mm thickness. Clearance between the punch and the gap is 0.02 mm from each side. Cutting using two types of knives – with edge angles 20° and 90° (Fig. 3b) was investigated. Flattened reed stalks were used for cutting experiments. Displacement, stress and energy data were collected on the computer. Stress and energy diagram can be obtained by means of Microsoft Office Excel program from the collected data.

Cutting shear stress for reed stalk material can be calculated using equation [2]:

$$\sigma = \frac{F}{A},$$ (1)

where

σ – ultimate cutting stress, N m^{-2};
F – maximal cutting force, N;
A – cutting area, m^2.

Specific cutting energy per area unit E_{scq} for stalk biomass can be calculated using equation [5]:

$$E_{scq} = \frac{E_c}{A},$$ (2)

where

E_{scq} – specific cutting energy per area unit, J·m^{-2};
E_c – cutting energy, J;
A – cutting area, m^2.
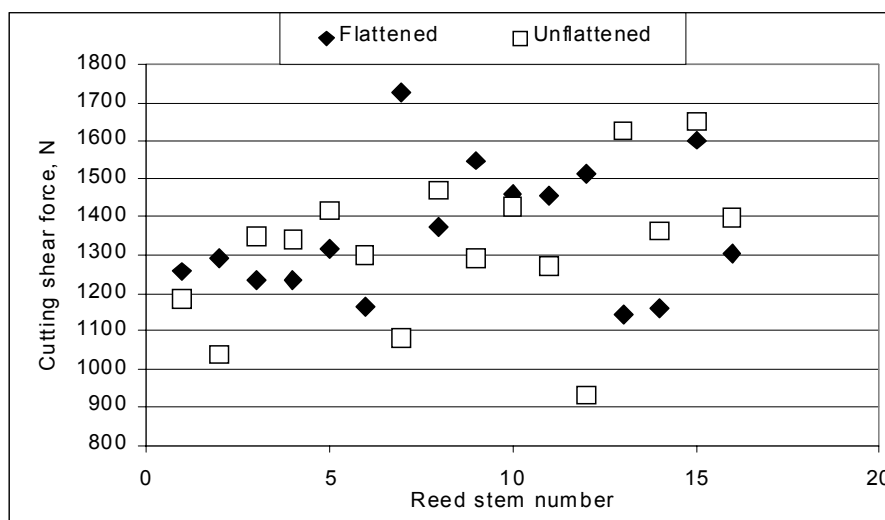
Fig. 4. Reed stem cutting shear force.
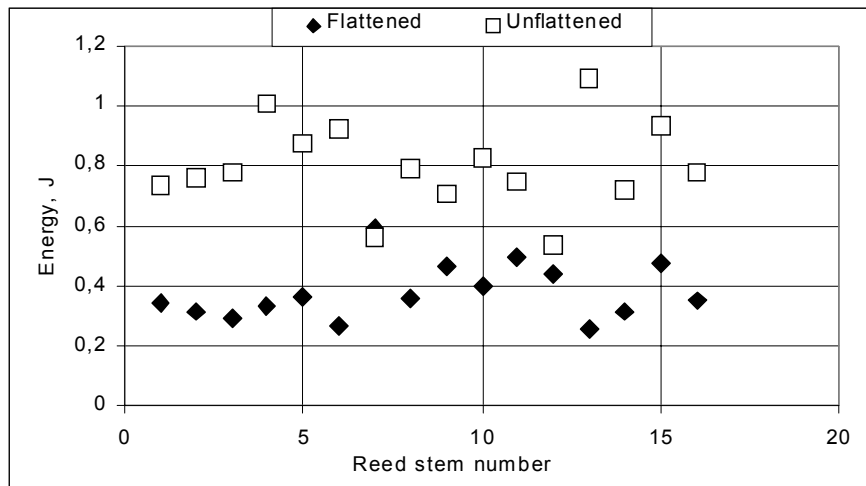
Fig. 5. Reed stem cutting energy.

Results

Reed stalk biomass cutting experimental investigations are necessary for new chopping equipment design. Stalks are the main part of any herbaceous material, their cutting properties determine the shredder and grinder design. Reed stalks consist of nodes and tubular internodes. The cross-section shows air channels for internal ventilation on periphery, because reeds are aquatic plants. Stalk cross section and structural studies show that it is a complicated structure. During cutting operation with counter shear, stalk flattening occurs first. Flattened and unflattened reed specimen cutting shear force (Fig. 4) average values were the same, using a knife with the edge angle of 90°. For the experiments, the same reed stem material was used (one part of stem was flattened and used for cutting, but the other part for cutting was used unflattened).

Exchange of flattened und unflattened common reed cutting energy consumption during this process is shown in Fig. 5. From force – displacement diagrams, energy consumption for cutting was calculated. Average energy consumption 0.8 J has been stated for unflattened single reed stalk cutting. But average energy consumption for flattened reed cutting is 0.38 J. The difference between flattened and unflattened reed stem cutting energy consumption is 0.42 J. From previous flattening experiments it is stated that flattening energy consumption for reed stem with length 6 cm is 0.2 J. Therefore it is more economically to use flattened reed stems for cutting. It is simpler also for tech-
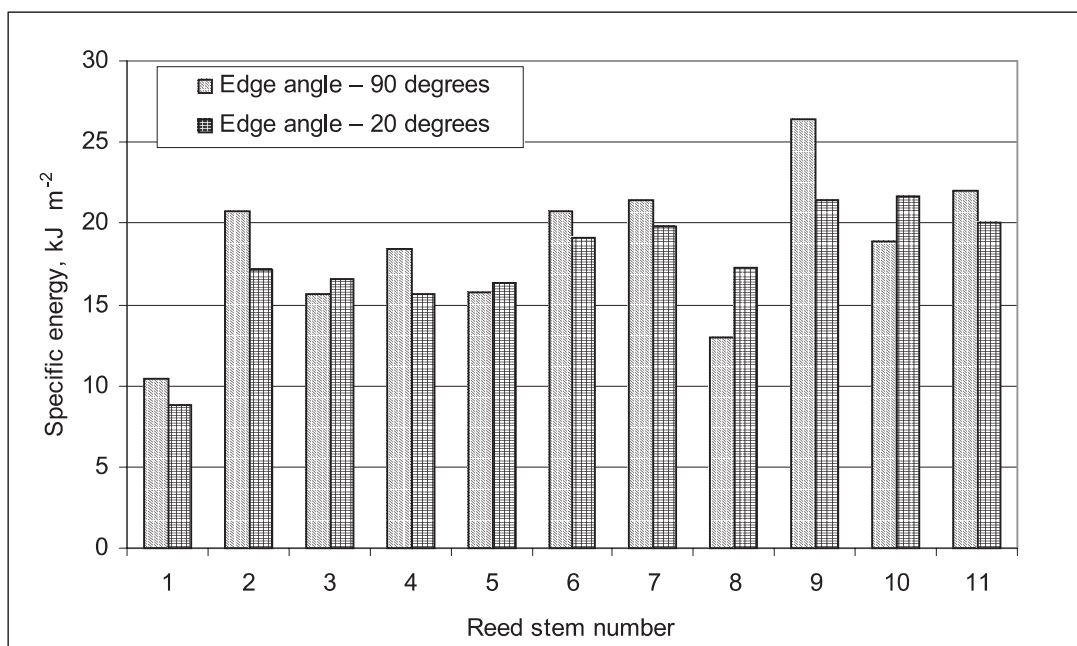
Fig. 6. Reed stem cutting with two type of cutting edge.
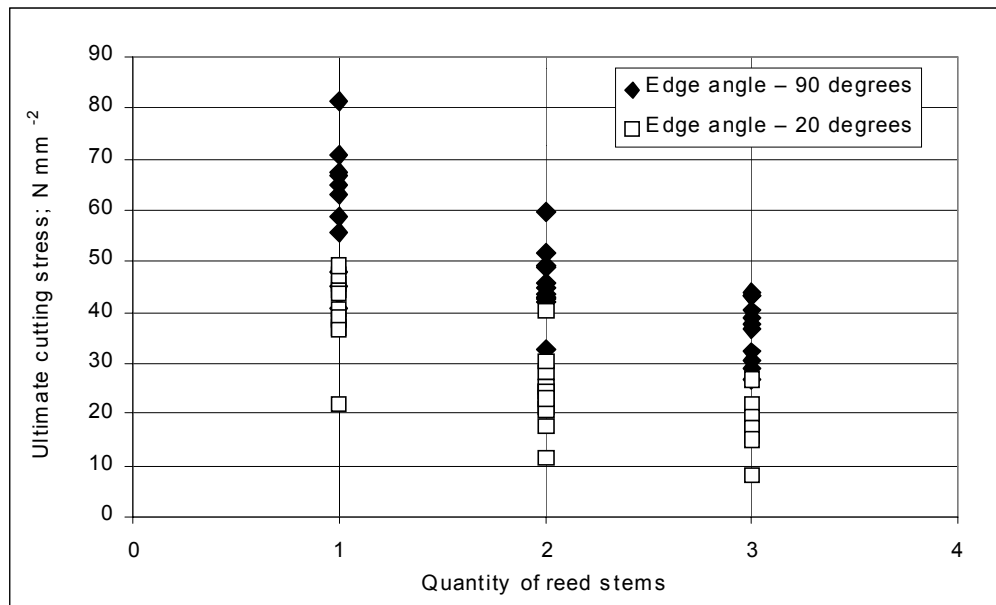
Fig. 7. Reed stem stack ultimate cutting stress.

nology, because reed stem transporting can be realised with drive rolls. Rolls can implement two functions – drive and flattening.

Fig. 6 demonstrates reed stalk cutting using two types of knives with edge angles 20° and 90°. Cutting properties of these two types cutting knives were compared. The differences were not sufficient in the specific energy values for single flattened reed stalk cutting (average difference is approximately 2.4 kJ m^{-2} for the two types of knives).

Figure 7 shows ultimate cutting stress of flattened reed stem stack. Ultimate cutting stress is lowest for stack with maximum amount of layers. Flattened reed ultimate cut-

ting stress for two types of knifes cutting edge is different. Ultimate cutting stress for the knife with cutting edge angle 20° is twice lower than the cutting stress for the knife with cutting edge angle 90°.

Cutting energy consumption for two types of knives and flattened reed stem stacks can be seen in Fig. 8.

For cutting two – and three – layer stack of flattened reed stalks, the knife with edge angle 90° shows twice more energy consumption than the knife with edge angle 20°. For a single flattened reed stalk there are no sufficient differences in the energy consumption values for the mentioned knives. Therefore, for reed stalk stack cutting, more
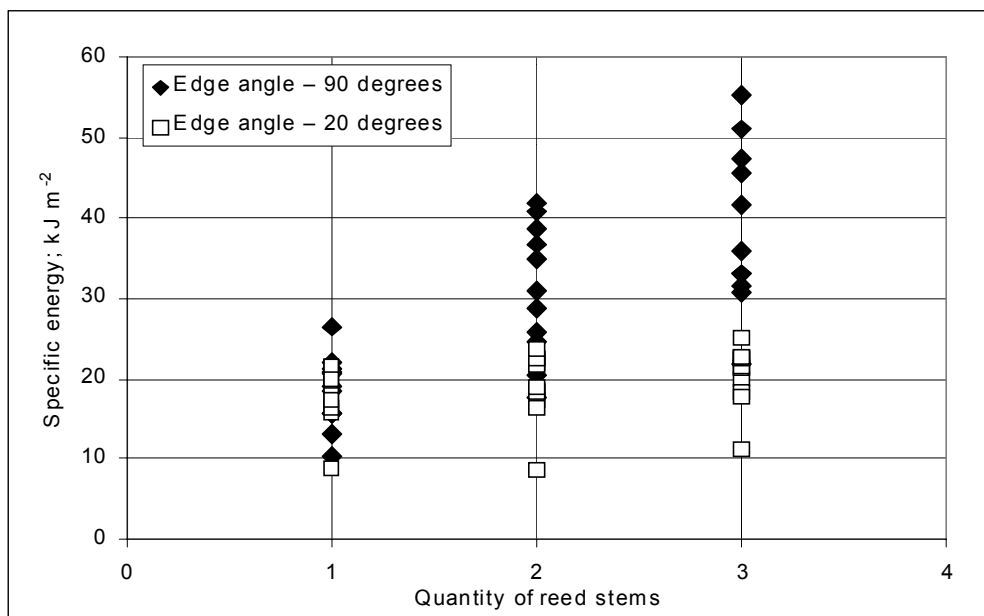
Fig. 8. Reed stem specific energy consumption.

favorable will be usage of single reed stalk layers and chopping with a cutter with the edge angle 90°. If the cutter edge angle is smaller, the cutter edge sties edgeless faster.

Conclusions

1. The main reed biomass size reduction processes are flattening and cutting.

2. The difference between flattened and unflattened reed stem cutting energy consumption is 0.42 J.

3. Ultimate cutting stress for the knife with cutting edge angle 20° is twice lower than cutting stress for the knife with cutting edge angle 90°.

4. There are no sufficient differences (2.4 kJ m^{-2}) in the energy consumption values for single flattened reed stalk cutting with knife edge angles 20° and 90°.

5. Thin herbaceous biomass layer cutting is recommended for shredder design.

6. Flattening and cutting force and energy consumption values obtained experimentally are necessary parameters for calculations and design of the cutting tools.

Acknowledgements

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INTERNAL STRESSES OF BIOMASS COMPOSITIONS

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Abstract

Relevant resources for biomass energy production are cereal straw residues and emergent vegetation from wetlands. This bulk herbaceous biomass is a material with low density. Density of briquetted straw and reed has been increased from 60 kg m^{-3} to 1000 kg m^{-3}. The storage, dosage and mixing of biomass bulk materials before compacting are necessary, which requires working knowledge of the bulk properties of materials. The angle of repose of straw, reed and peat particles was investigated. It was stated that angle of repose of straw and reed varies between 45–55 degrees. The angle of repose of peat particles varies between 37–50 degrees. The stress ratio between horizontal and vertical stress is important for equipment design. This ratio was investigated for different size particles of straw, reed and peat. Stress ratio of straw particles varies between ~0.6–0.71.

Key words: stalk materials, biomass briquettes, angle of repose, bulk properties.

Introduction

Ecological and economical situation in the world is increasing the demand for renewable energy sources with less impact on environment. There is a growing public concern about the environmental implications of in-field burning – air pollution, damage to the countryside, and the risk of accidents. This has led to a consideration of alternatives, notably the potential for using straw as a competitively priced fuel. Utilizing cereal straw residues and vegetation from wetlands (overgrown lakes with common reed) for energy consumption will enable the employment of more people in the countryside. Spruce environment will recruit tourists.

Herbaceous biomass is a material with low density. Density of briquetted straw and reed has been increased from 60 kg m^{-3} to 1000 kg m^{-3}. From preceding measurements it was ascertained that durability of straw and reed briquettes has to be increased therefore different compositions of straw, peat, reeds, etc. were tested. It was established that adding 50% of peat to straw or reed increases durability of briquettes 2.2 times.

In order to design silos, feeders, mixing and flow promoting devices for briquetting process it is necessary to know flow properties of bulk solids. The loading, storage container discharging and automatic feeding process depend on internal stresses acting in the biomass volume. Knowledge of the stresses acting in chopped biomass is important for many applications:
- storage container and hopper design for strength,
- storage container and hopper design for flow,
- loads on feeders and inserts,
- driving torque of feeders.

Many of the problems are associated with the bin and hoper design: the material does not exit from a hopper fast enough or material is cohesive enough that the particles form arch bridges or domes that hold overburden material in place and stop the flow completely. Dead spaces in the bin can prevent a bin from complete discharge of the material [5].

To prevent stacking and arching of the material it is necessary to investigate the dimensions and form of flow promoting devices accordingly to bulk material properties. One of properties is the angle of internal friction. The angle of internal friction is a measure of the force required to cause particles to move or slide on each other. Internal friction is influenced by many parameters including particle surface friction, particle shape, hardness, particle size, etc.

The Mohr stress circle represents the stresses in cutting planes, which are inclined through all possible angles [5]. Using the Mohr stress circle for predicting stresses in different locations of the storage bin it is necessary to know the stress ratio λ of stress σ_h (horizontal stress) to stress σ_v (vertical stress). Several methods are known for obtaining stress ratio λ. One of them is calculation of λ from the angle of internal friction of the bulk material. Obtained results give insufficient accuracy. Stress ratio measured directly from a uniaxial compression test [3,4] is more accurate because the process in the cylinder by direct measuring more like processes happened in real technological processes in silos, feeders, mixing and flow promoting devices.

In the Research Laboratory of Mechanics of the Latvia University of Agriculture, research on mechanical properties of straw, reed and peat particles has been made. Values of the angle of internal friction and stress ratio λ have been experimentally established.

Material and methods

Preceding measurements ascertained that durability of straw and reed briquettes have to be increased therefore different compositions of straw, peat, reeds, etc. were tested. It was established that adding peat to straw and reed increases durability of briquettes.

In order to design silos, feeders, mixing and flow promoting devices for briquetting process it is necessary to know the mechanical properties – flow properties of above mentioned bulk solids.

The angle of internal friction is an important flow property for calculating minimum outlet dimension of silo to prevent arching as well as critical rathole diameters. Furthermore, it is possible to estimate the stress ratio λ of the
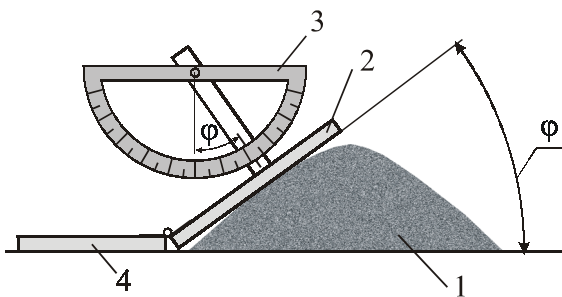
Fig. 1. Measuring of the angle of repose:
1 – bulk material, 2 – contact ledge, 3 – scale of angle,
4 – support.

bulk material. The angle of internal friction can be calculated from the angle of repose [6]. The angle of repose is a characteristic of solids, which characterizes the piling or stacking nature of particles. The angle of repose is considered to be mostly a measure of the internal friction between the particles as a whole, but not between individual particles. It is used in a number of correlations and estimates for behavior properties of the bulk solids. The best use of the angle of repose is to determinate the size of a pile of bulk materials, either volume or ground area that such pile will occupy.

The angle of repose is measured accordingly to Figure 1. Chopped to different length, reed and straw stalks with moisture content less than 10% are used for obtaining the angle of repose. Stalk material is sieved, then divided into the following fineness groups: 3 – 5, 2 – 3, 1 – 2, 0.5 – 1, and < 0.5 mm.

Bulk material is filled in cylinder and by lifting cylinder bulk material is poured out on the horizontal surface (Fig.2).

The angle of internal friction φ for different materials gives different relations with the angle of repose. For many materials, the angle of internal friction is approximately 2°–8° less than the angle of repose.

Coefficient of internal friction f is expressed from the angle of internal friction by equation:

$$f = \mathrm{tg}\varphi . \qquad (1)$$

In a bin filled with solid bulk material this material acts at the base of a bin and also on the walls with the horizontal stress σ_h. For the stress calculation, a bulk solid is considered as a continuum instead of single particles. Because of this the methods of continuum mechanics can be applied. If different sloped cuts through an element of bulk solid are considered it can be seen that different shear and normal stresses are acting at the different cutting planes. This is shown in a simplified way in Figure 3 where the stresses σ_h and σ_v, which act in different directions, differ from each other.

The stress ratio λ between horizontal and vertical stress is important for storage equipment design. Often the equation of Kèzdi (2) is used for the estimation of the stress ratio λ [1]:

$$\lambda = 1 - \sin\varphi , \qquad (2)$$

where
φ – angle of internal friction.

The German standard DIN 1055 part 6 [2] recommends the following equation, which is based on equation (2):

$$\lambda = 1.2 \cdot (1 - \sin\varphi) . \qquad (3)$$

The use of eq. (3) results in higher wall loads in the upper area of silo, i.e. wall normal stresses σ_h and shear stresses τ_α are greater than those calculated on the basis of eq. (2). Therefore, the load assumption for the structural design is on the safe side with eq. (3). To be on the safe side for applications where the maximum vertical stress is important (e.g. for the calculation of the feeder load or the maximum vertical stresses), the smaller λ should be used because it yields higher vertical stresses.

The values of the stress ratio calculated according to equation (3) in the practice are not correct in many cases because the stress ratio depends on a lot of parameters that are not taken into account in eq. (3). According to ISO-guideline TC98/SC3/W65, stress ratio can be measured directly from a uniaxial compression test [3].

Figure 3 shows an element of bulk solid in a bin filled with bulk solid (the inner walls assumed to be frictionless). The stress σ_v is acting on the element of bulk solid in the

Fig. 2. Obtaining of the angle of repose.
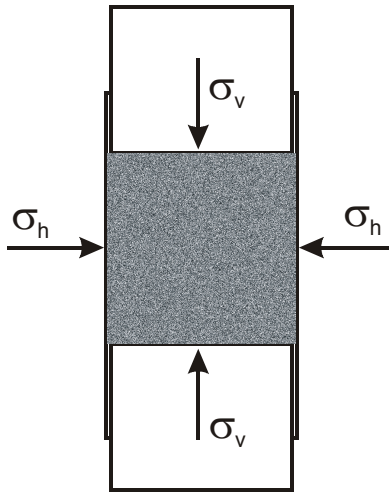
Fig. 3. Bulk material element:
σ_v – vertical stress, σ_h – horizontal stress.

vertical direction (note: in bulk solids mechanics compressive stresses are defined as positive stresses). The stress σ_h prevails in the horizontal direction as a result of the vertical stress. The ratio of stress σ_v to stress σ_h is defined as the stress ratio λ.

Stress ratio λ is calculated as a proportion of horizontal and vertical stresses [4]:

$$\lambda = \frac{\sigma_h}{\sigma_v}. \tag{4}$$

Experimental equipment design for estimating of stress
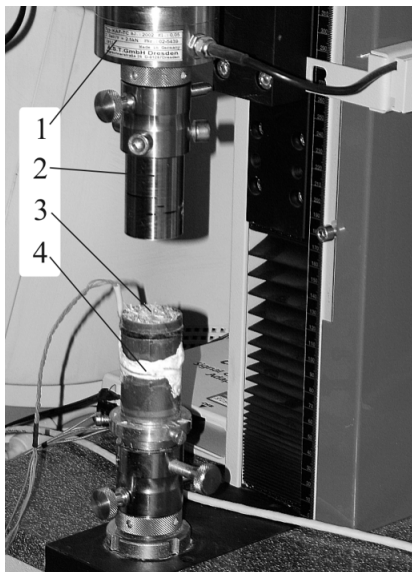
Fig. 4. Device for measuring horizontal stress:
1 – load cell, 2 – piston,
3 – bulk material, 4 – cylinder
with strain gauge.

ratio λ is shown in Figure 4. Horizontal stresses of material acting on the walls of the cylinder 4 leads to tension deformation of those thin walls. The deformation is proportional to the stresses σ_h and is measured using strain gauges. Fixed vertical stress is obtained with ZWICK testing machine of materials. As a result of compression in the bulk material, vertical σ_v and horizontal σ_h stresses arise (Fig. 3). Output voltage from strain gauges through the transducer *PicoScope - 212* is collected to PC. Chopped to different length reed and straw stalks with moisture content less than 10% are used for estimating of stress ratio λ. Stalk material is sieved, then divided in to following fineness groups: 5 – 7, 3 – 5, 2 – 3, 1 – 2, 0.5 – 1, and < 0.5 mm.

Strain gauges are calibrated by using oil pressure in active part of the cylinder.

Change of vertical stress in the range from 0.54 to 2.7 MPa was used for stress ratio calculation.

In figure 5, the bulk solid element from Figure 3 is shown again. No shear stress is acting on the top and bottom of the bulk solid element in figure 3 and also on the walls of the bin (assumed as friction less) in horizontal direction. A triangular-shaped element is considered, cut from bulk solid element in Figure 3. The normal stress σ_α and the shear stress τ_α acting in the plane, which is sloped at an angle α to the y-direction, are calculated from equilibrium of forces on the triangular element. This results in the following equations:

$$\sigma_\alpha = \frac{\sigma_v + \sigma_h}{2} + \frac{\sigma_v - \sigma_h}{2}\cos(2\alpha), \tag{5}$$

$$\tau_\alpha = \frac{\sigma_v - \sigma_h}{2}\sin(2\alpha). \tag{6}$$

If equations (5) and (6) are plotted on a σ, τ – diagram (normal stress vs. shear stress diagram), the resulting curve is a Mohr stress circle with its center at $\sigma_m = (\sigma_v + \sigma_h)/2$ and radius $\sigma_r = (\sigma_v - \sigma_h)/2$ (Figure 5). The Mohr stress circle represents the stresses in cutting planes, which are inclined through all possible angles α. Each Mohr stress circle has two points of intersection with the σ – axis (because the sin-function becomes zero for all multiples of π, τ_α in equation (6) becomes zero for $\alpha = 0$ and for $\alpha = \pi/2$). The points of intersection indicate the two cutting planes in which the shear stress τ is equal to zero. The normal stresses acting in these planes are called principal stresses. The larger stress is indicated with σ_1 ("major principal stress") and the smaller one with σ_2 ("minor principal stress"). The position of the Mohr stress circle is defined exactly by the two principal stresses.

In the example considered in figure 3, no shear stress is acting in the horizontal and vertical planes. Hence, these planes are the principal stress planes. The vertical stress σ_v has to be set equal to the major principal stress σ_1 because $\sigma_v > \sigma_h$. Therefore the horizontal stress σ_h is the minor principal stress, σ_2 [5].
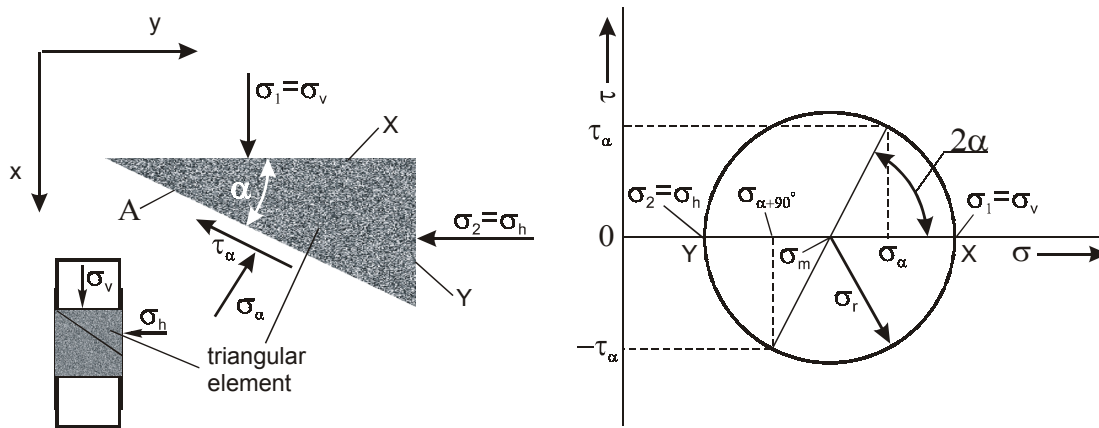
Fig. 5. Fofce eqilibrium on an element of bulk solid, the Mohr stress circle.

Results and discussion

The angle of repose has been obtained in dependence on the particle size of the bulk material (reed, straw and peat). It was stated that size of particles has relevant influence on the angle of repose. Particles with size less than 1 mm achieved value of the angle of repose $\varphi \approx 45°$, but particles greater than 5 mm – 55°. The range of the angles of repose for straw and reed particles is nearly similar. Peat particles less than 1 mm reach angle of repose $\approx 37°$ (see Fig. 6). The mass-flow and funnel-flow limits in silos are well known and have been used extensively in proper design; the limits for hoppers depend on the hopper half-angle Θ, the effective angle of internal friction φ and the wall friction angle ϕ. Once the wall friction angle and angle of internal friction have been determined by experimental means, the hopper half angle Θ may be determined as a function $\Theta = \phi(\varphi, \phi)$.

Stress ratio λ obtained by equation (3) is influenced by particle size of the bulk material (Fig. 7). Consider stress ratio λ of particles greater than 2 mm established that λ is quite similar for all investigated biomass materials. On average, calculated stress ratio for investigated materials ranged within 0.3–0.5. It conforms to results obtained by other researchers (0.3 to 0.6) [5].

The results of direct measuring of horizontal stress σ_h in dependence on vertical stress σ_v are shown in Fig. 8. The stress ratio λ calculated accordingly to eq. 4 shows no dependence on vertical stress. Experimental obtained stress ratio of straw particles varies between ~0.5–0.72 for particle size 0.25 to 7 mm (Fig. 9).

The value of stress ratio obtained in direct measuring is ~1.7 times higher than the value of stress ratio calculated from the angle of repose. The trend of dependence of the stress ratio on particle size is similar in the both measuring methods.
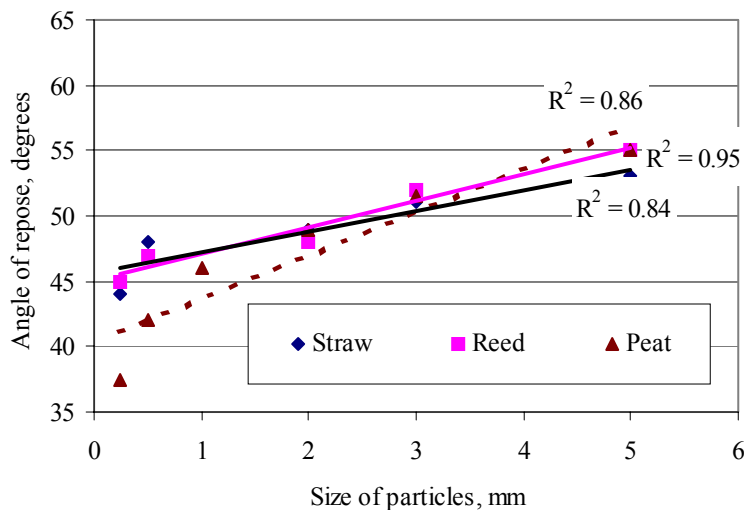
Fig.6. Dependence of the angle of repose on particle size.
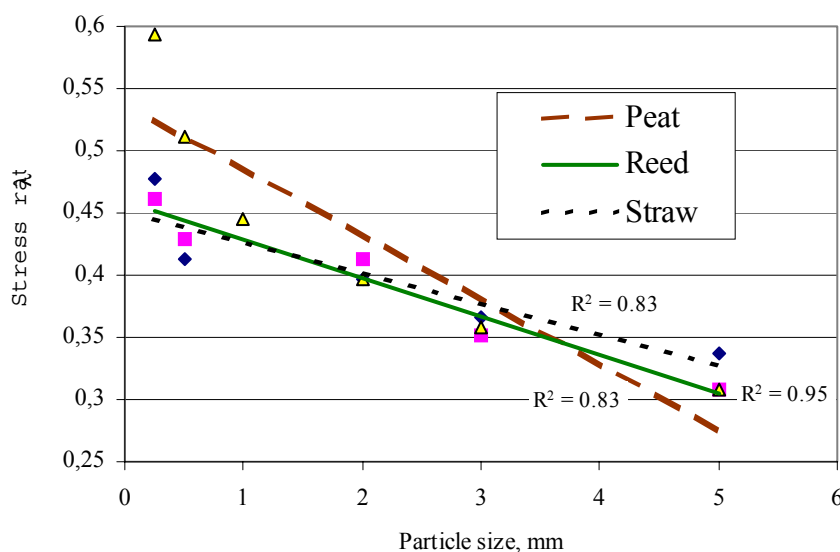
Fig. 7. Influence of particle size of the material on stress ratio λ
(obtained by equation (3)).

Direct measuring of stress ratio λ in the material arises great stresses in axial direction, which causes the material flow and stresses in radial direction. Physical process in the cylinder using method of stress ratio direct measuring conforms to physical process in technological equipment – silos, feeders, mixing and flow promoting devices. The values of the stress ratio which are calculated according to equation (3) and DIN 1055 part 6 [2], respectively, are not correct in any case because the stress ratio depends on a lot of parameters which are not taken into account in equation (3). Therefore, the load assumption for the calculation of silos wall strength is on the safe side with the stress ratio λ obtained in direct measuring, but the smallest λ is recommended for applications where vertical stress is important (e.g. for the calculation of the feeder load or the maximum vertical stresses).

An important qualitative result of the Mohr stress circle analysis is that shear stresses can occur in bulk solid at rest. This is impossible for a fluid at rest (in contrast to fluids, bulk solid can have a sloped surface even at rest). Therefore, a representation of the stresses (fluids: pressures) in different cutting planes of a fluid at rest in a σ, τ – diagram would yield a stress circle with the radius zero (equation (5) with $\sigma_h = \sigma_v$ yields $\tau_a = 0$).

In summary, the following can be stated with regard to the stresses acting in bulk solids:

- A bulk solid can transmit shear stresses even if it is at rest.
- In different cutting planes different stresses are acting.
- Stress conditions can be represented with Mohr stress circles [5].
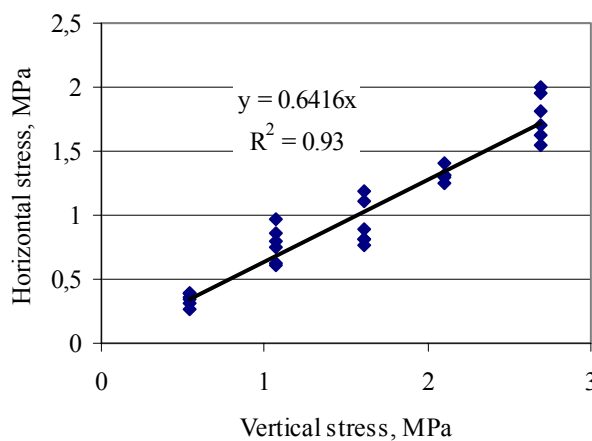
Fig. 8. Stress ratio.
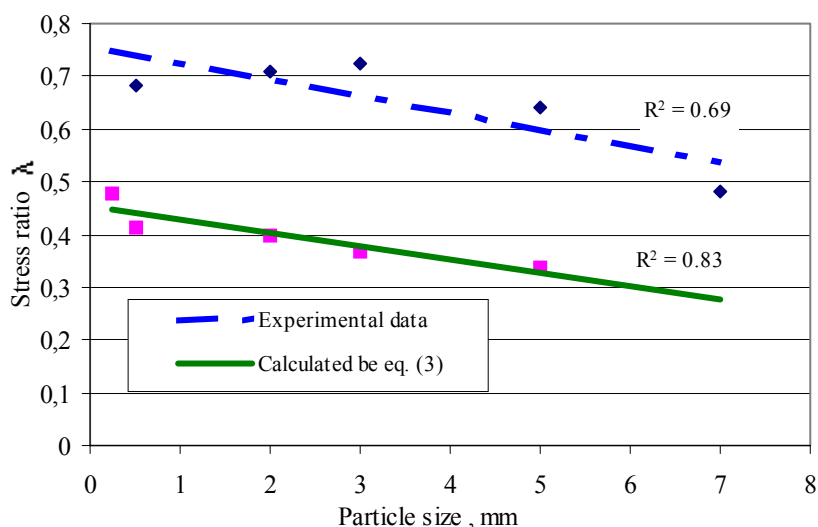
Fig. 9. Stress ratio of different–size straw particles.

Conclusions

1. The angle of repose is dependent on the size of biomass material (straw, reed, peat) particles, increasing of particle size leads to increasing of the angle of repose. The angle of repose for straw and reed is in the range from 45° to 55°, but for peat it is 37° to 50°. The ranges of the angle of repose for straw and reed particles are nearly similar.

2. Experimentally obtained stress ratio of straw particles varies between ~0.5–0.72 for particle size 0.25 to 7 mm.

3. Experimentally by direct measuring obtained values of stress ratio λ are ~1.7 times higher than λ values obtained from the angle of internal friction.

4. The load assumption for the calculation of silos wall strength is on the safe side with stress ratio λ obtained in direct measuring (higher value), but the smallest λ is recommended for applications where vertical stress is important (e.g. for the calculation of the feeder load or the maximum vertical stresses).

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WATER MANAGEMENT

STREAM WATER QUALITY IN THE KARST ZONE OF LITHUANIA

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Abstract

The paper gives the data about the mineralization process (sum of ions) and the amount of nutrient ions (nitrogen, phosphorus) contained in water of two streams (basin areas 1.63 km^2 and 2.02 km^2) located in soils of different texture in the karst zone. As the study results have shown, higher amounts of DIN (dissolved inorganic nitrogen) were determined under the conditions of higher humus content in the soil (more humus (0.8–3.0%) was observed in glacial lacustrine soils), uneven runoff distribution (when its formation process is interrupted), and increasing DIN concentrations in silt. N-NO$_3$ purification coefficient in stream water was higher when the stream was flowing via non-drained wood-covered area, also under the conditions of higher air temperatures. TP (total phosphorus) concentrations contained in stream water mostly depended on large amount of precipitation (especially in summer) as well as on phosphorus contained in silt: higher P$_2$O$_5$ concentrations contained in silt determined lower TP concentrations in water (determination coefficient of the relation r^2 = 0.24–0.30).

Key words: streams of karst zone, nitrogen, phosphorus, silt, water purification coefficient.

Introduction

The research data on the climatic conditions, hydrogeology and subsurface water protection in the karst zone of Lithuania is summarized in publications by different authors (Juodkazis, 1992; Paukštys, 1996; Narbutas et al., 2001). As it was determined, the chemical composition of water is most significantly affected by karst phenomena in the Tatula mid-river and the Lėvuo downstream (Povilaitis, 2003). The extent of researches much depended on permanent karst processes of gypseous Devonian sediment that resulted in environmentally incompatible phenomena from the agricultural point of view. Karst process of gypseous rocks is also affected by chemical pollution, because chemical pollutants are easily transported from soil surface into deeper layers of karst rocks.

The effect of pollution on the environment is obvious in the changes of indices of river water quality. In the Middle Lithuanian Plain, where the river runoff is exclusively affected by surface water, rivers contain the largest concentrations of nutrients (Tumas, 1997). The highest average total nitrogen (TN) concentrations (up to 7 mg l^{-1}) were observed in the rivers of karst zone (the Mūša upstream and the Tatula downstream) that experience the inflow of different industrial and domestic wastewater; lower concentrations (4.28 mg l^{-1}) were determined in river basins (the river Požemis) where intensive agriculture is being developed; the lowest concentrations (1.38 mg l^{-1}) occurred in rivers fed by subsurface water (the river Smardonė) (Chomčenko et al., 2000). Due to the intensive farming, in the Middle Lithuanian Plain the average annual 14.4 kg ha^{-1} nitrogen leaching in streams was determined by high nitrogen concentrations (5.9 mg l^{-1}) (Gaigalis et al., 2001).

Water quality depends on many different factors including the intensity and duration of precipitation, the season of the year and soil texture (Jaakkola, 1984).

The basins of the streams under investigation are not very large; here the agricultural activity is being developed. Besides, the basins differ both in their relief and soil texture.

The objective of the studies was to estimate the characteristics of the changes in the mineralization and nutrient concentrations contained in streams of the karst zone.

Study conditions and methodology

The streams under investigation are situated in the active karst zone (Biržai district). The study included the analysis of hydrochemical indices of the streams within the period of 2000–2004. One of the studied streams is the stream G-1, a tributary of the river Apaščia, flowing through the land areas of villages Paežeriai and Liesiškiai; the other one is the stream Bėrė, a tributary of the river Muša, flowing through the lands of Kirdonys village (Fig. 1).

Soils prevailing in the catchment area (1.63 km^2) of the stream G-1 are moraine sandy loam soils; type of the soils is Hapli-Calc(ar)ic Luvisols with a low content of humus (0.47–0.81%) in the topsoil layer. Soils in the stream Bėrė catchment area (2.02 km^2) are light and medium textured glacial lacustrine clay soils with a medium content of humus (0.8–3.0%); type of the soils is Endocalcari-Endohypogleyic Cambisols.

The average surface gradient (between the watershed and the stream bed) was 0.5–1.5% in G-1 and 0.2–0.3% in the Bėrė basin.

Forest density in the catchment areas of the streams G-1 and Bėrė is 14.2% and 23.7% respectively. However, here the arable land covers 65%, fallow land makes up 30%, while in basin of the stream G-1 the arable land covers 35% and pasture makes up 47%.

Water samples were taken in two posts in both streams once per month. Analysis of water samples was made at
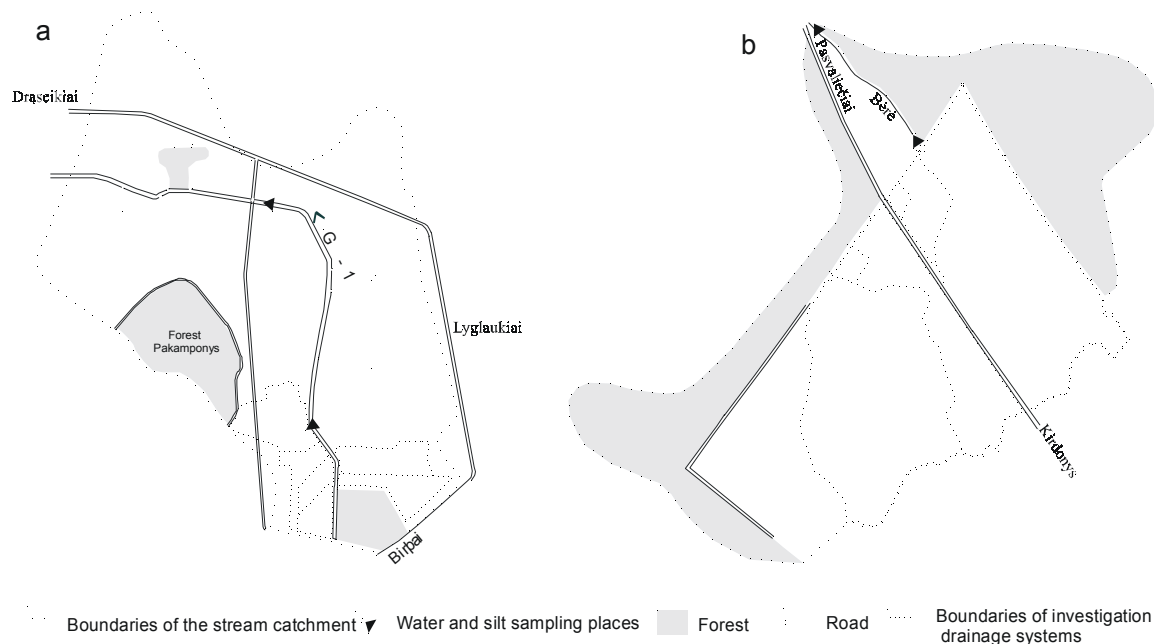
Fig. 1. Schemes of catchment areas of the studied streams: a) G-1 stream; b) Bėrė stream.

the Chemical Analysis Laboratory of Water Management Institute of LUA considering the methods approved by the Ministry of Environment of Lithuania (Unifikuoti…, 1994).

Study Results

In 2000, according to the average DIN values, water was considered as clean in 20% of rivers; according to P-PO_4 values it was considered as clean in 59% of all studied rivers in Lithuania. Slightly or moderately polluted water according to the average DIN and P-PO_4 values was determined in 74% and 25% of rivers respectively; heavily or very heavily polluted water occurred in 6% and 16% of all studied rivers of Lithuania respectively (Lietuvos upių…,2002).

DIN concentrations in water of the stream G-1 and the Bėrė were insignificant or moderate (average annual concentrations were 1.4–4.0 mg l^{-1} and 2.0–9.4 mg l^{-1} respectively), except for the year 2003, when water of the Bėrė

was distinct for heavy pollution (9.4 mg l^{-1}) (Table 1). During the whole study period, higher DIN and TP (total phosphorus) concentrations were observed in the stream Bėrė. This might have occurred due to a higher humus content in the soil where the stream is flowing.

In the stream Bėrė, higher average annual N-NO_3 concentrations were determined by the runoff formation that did not occur throughout the whole year (in summer the stream often gets dry). At the onset of the runoff, N-NO_3 concentrations are particularly high especially in autumn (15.1 mg l^{-1} in November 2002 and 15.4 mg l^{-1} in September 2003). When the territory experienced 766 mm (126% of perennial rate) of precipitation in 2001 and 756 mm (125% of perennial rate) of precipitation in 2004, the runoff of the stream Bėrė occurred throughout the whole year, which resulted in even distribution of N-NO_3 leaching and thus

Table 1

Precipitation, N-NO₃ and TP concentrations in the stream water

Year	Precipitation, mm	N-NO_3, mg l^{-1}		TP, μg l^{-1}	
		G-1	Bėrė	G-1	Bėrė
2000	595	0.3-3.0 1.4	0.9-6.3 3.8	22-88 56	26-206 75
2001	766	0-4.6 2.2	0.5-4.6 2.0	4-118 63	44-176 89
2002	626	0.5-7.4 2.8	0-20.6 6.2	8-102 47	18-222 77
2003	613	0.3-9.5 3.5	2.1-31.3 9.4	12-80 37	16-164 76
2004	758	0.6-8.3 4.0	0.3-8.5 3.3	10-94 42	24-180 92

Fig. 2. Fluctuations in N-NO$_3$ and TP concentrations contained in water of the streams.

lower average annual DIN concentrations than those contained in the stream G-1.

In both streams, the average annual TP concentrations did not exceed the maximum contaminant limit (200 μg l^{-1}) for river water: in the stream G-1 it was 37–63 μg l^{-1} in the Bėrė it was 48–92 μg l^{-1}). In 2000, in the natural river Skroblus the average value of TP was 108 μg l^{-1} (Lietuvos upių....2002). This shows that water of the streams under investigation contained lower concentrations of TP than water of natural rivers.

A rather significant fluctuations in TP monthly concentrations contained in water of both streams were observed: 4–118 μg l^{-1} in the stream G-1 and 16–222 μg l^{-1} in the Bėrė (Fig. 2). During the whole study period, only in the stream Bėrė TP concentrations exceeded the maximum allowable concentration 2 times out of 38 measurements. More intensive precipitation enhanced the increase in TP concentrations contained in water of both streams. In July 2001, the territory experienced 119 mm of precipitation. In June 2004, the precipitation amount was 101 mm; thus in these periods TP concentration in Bėrė stream was 164 and 150 μg l^{-1} respectively; in the stream G-1 it was 98 and 48 μg l^{-1} respectively. The P inflow into the stream might

have occurred due to the surface runoff. As the literature refers (Gaigalis et al., 2001), the TP concentration in stream water increases due to P amount contained in precipitation.

Both biogenic and organic pollution are characteristic for the rivers of Lithuania. As the study results of the year 2000 show according to BOD$_7$ values, water of Lithuanian rivers studied in 76% of measurement posts is clean; in 20% of all studied measurement posts, water is insignificantly or slightly polluted; 4% of all studied rivers contain heavily polluted water (Lietuvos upių…., 2002).

According to the average annual BOD$_7$ values water in the streams under investigation is considered as clean. However, there were some cases (most often in March, April and May) when water was slightly or moderately polluted: in water of the stream G-1, the index BOD$_7$ was fluctuating within the range of 4.6 to 7.0 mg l^{-1} of O$_2$ in the Bėrė water it was changing from 6.2 to 9.8 mg l^{-1} of O$_2$. Higher BOD$_7$ amounts contained in the Bėrė water than in water of the stream G-1 also depended on the soil of the vicinity (glacial lacustrine clay soil). Clay particles are capable to absorb organic matter. Under the conditions of runoff, the absorbed organic matter may be turned into the source of

Table 2

BOD$_7$ content (mg l^{-1} of O$_2$) in water of streams

Stream	III – IV months	V – XI months	XII – II months
G-1	1.0-4.6 / 3.0	0.7-7.0 / 2.7	1.1-3.1 / 2.2
Bėrė	1.5-6.2 / 3.6	0.7-6.8 / 3.3	1.4-9.8 / 3.8
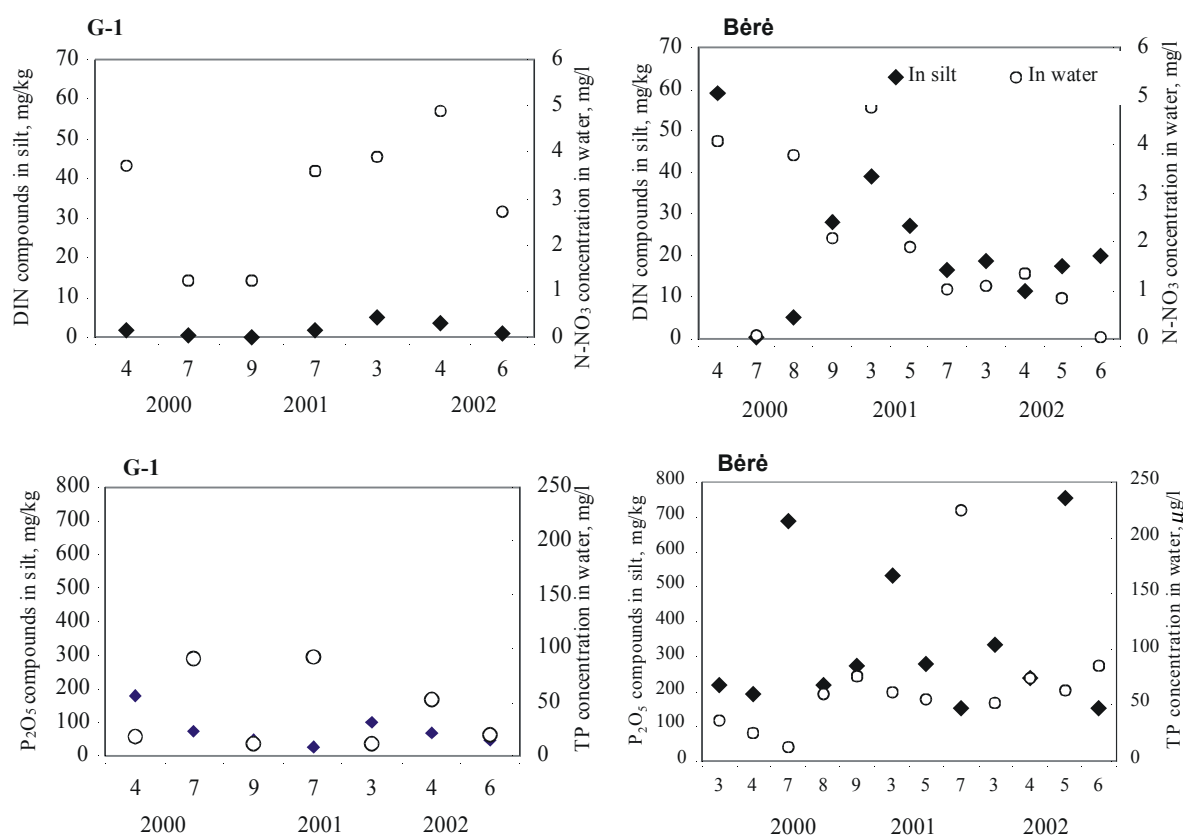
Fig. 3. Fluctuations in N and P compounds contained in stream water and sediment (silt).

organic matter contained in water. During the snow thaw period in spring, higher runoff also determined higher amounts of organic matter contained in water of streams (on the average 3.0 mg l^{-1} of O_2 in the stream G-1 and 3.6 mg l^{-1} of O_2 in the Bėrė) (Table 2).

Smaller amounts of organic matter in stream water occurred in the warm period of the year, when there are favorable conditions for the decomposition of organic matter. As the correlation analysis has proved, the fluctuations of water temperature affect the changes in BOD_7 by about 22-23%. Higher water temperatures determine smaller amounts of organic matter.

Affected by bacteria, mineralizing organic matter might be one of the factors determining N and P occurrence in stream water. During different physico-chemical processes, phosphates may be adsorbed by clay and organic particles, but only under the conditions of high phosphate concentrations. When phosphate concentrations contained in water are low, a reverse process – desorbtion – is possible (Tumas, 1999).

Almost 12 times larger amounts of dissolved inorganic nitrogen (DIN = N-NO_3+N-NH_4) and about 5 times higher amounts of phosphorus compounds (P_2O_5) were observed in silt of the Bėrė flowing via glacial-lacustrine clay soils than in the stream G-1 flowing via moraine loam soils (Fig. 3).

In silt of both streams, the highest DIN concentrations were determined in spring; the highest amounts of P_2O_5

occurred in March and April in the stream G-1 and in May and July in the Bėrė. In spring during slow vegetation processes of aquatic flora, DIN and P_2O_5 are accumulating in silt. The amounts of those compounds contained in silt of streams might have been saturated with nitrogen and phosphorus compounds contained in the sediment washed out with drainage runoff during the spring flood period. In May, larger amounts of P_2O_5 contained in silt of the Bėrė might have been determined by warmer air temperature (average monthly air temperature was 14.7 °C) and more intensive mineralization process of organic matter, as well as by large precipitation amount (128 mm) in May of 2000 and sediment inflow with surface water runoff.

As the literature refers (Kormondis,1992; McDowell et al.. 2001), erosion of phosphorus contained in ground and sorption properties of bed sediment make a significant effect on phosphorus runoff.

Nitrogen and phosphorus concentrations contained in silt (sediment) of studied streams make a strong effect on the formation of those elements in water. Increasing DIN concentrations in silt result in the increased nitrate nitrogen (N-NO_3) concentrations in water (Table 3). Such dependence might have been determined by the fact that nitrogen is a mobile soil element, only ammonia that makes an insignificant part of inorganic nitrogen is adsorbed by ground particles therefore it may be leached easily. When sediments contained larger amounts of P_2O_5, lower con-

Table 3

Characteristics of the correlation connection between N and P compounds contained in stream water and sediment (silt)

Elements	G-1		Bėrė	
	Form of relation	r	Form of relation	r
N	$N_y=0.67N_x+1.70$	0.84	$N_y=0.088N_x+0.10$	0.60
P	$P_y=-0.0004P_x+0.079$	-0.55	$P_y=-0.0004P_x+0.17$	-0.49

Note. r – coefficient of correlation; N_x, P_x – N and P compounds contained in sediment (silt); N_y, P_y – N and P concentration in stream water.

centrations of TP were observed in water as phosphorus contained in sediment may form insoluble compounds.

Chemical matter is transformed in stream water. Different complex chemical processes are observed in water flow, which results in the changes in amounts of chemical matter. The quantitative description of those processes is expressed in complex mathematical equations. The following formula may be used for the calculation of water purification (Tumas, 2003):

$$C_L = C_0 e^{-\alpha L},\qquad(1)$$

where

C_0 and C_L – concentration of chemical matter at the beginning and at the end of the stream, mg l^{-1};

L – length of the river interval, km;

α – river water purification coefficient.

Concentrations of the studied elements contained in stream water at the distance of 500 m from the initial water quality measuring post differed significantly. As the calculated water purification coefficient has shown, in the stream Bėrė, when it is flowing through non-drained woody area, N-NO$_3$ concentration is decreasing, i.e. water is purifying throughout the year (Fig. 4). The highest purification coefficient was determined in summertime. The correlation analysis has proved that the fluctuations in air temperature affect the changes in the intensity of N–NO$_3$ retention by 27–36%.

N–NO$_3$ purification in the stream G-1 flowing via moraine sandy loam soils is more intensive in summer, when the stream is mostly fed with ground water. During the spring flood period or when drainage runoff starts in autumn, water purification gets less intensive and stream water may even be saturated with N-NO$_3$. As the literature states (Rudzianskaitė et al., 2000; Šukys, 2001). stream water mineralization and its quality much depend on drainage water. The fluctuations of N-NO$_3$ contained in drainage water determined TP concentrations by 28–89% or did not determine at all in stream water flowing through glacial lacustrine soils, and slightly determined (only by 14%) concentrations of those elements contained in stream water flowing via moraine loam soils.

TP purification. the same as for nitrogen, was observed to be higher in both streams in summer under the conditions of active processes of biota.

Conclusions

1. According to N-NO$_3$ concentrations, water in the streams G-1 and Bėrė was slightly or moderately polluted (average annual concentrations were 1.4–4.0 mg l^{-1} and 2.0–6.2 mg l^{-1} respectively) except for the 2003, when water of the Bėrė was distinct for heavy pollution (9.4 mg l^{-1}). A higher humus content in the soil and uneven runoff (when its formation is interrupted) determined higher N-NO$_3$ concentrations. Increasing DIN concentrations in silt result in the increased nitrate nitrogen (N-NO$_3$) concentrations in water.

2. TP concentrations contained in the stream water showed particularly significant fluctuations (4–118 μg l^{-1} in the stream G-1 and 16–222 μg l^{-1} in the Bėrė). Concentrations much depended on the precipitation amount, particularly in summer. as well as on phosphorus contained in
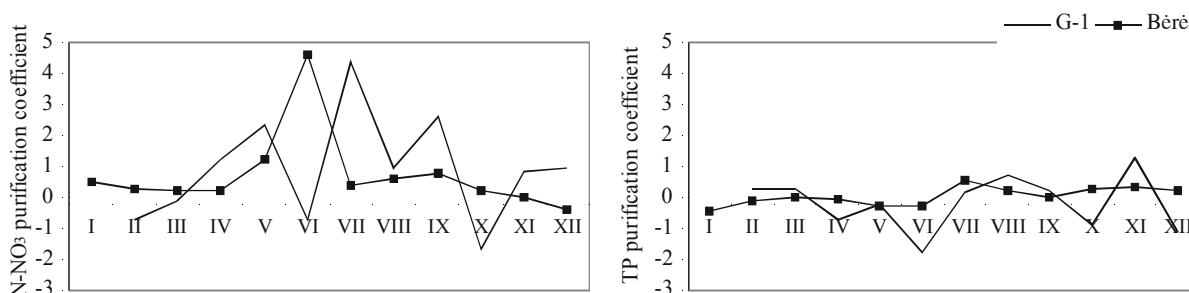
Fig. 4. Changes in the purification coefficient of N-NO$_3$ and TP contained in stream water.

silt: higher P_2O_5 concentrations contained in silt determined lower TP concentrations in water (determination coefficient of the relation $r^2 = 0.24$–0.30).

3. According to the average annual BOD_7 values, water of the streams is considered as clean. Organic matter amount in the stream water much depended on the soil where the stream was flowing (higher BOD_7 value was determined in glacial lacustrine clay soils).

4. N-NO_3 purification coefficient in stream water was higher when the stream was flowing via non-drained wood-covered area, also under the conditions of higher air temperatures (determination coefficient of the relation $r^2 = 0.27$-0.36).

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ACCUMULATION OF SLUDGE DURING THE TREATMENT OF WASTEWATER FROM MILK PROCESSING COMPANIES AND ITS APPLICATION AS A SOIL FERTILIZER

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Abstract

The processing of milk in dairy companies produces a certain amount of wastewater and liquid wastes. During the treatment process of such wastes sludge is accumulated in treatment facilities. The sludge is a rather valuable soil fertilizer; however, apart from plant available nutrients, it also contains large amounts of pollutants. The paper analyzes the quality of wastewater treatment process performed in treatment facilities of dairy companies, and specifies the amounts of plant available nutrients contained in sludge accumulated during the treatment process of wastewater and liquid wastes. The amounts of heavy metals contained in sludge are compared with their maximum allowable concentrations determined in the environmental requirements for soil fertilization (Aplinkosaugos reikalavimai…, 2001).

On the basis of the study results and normative documents of environment protection, the article presents optimal rates and regime for sludge fertilization as well as analyzes the agro-technical and qualitative characteristics of sludge spreaders made at the Water Management Institute of Lithuanian University of Agriculture and used during the technological process of fertilization.
Key words: wastewater, sludge, pollution, treatment efficiency, spreaders.

Introduction

Large amounts of heavily polluted wastewater and liquid wastes are constantly accumulating in milk processing companies in the whole country. These wastewater and liquid wastes are either supplied into municipal treatment facilities, spread over fields as a fertilizer, or are collected into special storage reservoirs. Wastewater and liquid wastes from milk processing companies that are supplied into municipal treatment facilities are usually mixed with industrial and domestic wastewater from municipalities. During the treatment process, different pollutants and sludge are formed. Such kind of sludge is rich in plant available nutrients; when applied on fields, such sludge provides the soil with different organic matter and microelements that enhance significantly the humification processes in soil. However, the sludge also accumulates various harmful pollutants contained in wastewater (e.g., heavy metals). According to the "Nijhius Water Technology" project (the Netherlands), stock company "Rokiškio sūris" has arranged autonomous computer-controlled wastewater treatment facilities where the treatment process of wastewater and liquid wastes is performed in oxidation ponds using flocculants.

The objective of the studies was to evaluate the quality of wastewater treatment in facilities arranged in milk processing companies, to estimate the possibilities of sludge as a fertilizer of soils, to determine the fertilization value and applied rates of the sludge, and to evaluate the agro-technical characteristics of sludge spreaders used for technological soil fertilization process.

Study methodology

Before the new wastewater treatment facilities had been arranged in SC "Rokiškio sūris", different studies were carried out evaluating the possible usage of industrial wastewater and liquid wastes formed during the production process. During the studies the chemical composition of wastewater was analyzed, and the recommendations for possible application of wastewater were approved (Strusevičius…, 1999). Having evaluated the quality of sludge formed during the treatment process of wastewater and liquid wastes in treatment facilities and its suitability for soil fertilization, the analysis of the pollution load contained in wastewater and liquid wastes was made, and the efficiency of their treatment results in the facilities was estimated. The analyses were made in the Chemical Analysis Laboratory of Water Management Institute of Lithuanian University of Agriculture, assessed by the Ministry of Environment of Lithuania (Unifikuoti nuotekų…, 1994) and in Agrochemical Research Center of Lithuanian Institute of Agriculture. Qualitative indices of the sludge accumulated in the treatment facilities of the company and applied for soil fertilization were determined considering the amounts of nutrients and heavy metals contained in the sludge on the basis of LAND 20-2001 requirements (Nuotekų…, 2001). During the treatment process in modern wastewater treatment facilities arranged in the company, water is removed from sludge until the content of dry matter in the sludge reaches only 14.9%. Therefore, when using such kind of sludge for soil fertilization, special requirements for the technological fertilization process are to be considered, including the width of sludge spreading strip, spreading intensity and smooth spreading surface. The fertilization process should also follow the requirements of sludge fertilization rates and sludge spreading quality. Moreover, the removal and spreading processes of sludge should be absolutely innocuous for the environment. Such characteristics were considered when creating the sludge spreaders of the Institute (Trąšų paskleidimo…, 1997).

Study results

Autonomous wastewater treatment facilities arranged in SC "Rokiškio sūris" were started being operated at the end of 2001. Wastewater sewerage network is supplied

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Table 1

Treatment efficiency of wastewater and liquid wastes treated in wastewater treatment facilities of SC "Rokiškio sūris"

Index, mg l^{-1}	Waste-water before treatment	Liquid wastes before treatment	After treatment	Treatment efficiency, %	Waste-water before treatment	Liquid wastes before treatment	After treatment	Treatment efficiency, %
	2002				2003			
BOD$_7$	3010	46260	10.24	99.6	1955	148000	5.77	99.7
SS	837	11368	22	95.29	586	22614	21.63	96.54
N	64.6	1354	0.8	93.11	57.9	2016	2.5	95.93
P	45.6	3502	7.9	84.27	28.5	2880	7.16	78.61
COD	5059	87677	35	99.09	952	168710	37.2	98.78
Fat	89.3	742.3	2.3	95.41	29.8	560	1.2	98.59
pH	5.84	4.7	7.8	2.29	2.63	3.8	7.45	-
Amount, t	375556	786	376342	-	223208	393	223605	-

Note. BOD$_7$ – Biochemical Oxygen Demand, SS – Suspended Solids, COD – Chemical Oxygen Demand, N – Nitrogen, P – Phosphate.

with industrial wastewater – i.e., heavily polluted domestic wastewater from milk processing equipment as well as liquid wastes containing high concentrations of fresh organic lactic acids and pulps. The analysis of the data about the pollution of wastewater and liquid wastes accumulated and treated in the company was made within the period of 2002–2003. Systematic average annual pollution indices of treated wastewater and liquid wastes are given in Table 1.

The wastewater formed during the milk processing in the company contains high concentrations of organic matter. According to BOD$_7$ value, the momentary pollution of industrial wastewater and liquid wastes was fluctuating within the range of 1511 to 7506 mg l^{-1} and 1135 to 148000 mg l^{-1} respectively, during the study period. As the data in Table 1 shows, autonomous treatment facilities ensure rather efficient treatment of wastewater and liquid wastes. During the treatment process the suspended solids accumulating in retention ponds and the sludge accumulating in aerotanks are mineralized in the oxidation reactor. After the mineralization process the sludge is pressed in a special filter until the consistence of paste. The composition and fertilization value of such sludge was disputable there-

fore the studies in three replications were made in the assessed Chemical Analysis Laboratory at Water Management Institute of Lithuanian University of Agriculture. The average values of the study results are given in Table 2.

To evaluate the possibilities of sludge application for soil fertilization, one should be aware of the category the sludge is attributed to, considering the concentration of heavy metals contained in it. Those indices are presented in Figure 1.

When heavy metals concentration exceeds the maximum allowable concentration for category II, such sludge is attributed to category III and cannot be applied for soil fertilization. The data obtained was compared with the maximum allowable environment-friendly concentrations. The comparison results are given in Table 3.

The study results given in Table 2 show that according to N, P, and K concentrations the fertilization value of the sludge is rather high; considering the fertilization characteristics of sludge, this substance is more valuable than slurry that contains up to 5.3 kg N, 2.5 kg P and 5.9 kg K in one ton. As the data in Table 3 shows, the amounts of heavy metals contained in sludge refer that the sludge fully corresponds to the environment protection requirements of cat-

Table 2

Composition and fertilization value of the sludge

Year	Moisture content, %	Mass, kg m^{-3}	N kg ton^{-1}	P kg ton^{-1}	K kg ton^{-1}	Dry matter, %
2002	88.65	1320.0	6.15	2.18	1.35	11.1
2003	85.1	1312.0	6.78	4.31	0.81	14.9

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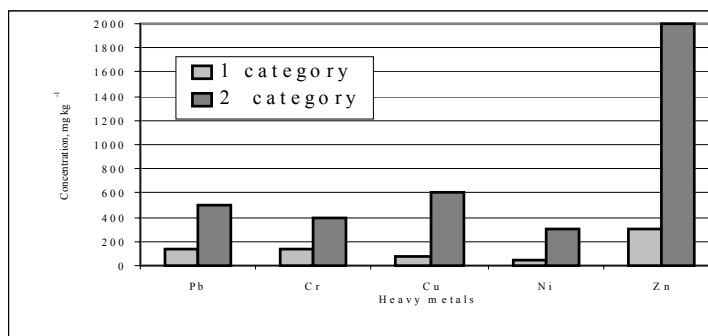
Fig. 1. Sludge categories according to LAND 20-2001.

Table 3

Average concentrations of heavy metals contained in wastewater sludge

Year	Heavy metals, mg kg^{-1}						
	Cd	Cr	Cu	Ni	Pb	Zn	Fe
2002	0.0	26.5	58.0	12.6	12.0	1845	31000
2003	1.0	40.0	32.0	22.4	16.6	336.0	52800
MAC	6.0	400	600	300	500	2000	-

egory II and may be used for soil fertilization considering the determined NPK fertilization rates.

According to all indices, the concentrations of heavy metals contained in wastewater sludge are not very high, except for iron (Fe) and zinc (Zn). Rather high Fe concentration in sludge is determined by wastewater influent into the treatment facilities from Fe-removal facilities. When applying the sludge for soil fertilization, no normative restrictions on Fe input rates are to be followed.

As the study results show, the only Zn load in sludge exceeds the maximum allowable concentration of zinc for the sludge of category I, therefore the sludge that accumulates in wastewater treatment facilities of the company "Rokiškio sūris" is to be attributed to sludge category II. According to LAND 20–2001 requirements (Nuotekų …, 2001), the highest rate of sludge applied in light-textured soils (sand and sandy loam) should not exceed 4 t ha^{-1} of dry matter; in heavy-textured soils the maximum applied rate of sludge should be 5 t ha^{-1} of dry matter. As the study results show, 1 t of sludge contains 111–149 kg of dry matter (Table 2), thus the applied rate of sludge might be 26.8 t per year in light-textured soils and 33.5 t per year in heavy-textured soils. Such soil fertilization rates also correspond to the fertilization rates by NPK amounts. During the implementation of the program determined in the Directive 91/676/EEC approved by the EU Council, the annual N fertilization rates must be reduced to 170 kg/ha^{-1} in the future; thus the highest rate of applied sludge should not exceed 30.2 t ha^{-1}.

During the investigations on the possibilities of sludge application it was determined that pathogenic microorgan-

isms contained in sludge are decomposed after the thermal treatment of sludge, thus the pathogenic sludge pollution does not determine the usage of sludge for the fertilization of soils (Haker, Lackeby…, 2003).

In Lithuania, the production of slurry and wastewater spreaders is not developed enough, and different modern up-to-date spreaders of organic fertilizers are very expensive to obtain as they are produced only in foreign countries. Since 2001, the SC "Rokiškio sūris" has been using sludge spreaders made in our Institute. The lifting capacity of the spreaders is 10 t, they are usually aggregated with tractors of class 3.0 and are used for the spreading of semi-liquid or paste-textured sludge (Steponavičius…, 2004). Considering the requirements of the methodology LST (Trąšų paskleidimo…, 1997; Koenig…, 1994), the agro-technical assessment of the spreaders has been made and possible rates of applied sludge (1–60 t ha^{-1}) as well as optimal working width of the spreaders have been determined. The study results of transverse sludge application are presented in Figure 2.

As Figure 2 shows, the spreaders are spreading the sludge on a 20-m wide strip, while the optimal working width is only 14 m wide (Organinių trąšų…, 1995). The unevenness of spreading in the strip of such width usually does not exceed 10%; longitudinal unevenness usually does not exceed 7.6%. This implies that the spreaders used in the technological process of fertilization are functioning efficiently enough and correspond to all requirements for the environment protection where the permissible spreading unevenness is determined to be no higher than 20%.
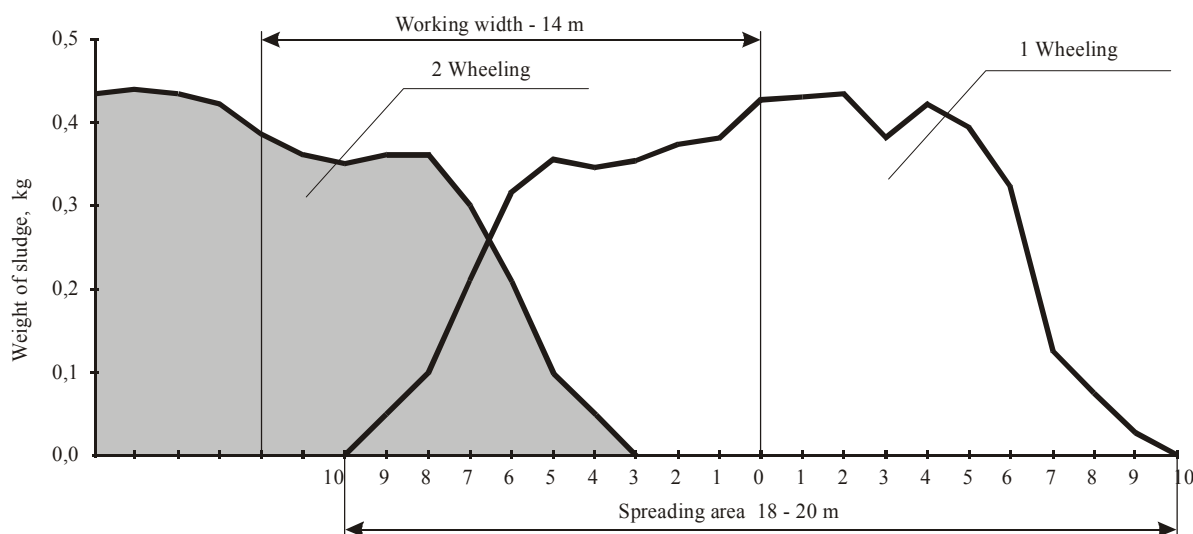
Fig. 2. The weight of sludge (kg) accumulated in 0.25-m^2 measuring tubs during the spreading process.

Conclusions

1. The sludge accumulated during the treatment process of wastewater and liquid wastes in milk processing companies is usually of high fertilization value. One tone of such sludge contains 6.15–6.78 kg of N, 2.13–4.31 kg of P and 0.81–1.35 kg of K.

2. Considering the environment protection requirements for field fertilization according to NPK rates, the applied rate of sludge should not exceed 30.2 t ha^{-1}.

3. As the investigations of sludge spreaders created at the Institute have shown, the optimal working width of spreaders is up to 14 m. In such case the spreading unevenness of sludge within the working width does not exceed 10.0% and the longitudinal unevenness does not exceed 7.6%.

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WASTEWATER PRODUCED ON DAIRY FARMS AND ITS TREATMENT EFFICIENCY IN CONSTRUCTED WETLANDS

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Abstract

The paper presents the results of investigations on wastewater formation and its treatment in constructed wetlands (CW) with horizontal flow. The investigations were carried out on a dairy farm in the period of 1995–2004.

On farmsteads containing cattle sheds, the pollution of wastewater is 2–3 times higher compared with domestic wastewater.

The largest amount of slowly decomposing organic pollutants is retained during wastewater filtration via a septic tank (62.7% according to COD_{Cr}).

During wastewater filtration through a horizontal CW, the amount of retained organic pollutants biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD_{Cr}) is 93.6%.

During wastewater filtration through CW, nutrients (N_{total} and P_{total}) treatment efficiency on the dairy farm, where N_{total} concentration is 101.0 mg l^{-1}, is on the average 61.4% of nutrient load, and 41.4% of P where P_{total} concentration is 21.5 mg l^{-1}.

The analyzed wastewater treatment facilities (septic tank + CW) are distinct for their buffering capabilities. They are effective enough, however due to limited P removal processes in sustainable natural environment, additional P-removal means are to be used in wastewater treatment facilities arranged on dairy farms.

Key words: wastewater, retention of pollutants, septic tank, constructed wetlands.

Introduction

Since 1990, there has been an agricultural shake-up in Lithuania, which resulted in the extinction of a large number of farms constructed in the Soviet period. Cattle-breeding production has moved to new private farms. In 1990, no private dairy farms existed. At the moment there are 410 dairy farms containing 20 to 500 animal units.

While searching for new technological solutions, the Environment Ministry of Lithuania initiated a program of scientific research in 1994. This program was based on the treatment of wastewater in constructed wetlands (CW). The research was carried out in collaboration with scientists from Germany (G. Geller) and Switzerland (U. Schori, Ph. Wyss). This collaboration was of great importance and contributed much into the arrangement of first wastewater treatment facilities of this kind on cattle-breeding farms in 1995.

Wastewater treatment facilities containing plant filters might be constructed using local material workforce therefore their arrangement is not expensive. All geographical zones in Lithuania contain sufficient resources of sand suitable for the construction of sand filters.

When calculating constructional and technological parameters of experimental treatment facilities, the attention was first of all paid on primary wastewater treatment quality and particularly on the reduction of suspended sediment (SS) load, as these are the main factors determining the durability of constructed wetlands. For the primary pretreatment of wastewater, a three-chamber septic tank was selected the design of which was selected considering the industrial rates approved in Germany (DIN 4261). The investigations on the functioning efficiency of constructed wetlands have been carried out for over two decades (Kadlec and Knight, 1996; Geller et al., 1991; Reed et al., 1984; Wyss, 1996; Geller, 1996; Burka 1990).

Constructed wetlands may be of vertical as well as horizontal filtration. Both methods may be applied equally successfully. Vertical filters cover a smaller area and create favorable nitrification environment, however their operation is more expensive. Besides, under climatic conditions of Lithuania, vertical filters may freeze up in winter (when temperatures are sometimes below 30°C). Therefore, CW of horizontal filtration were chosen for the first study objects in the country.

The paper presents the results of the investigations on wastewater formation on a dairy farm and discusses wastewater pollution load and its treatment efficiency in treatment facilities with CW of horizontal filtration.

The main objectives of the study included the analysis of wastewater treatment process when wastewater was flowing via a three-chamber septic tank and CW.

Materials and methods

The pilot object was arranged in intensive karst region in Northern Lithuania (Biržai district) on A. Visockas dairy farm in 1999. The farm (100 milking cows) contains modern Alfa-Laval systems for milking and milk refrigerating. Wastewater from the dwelling house (7 members of the family) and wastewater from dairy equipment rinsing are canalized into a 17 m^3 three-chamber septic tank. After pretreatment in a septic tank, wastewater flows into CW the area of which is 100 m^2 (L=B=10 m). Wastewater enters the filter through distribution pipes arranged on both sides of the septic tank. The principal scheme of wastewater treatment facilities arranged on the farm is given in Figure1.

Natural sand from a quarry was used in the study object. Chemical composition of the sand is as follows: pH 8.9–9.1, organic matter – 0.15–0.32%, Si – 43.7–45.1%, Fe – 0.71–0.99%, Ca – 0.43–0.63%, Mg – 0.11–0.18%, porosity – 34.40%, comparative mass – 2620-2680 kg m^{-3}, sand particles d_{10} – 0.27–0.33 mm, d_{60} – 0.68-0.77 mm ($CU=d_{60}/d_{10}=2.33–2.52$). Sand filtration coefficient is

18.5–20.4 md^{-1}. The distance from wastewater distribution pipe to drainage pipe is 5.0 m.

The investigations on wastewater formation and treatment process on a dairy farm were carried out in the period of 1999-2004. During the study period, wastewater samples were taken for laboratory analysis every month at the following points of wastewater treatment process: wastewater inflow into the septic tank, wastewater treated in chambers 1 and 2 of the septic tank, wastewater outflow from the septic tank, and wastewater outflow from CW. While sampling wastewater the wastewater discharges were measured, too.

Laboratory analysis of wastewater chemical composition was done in the Chemical Analysis Laboratory of Water Management Institute of Lithuanian University of Agriculture. The laboratory is provided with the license approved by the Environment Ministry of the Republic of Lithuania.

The decrease in concentrations of pollutants BOD_7, SS, N_{total} and P_{total}, when wastewater is flowing through each chamber of a septic tank, was calculated by the following equation (Kadlec and Knight, 1996):

$$E = 100(Q_{in}C_{in} - Q_{out}C_{out})/(Q_{in}C_{in}), \qquad (1)$$

where

Q_{in} and Q_{out} – wastewater inflow and outflow, m^{3}d^{-1};
C_{in} and C_{out} – pollutants concentration in wastewater inflow and outflow, mg l^{-1}.

Results and discussion

On A. Visockas dairy farm, the duration of wastewater flow into treatment facilities fluctuated in the range of 2.51 to 3.28 h within a 24-hour period. Maximum momentary wastewater discharges were measured during the washing process of milk refrigerator and other premises (0.91 l s^{-1}). Wastewater non-uniformity coefficients of an hour (C_h^{max}) were changing from 7.38 to 15.48. Wastewater discharge of a 24-hour period (Q_d) measured in different study periods was fluctuating from 1.6 to 3.7 m^3 d^{-1} on the dairy farm.

The study results showed a rather high wastewater pollution load that exceeded the one of domestic wastewater 2–3 times. Similar wastewater pollution load was noticed by other scientists as well (Kern, 1998; Bidlestone et al., 1991).

The average amount of easily decomposed organic pollutants contained in wastewater according to BOD_5 value was determined to be 920.0 mg l^{-1} of O_2 on the dairy farm. The percentage of easily decomposed organic pollutants (BOD_5/COD_{Cr}) was 40.6%. Comparatively high N and P concentrations were determined in wastewater produced on the dairy farm – 135.0 and 30.0 mg l^{-1}. Ammonia nitrogen $N-NH_4$ makes up the largest proportion of pollutants contained in wastewater produced on the farm (71.5%).

Mineral phosphorus $P-PO_4$ makes up the largest amount of total phosphorus contained in wastewater (68.0%).

The decrease in pollutants concentrations was observed when wastewater was flowing successively via a three-chamber septic tank. Having estimated wastewater amount produced on the study object and also considering the storage capacity of the chambers of septic tank, the analysis was made on the change in pollutants concentrations contained in wastewater depending on the duration of wastewater residence in a septic tank, i.e. in chambers 1, 2 and 3 of a septic tank.

Regressive analysis of the data showed rather reliable correlation connections – regression coefficient R^2 fluctuated within the range of 0.79 to 0.90. Wastewater pre-treatment efficiency E% according to BOD_7, SS, N_{total} and P_{total} with respect to the duration of wastewater treatment process in a septic tank t_{sept} is expressed by the following empirical equations:

$$E_{BOD} = 0.487\,t^2_{sep} + 9.35\,t_{sep} + 3.01\ (R^2=0.90); \qquad 2)$$

$$E_{SS} = 0.69\,t^2_{sep} + 13.77\,t_{sep} + 0.70\ (R^2=0.89); \qquad (3)$$

$$E_N = 0.33\,t^2_{sep} + 6.53\,t_{sep} + 3.28\ (R^2=0.79); \qquad (4)$$

$$E_P = 0.30\,t^2_{sep} + 5.98\,t_{sep} + 1.40\ (R^2=0.88); \qquad (5)$$
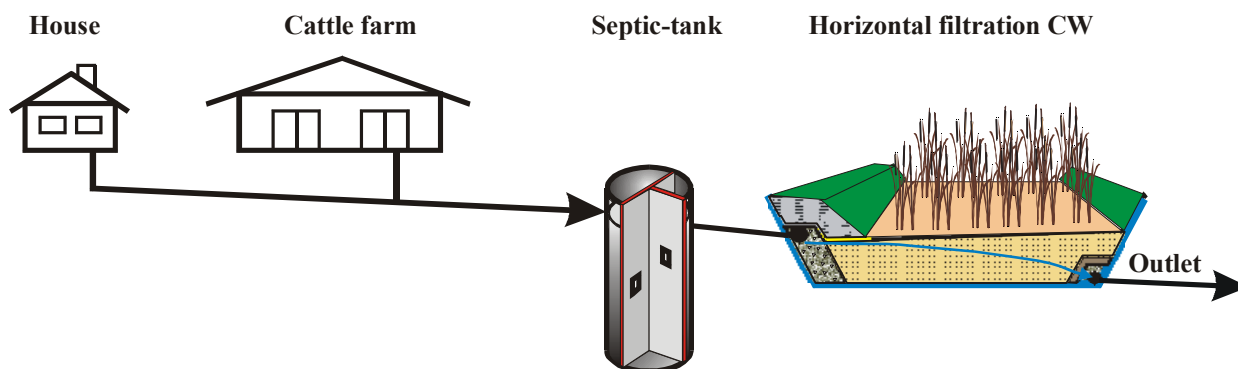
Fig. 1. Technological scheme of the treatment process of wastewater produced on a cattle-breeding farm.

Table 1

Wastewater treatment efficiency on the dairy farm

Investigated wastewater	pH	BOD$_5$	COD$_{Cr}$	N$_{total}$	N-NH$_4$	P$_{total}$	P-PO$_4$	SS
				mg l^{-1}				
1	2	3	4	5	6	7	8	9
Before treatment	6.5±0.12	920±215.0	2266±377.0	135±21.0	96.5±21.4	30.0±5.9	20.4±4.2	480.0±127.8
After treatment in a septic tank	7.0±0.21	452.7±102.0	846.0±127.0	101.0±14.0	70.6±14.6	21.5±4.7	16.9±3.3	172.0±68.0
After treatment in CW	7.26±0.24	28.7±17.8	109.0±21.4	39.2±8.2	28.7±7.7	12.6±2.1	10.6±2.7	18.3±9.4
Treatment efficiency, %: septic tank CW wastewater treatment facilities	+0.5 +0.26 +0.76	50.9 93.6 96.9	62.7 87.2 95.2	25.2 61.4 71.1	26.2 59.3 70.3	28.4 41.4 58.0	17.2 37.3 48.1	64.2 89.3 96.2

Having summarized the results of 6-year studies carried out on the dairy farm it was determined that a septic tank is most capable in retention of SS (64.5% on the average). The retention of organic matter (according to BOD$_5$) is 50.9%, the amounts of retained nutrients (N$_{total}$ and P$_{total}$) are 25.2% and 26.8% respectively. Investigations on wastewater treatment efficiency in CW were performed under the conditions of free wastewater filtration (i.e. without drainage affluent). Summarized data on the investigations carried out on the dairy farm are given in Table 1.

A septic tank is an important device when preparing wastewater for further biological treatment. It stabilizes the pH of wastewater and is capable to retain large amounts of SS and slowly decomposing pollutants COD$_{Cr}$ (64.2% and 62.7% from wastewater on dairy farms). BOD$_5$ amounts are reduced in a septic tank, too. The retention of BOD$_5$ here is 50.9 % respectively.

The wastewater flow gets abated in a chamber of the septic tank. Under the influence of gravitational power, pollutants that are heavier than water deposit on the bottom, while light pollutants are floating on the surface.

The largest amounts of pollutants deposit in the first chamber of the septic tank; here the mineralization process of wastewater under anaerobic conditions occurs.

Decomposition process of organic matter might be expressed as follows:

organic matter + microbes, ferments → fat acids + microbes, ferments → $CH_4 + CO_2H_2$ + alcohols + CO.

The formation process of glucose under anaerobic conditions is as follows:

$$58C_6H_{12}O_6 \rightarrow 62CH_3COOH + 22CH_3CH_2COOH + 16CH_3CH_{12}COOH + 60,5CO_2 + 33,5CH_4 + 27H_2O.$$

The following gas is produced during the fermentation process of organic matter:

methane (CH_4), carbon dioxide (CO_2), sulphuretted hydrogen (H_2S), nitrogen compounds (NH_3, N_2O, N_2).

The decomposition process of fat is rather slow. Affected by different microorganisms and ferments, fat is decomposed into fat acids, which on its turn decomposes into water and carbon dioxide. The mineralization of fiber is also slow. Special construction of the septic tank allows the accumulation of sludge for 2-3 years. The openings (holes) arranged in the walls of the septic tank ensure free flow of wastewater from one chamber of the septic tank into the other. The second and the third chambers of the septic tank contain less amounts of sludge and floating crust on wastewater surface, as here inflowing wastewater is already purified. Further mineralization of fine colloids formed in the first chamber during the decay process of organic matter is observed in the proceeding chambers. Moreover, a certain amount of flocculants moving vertically between the bottom and floating crust gets from the first chamber into the second one. Flocculants are periodically raised from the bottom by gas produced in the sludge. The flocculants are moving vertically through a special hole connecting two adjacent chambers. The flow occurring between the chambers transports moving flocculants into the following chamber. Further treatment of wastewater purified in the septic tank is performed in constructed wetlands (CW) (Strusevičius, 1996).

In CW, wastewater is filtrated through sand media containing roots of wetland vegetation. Here wastewater is purified during different physical, biological and chemical processes. Plants contribute to the treatment process of wastewater indirectly. Plants are to maintain the condition of sand media that would ensure free movement of water. If there were no plants, such filters would easily be clogged. Plants help to maintain filtration qualities of sand. Moreover, they act as a catalyst (i.e. they ooze oxygen and other

materials, such as root excrements) and thus create favorable conditions for vegetation to grow and other living organisms to reproduce and participate in the removal process of different nutrients. It is not enough to optimize only one component (e.g. sand) of the whole system according to one index (e.g. conductivity). Integration of all components is much more than only a sum of separate system parts therefore it needs a thorough estimation. Actually, during the construction of CW certain difficulties occur due to the necessity to coordinate two contradictory requirements: first, sufficient conductivity of media, and second, large area of pore surface (e.g. in the case of clay soil) in order to ensure sufficient space for the reproduction of bacteria and performance of chemical reactions. Sand is to meet hydraulic as well as grain-size composition requirements (Conley, Dick, Lion 1991).

CW are complex systems that are changing in the course of time. For example, bacteria needs some time to adapt to the type of wastewater; plants need the whole year to naturalize their roots into sand media. Despite of this, the systems mentioned start functioning efficiently enough from the onset of their operation.

Reed is the most suitable vegetation cover for such type of treatment systems. Reeds are the only plants the roots of which may reach the layer of 60–100 cm deep. When supplying oxygen into the root layer, reeds ensure efficient treatment process. Due to their growing characteristics, reeds may easily grow through parts of old plant stems (Geller, 1996).

Different aerobic and anaerobic decomposition processes of organic matter are observed inside the filter. Proteins that make up the greatest part of organic matter usually contain a group of amino acids (NH_2) that tends to decompose into ammonia and other compounds (hydrogen, carbon dioxide, etc.) due to different microbes and ferments (Reddy et al., 1980).

Decomposition of cellulose and lignin is perhaps the longest process. With the help of bacteria and fungi, cellulose and lignin are decomposed into secondary organic matter contained in the composition of microorganisms.

During those complex processes, nitrogen and phosphorus are removed. About 10% of nitrogen and phosphorus are used for the development of vegetative biomass; the rest amount of those elements is contained in the biomass of microorganisms or is removed in other ways:

- under aerobic conditions, ammonia along with oxygen make up nitrates and hydrogen (nitrification process);
- under anaerobic conditions, nitrates make compounds with glucose; in the result, nitrogen, carbon

dioxide and water are released (denitrification);
- phosphorus not used by plants and microorganisms makes compounds with Al, Fe, Mn and Ca contained in sand and thus forms dissoluble components (Khalid et al., 1977).

Thus, favorable conditions for the development of plants and microorganisms as well as for occurrence of aerobic and anaerobic processes in constructed wetlands may ensure efficient removal of pollutants.

During the wastewater filtration process via CW, 93.6% of organic pollutants (according to BOD_5 and COD_{Cr}) are retained. Removal of nitrogen contained in wastewater has seasonal tendency (on the average 61.4% of N are removed). Considering the data obtained, the following conclusion can be made: CW is a perfect evaporator of nitrogen compounds, however its elimination capabilities of phosphorus compounds are limited as natural sand contains small amounts of Fe+Ca+Mg (on the average 1.52%).

The results of calculations of CW load with phosphorus show that on pig-breeding farm, when average CW load is 0.22 g m^{-2} d^{-1} of P, 1 m^2 of CW retains on the average 0.2 g m^{-2} d^{-1} of phosphorus. On the dairy farm, where average CW load is 0.43 g m^{-2} d^{-1} of P, 1 m^2 of CW retains the same amount of phosphorus as 1 m^2 of CW on the pig-breeding farm – 0.18 g m^{-2} d^{-1}. The studies performed in Estonia (Mander et al., 2001) show similar results of wastewater treatment efficiency in CW with horizontal filtration (0.22 g m^{-2} d^{-1} of P).

Conclusions

1. On the dairy farm containing modern milking and milk refrigerating equipment, the pollution of wastewater is 2-3 times higher compared with domestic wastewater from a dwelling house.

2. The largest amount of slowly decomposing organic pollutants is retained during wastewater filtration via a septic tank (62.7% according to COD_{Cr}).

3. During wastewater filtration through a horizontal CW, the amounts of retained organic pollutants (BOD_5 and COD_{Cr}) is about 93.6%.

4. During wastewater filtration through CW, nutrients (N_{total} and P_{total}) treatment efficiency is on the average 61.4% of N on the dairy farm, where N_{total} concentration is 101.0 mg l^{-1}, and 41.4% of P where P_{total} concentration is 21.5 mg l^{-1}.

5. The analyzed wastewater treatment facilities (septic tank + CW) are distinct for their buffering capabilities. They are effective enough, however due to limited P removal processes in sustainable natural environment, additional P-removal means are to be used in wastewater treatment facilities arranged on dairy farms.

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THE MODELLING OF REGIONAL ECONOMICAL MANAGEMENT OF LAND RECLAMATION WORKS

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Abstract

According to EU Water Framework Directive, a new model of land reclamation management and financing will be developed. Taking into consideration the high value of state investment required to ensure a steady work of land reclamation systems, it is important to reject the funds allocated on an equality principles and to give preference to the regions where the maintenance, rehabilitation and repair of these structures is more effective. The discussion concerning the allocation of state funds is elaborated in this paper. On the basis of statistical analysis, natural and economical regional differences were evaluated. Four scenarios of the allocation of special subsidies from state budget are submitted for approval. When modelling the financing results based on the regional distribution methodology, the changes in base financing indices are under discussion.
Key words: state subsidies, land reclamation structures, depreciation, financing scenarios, modelling.

Introduction

Considering the regulations of agricultural and rural development strategy, it is necessary to create appropriate means that would ensure the rational development of regional agricultural specialization corresponding to natural conditions (Stanikūnas et al., 2002). Lithuania has sufficient amount of natural resources in its disposition to develop the agricultural industry. Agricultural land covers more than a half (51.6%) of total area of the country (Lietuvos…, 2004); more than 88% from the whole area of agricultural land are drained (Melioruota…, 2004). High land fertility here (on the average 39.1 points) ensures an active and quite rapid integration into the EU market of agricultural production (Buivydaite et al., 1999).

Land reclamation systems installed for water regime control (water discharge network, subsurface drainage systems, surface water collectors and other equipment of hydraulic engineering) play a major role in agro-industrial development in most countries of Eastern Europe. Therefore it is necessary to follow the regulations of the governing policy and monitoring approved in all European countries (Maziliauskas, 1997; 2001).

Some problems of operation and maintenance of land reclamation systems emerged after Lithuania restored its independence in 1990. The land reclamation management was disbanded. As a result, nobody felt responsible for the operation and maintenance of the land reclamation infrastructure anymore. The major cause was the incapability of the State to carry out the necessary reorganisation of the land reclamation management before the land reform was started. Despite the approval, in 2004, of a new Land Reclamation Law that transfers drain laterals and collectors with a diameter of less than 12.5 cm to landowners, the State still remains always responsible for the operation and maintenance of the major part of the land reclamation infrastructure.

In Latvia, the situation was handled differently. At the onset of the land privatisation process in 1991, people received, for free, land reclamation systems that were realised during the soviet period along with their land. The land reclamation systems were divided into three categories according to their use and ownership: state, public and private property. By 1999, about 50% of all land reclamation systems belonged to the landowners (Ministry of Agriculture, 2002).

The Estonian Soil Reclamation Law took effect in 1994. The emergence of private ownership resulted in a need to establish non-governmental associations, which would work jointly to maintain soil reclamation systems. Currently, a total of 43 cooperatives have been established on the basis of drainage basins (FAO, 1998).

In Lithuania, the situation is bizarre and abnormal because private land has two owners: (1) the owner of the plot, and (2) the State as authority for the operation and maintenance of the land reclamation systems. As the landowners are economically weak, they are not interested in taking over the responsibility for the operation and maintenance of drainage systems while the State, as authority, cannot always carry out the necessary maintenance works because of lack of funds. Consequently, many drainage systems covering thousands of hectares deteriorate in Lithuania every year.

Currently, one of the most urgent problems in Lithuania is the condition of land reclamation structures. Maintenance of land reclamation infrastructure may be done properly and on time only when the financing is sufficient, or if the draining areas are reduced (Saulys and Lukianas, 2003). A new Land Reclamation Law was approved only on the 21st of February 2004. It regulates the transfer of land reclamation structures located in a private land plot to the land owners (Lietuvos…, 2004). According to the Law, the greatest part of subsurface drainage has come into the possession of the landowner. This resulted in certain changes in the value of land reclamation structures disposed by the government. The previous financing situation needs to be changed, too. From now on the owners of drained land themselves will have to take care of land reclamation systems located in their land plots and belonging to them by

ownership rights (Smilgevicius, 2004). The regulations of state financial support provided to the owners of drained land for the construction, repair, maintenance and reconstruction of land reclamation structures refer that the share of personal funds should be no less than 15% of total costs required for repair and maintenance works. The whole financing from state budget will be provided only for repair works of drainage collectors with the diameter no less than 12.5 cm.

Currently, active discussions concerning the allocation methodology of state subsidies are being held. This also concerns the water management sector. Further financing of systems, which are really in disrepair from the state budget, is considered as economically inefficient because their operation is not payable. In order to avoid more serious social rural problems that might occur during the implementation of certain changes in the governing and financing of water management sector, the government is going to approve special regulations enhancing people to re-establish natural condition of land in areas non-favourable for the agriculture.

The objective of the studies was to determine the criteria influencing the economical efficiency of the financing of land reclamation activities as well as to prepare new scenarios for the allocation of special subsidies from the state budget.

Methods

The studies were based on the analysis and evaluation of laws and normative acts of laws in water management sector, also on the analysis of present situation in the financing of state land reclamation practice. During the investigations the data from the Statistics Department of Lithuania, State Land Management Institute, Agrarian Institute of Lithuania, Ministry of Environment of Lithuania as well as Agricultural Ministry of Lithuania was used. The data was processed in the method of statistical analysis. The algorithm for the calculations of special subsidies allocated from the state budget was prepared with the help of "MS Excel 2000" program.

Results

The activity of land reclamation is a particularly important part of the infrastructure of agricultural production. On the 1st of January, 2004, total residual value of land reclamation structures was 3 493 113 thousand Lt (Melioruota…, 2004). After the new Land Reclamation Law had been approved, the amount of state and private land reclamation structures were distributed into much the same parts: about 50.1% of land reclamation structures is still possessed by the state (residual value 1 751 309 thousand Lt), about 49.9% of it is transferred to land owners (residual value 1 741 804 thousand Lt). Until the year 2005, special state budget subsidies for land reclamation sector were mainly allocated considering the area of drained land in municipalities. Having transferred a part of drainage network to private land owners, the part of state land reclamation structures has been

distributed among the municipalities unequally: from less than 30% to more than 80% therefore the former financing order is no more acceptable.

Statistical estimation shows a strong relationship between subsidies allocated for land reclamation activities (maintenance, repair and reconstruction) (S_{rec}) and the area of drained land (A) in municipalities as well as residual value (V_r) of land reclamation structures:

$$S_{rec} = 12.88\,A + 79.73, r = 0.98, \qquad (1)$$

$$S_{rec} = 11.01\,V_r + 60.62, r = 0.92. \qquad (2)$$

Considering that longer lifetime of land reclamation structures determines higher possibility of their failures (correlation coefficient $r = 0.94$) (Bastiene, 2002), the base financing for land reclamation activities should depend on their residual value.

Inequality in regional income of agricultural subjects determines different possibilities for the establishment of competitive farms. According to the data collected by the Lithuanian Institute of Agrarian Economics, marketable plant growing is payable only in regions where agricultural land productivity exceeds the mean value of the whole country (39.1 points) (Lietuvos…, 2001). Depending on land productivity, the income from crop cultivation differs 3.5 times (calculating for 1 ha of agricultural land areas) while comparing common income of farmers possessing the rich and the poor soils, it was determined that their income differs 1.5 times.

Statistical estimation shows a strong dependence of the income of farms from crop cultivation on the land productivity:

$$I_{crop} = 35.01\,B - 729.96, r = 0.98. \qquad (3)$$

However, as mentioned above, the land productivity much depends on the water regime control (draining or irrigation structures). Thus, when creating the means for rational development of regional agricultural activities, the financing for state land reclamation structures should be adjusted in respect of the fact how much those means grade up land productivity. Due to the non-homogeneous composition of topsoil layer the draining efficiency in all territories is different. For example, in Šalčininkai municipality, drainage grades up the land fertility by 7.2 points, while in Pakruojis municipality land upgraded with the highest number of 21.4 extra points after draining. *Cambisols* prevailing in Middle Lithuania are particularly fertile: here soil fertility index is more than 50 points (this evaluation includes the increased soil fertility due to land draining). Thus, the region of Middle Lithuania is obviously superior from the point of view of other regions of the country (Fig. 1).

Analysing the rural development tendencies of the last years it will be observed, that the area of unused agricultural land is constantly increasing (Lietuvos…, 2002). The
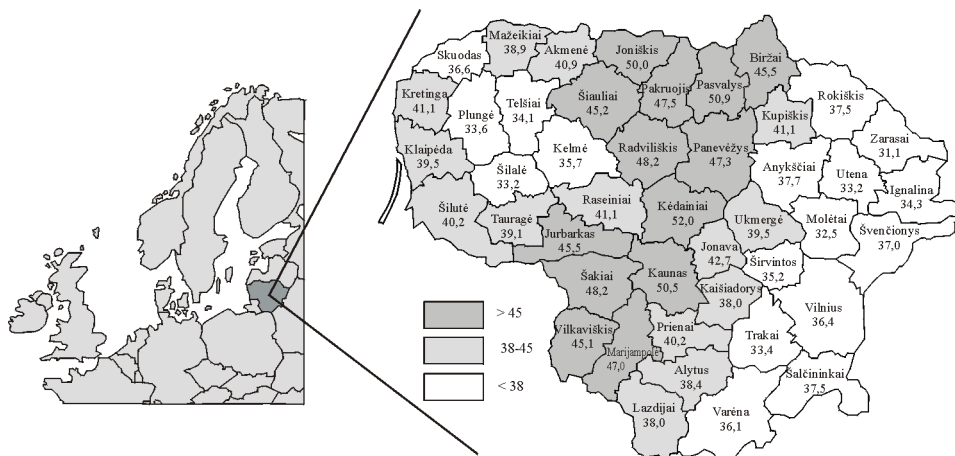
Fig. 1. Soil fertility of the various districts of Lithuania.

area of derelict land makes up only 0.2–0.8% in the Middle region, while in Eastern region it reaches 14.1–17.9%. By the methods of mathematical analysis and statistical grouping, Gurskiene has determined that in Middle Lithuania with rich soils there are relatively more economy subjects (Gurskiene, 2000). The increasing value of the average productivity point of agricultural land determines the decrease in the number of farmers not using their land by the linear equation ($N_\% = 14.47 - 0.24\ B$). This implies that the increasing productivity of agricultural land areas results in less amount of derelict or wasteland. Natural investigations of the changes in the amount of derelict land and average land productivity points in cadastre vicinities of Middle Lithuania region were carried out by Brusokaite-Stravinskiene, too (Brusokaite-Stravinskiene, 2002). As the researcher has determined, decreasing land productivity points result in expanding area of derelict land by the exponential equation (r = 0.95). Analogous dependence (r = 0.62) is obtained in the whole country having analysed the data collected by Palciauskaite, a researcher of the National Land Management Institute. The comparison of both equations shows that in municipalities where the productivity of agricultural land areas exceeds the mean value of the country, better land tends to become derelict compared to the areas where land productivity is lower. This often depends on economical reasons: in productive land areas the profit of farms is relatively low for the meantime, while in regions where poor soils are prevailing the agricultural activity is unprofitable.

Changes in derelict land area (A_{der}) in the Middle Lithuania region in respect of land productivity points (B):

$$A_{der} = 5\ 182.5\ e^{-0.14\ B},\qquad(4)$$

and the whole country:

$$A_{der} = 236.2\ e^{-0.11\ B}.\qquad(5)$$

Brusokaite-Stravinskiene distinguishes two groups of

reasons determining the occurrence of derelict arable land: (1) low farming, unfavourable farming structures and fragmentation of land plots; (2) failures of land reclamation structures. According to the author's study results, land areas of the first group make up 92.2%, those of the second group cover only 7.8%. Naturally, under the conditions of intensive farming, land reclamation systems located in high-productivity arable land areas are being repaired as soon as possible. On the other hand, drainage failures most often occur in derelict land areas (Bastiene, 2002). Considering the fact that it is not economically feasible to allocate funds for the maintenance of land reclamation structures located in derelict land areas, the area of derelict land plots in municipalities should be regarded as one of the evaluation criteria when allocating the budget subsidies for land reclamation activities.

On the base of the analysis results, special state budget subsidies for land reclamation sector are suggested being allocated considering the residual value of state-owned land reclamation structures located in the territories of municipalities, and adjusting them according to the increased land productivity point due to water regime control and the area of derelict land plots. As the practical studies have shown, about 2% of special state subsidies should be allocated to the repair and reconstruction of pumping stations arranged in polders. Those funds would be distributed according to the applications of municipalities, while the rest part of subsidies (about 98%) would be given to the maintenance, repair and reconstruction of land reclamation structures.

Four possible scenarios of the allocation of special state budget subsidies for land reclamation sector are distinguished:

scenario (I) State budget subsidies for land reclamation sector allocated considering the residual value and depreciation of state-owned land reclamation structures located in the territories of municipalities (base financing –($F_{(I)_i}$);

scenario (II) Base financing adjusted according to the increased land productivity point due to water regime control ($F_{(II)_i}$);

scenario (III) Base financing adjusted according to the area of derelict land located in municipalities ($F_{(III)_i}$);

scenario (IV) Base financing adjusted according to both criteria (increased land productivity point due to water regime control and the area of derelict land located in municipalities – $F_{(IV)_i}$).

According to the scenario (I), state budget subsidies for land reclamation sector for different municipalities are calculated and allocated by the following equation: ,

$$F_{(I)_i} = k_{V_i} \cdot S_{rec} \qquad (6)$$

where

$F_{(I)_i}$ – state budget subsidies (base financing) for the ith municipality, thousand Lt;

S_{rec} – special state budget subsidies for the maintenance, repair and reconstruction of land reclamation structures;

k_{V_i} – coefficient assessing the residual value and deprecition of land reclamation structures in the ith municipality. The coefficient is calculated by the following equation:

$$k_{V_i} = \frac{V_{r_i} \frac{D_i}{100 - D_i}}{\sum\limits_{i=1}^{n} V_{r_i} \frac{D_i}{100 - D_i}} , \qquad (7)$$

where

V_{r_i} – residual value of state land reclamation structures located in the ith municipality;

D_i – depreciation of land reclamation structures located in the ith municipality in percent.

According to the scenario (II), state subsidies for the municipalities are calculated by the following equation:

$$F_{(II)_i} = \frac{k_{B_i} F_{(I)_i}}{\sum\limits_{i=1}^{n} k_{B_i} F_{(I)_i}} \cdot S_{rec} , \qquad (8)$$

where

k_{B_i} – coefficient assessing the increased land productivity point due to water regime control in the ith municipality. The coefficient is calculated by the following equation:

$$k_{B_i} = \frac{B_{rec_i}}{\sum\limits_{i=1}^{n} B_{rec_i}} \sum\limits_{i=1}^{n} F_{(I)_i} , \qquad (9)$$

where

B_{rec_i} – increased land productivity point due to water regime control in the ith municipality.

According to the scenario (III), adjusted subsidies for the ith municipality are calculated by the following equation:

$$F_{(III)_i} = \frac{k_{A_i} F_{(I)_i}}{\sum\limits_{i=1}^{n} k_{A_i} F_{(I)_i}} \cdot S_{rec} , \qquad (10)$$

where

k_{A_i} – coefficient assessing derelict land areas in the ith municipality. The coefficient is calculated by the following equation:

$$k_{A_i} = \left(\overline{A}_{der_i} - \frac{\frac{A_{der_i}}{A_{ag_i}}}{\overline{A}_{der_i}} \right)^{2.5} \qquad (11)$$

where

A_{der_i} – area of derelict land in the ith municipality, ha;

A_{ag_i} – area of agricultural land in the ith municipality, ha;

$\overline{A}_{der_i}$ – mean value of derelict land area in the country, ha.

When allocating the funds according to scenario (IV), a certain part of base subsidies is adjusted considering the increased land productivity points due to water regime control, the other part of subsidies is regulated on the basis of derelict land areas in municipalities. In this case adjusted state budget subsidies for the ith municipality will be the sum of the above-mentioned values of the equations (8) and (10):

$$F_{(IV)_i} = F_{(II)_i} + F_{(III)_i} . \qquad (12)$$

On the basis of the given algorithm, a special calculation program "MS Excel 2000" has been created for the calculation of all possible variants of the adjustment of state subsidies. When calculating according to scenario (II), regions where land productivity grades up to 10 points due to water regime control would obtain 30–50% lower state budget subsidies; while regions where land productivity rises by 18–21 points would get higher subsidies (125–145%). When calculating to scenario (III), the state subsidies are reduced when derelict land areas in the municipality exceed the average value of the whole country (about 3.8%); when derelict land areas are less than the mean value of the country, the financing is increased.

When taking into consideration natural and economic conditions in different regions of the country, special state budget subsidies for land reclamation sector are recommended to be allocated according to scenario (IV). Here several financing variants may be applied, depending on which part of subsidies is re-allocated due to increased land productivity point (B_{rec_i}) and which part is allocated considering derelict land area (A_{der_i}).

It should be noted that there might be a great deal of transitional variants between financing scenarios (II) and (III). Having modelled the results of financing of land reclamation activities in different regions according to the given methodology, the amount of subsidies for any selected variant may be calculated. The adjustment of base financing according to the single scenario (II) results in the

Fig. 2. Regional distribution of base financing index when modelling scenario IV b.

changes of base financing index from 0.6 to 1.4, i.e. the funds are re-allocated only by 40%.

Similar adjustment of allocated state funds would increase the base financing index up to 1.39 for the municipalities in Middle Lithuania region where water regime control is particularly important (due to water regime control land productivity here grades up to 20 points). For the municipalities where water regime control is less significant (land productivity grades up to only 10 points) the base financing index is only 0.65, which means that base financing would be reduced by about 35%. These regulations most affected the municipalities of Eastern Lithuania region, also municipalities in Zemaiciai Highland where base financing index reaches 0.77. Naturally, in the vicinities with medium importance of water regime control (where land productivity grades up by about 1.4 points) the impact of the adjustment of base financing is minimal (±3%).

As Figure 2 shows, during the modelling of the financing of regions according to scenario (III), in one case when water regime control is significant and derelict land area makes up 0.25%, the base financing index may increase up to 1.44; or it may decrease to 0.87 if the area of derelict land expanded to 5%. Such changes in derelict land area would reduce the allocated subsidies by 60%. In the other case, when water regime control is less significant and the area of derelict land makes up more than 7.5–10%, the base financing index would decrease to 0.40–0.58%. In order the base financing would not be reduced, the area of derelict agricultural land should not exceed 3.6%.

When modelling the financing according to scenario (IV), both factors are considered with making no priority of any of them. For example, in a certain group of municipalities with less importance of water regime control, the base financing index is 0.65 according to scenario (II), and

0.42 according to scenario (III) (when derelict land area makes up 10%). Having applied scenario (IV), the base financing index would be 0.54. If in this case the area of derelict land made up only 2.5%, then the financing index would be 1.14 according to scenario (III) and 0.89 according to scenario (IV). Figure 5 shows the base financing index of regions when scenario (IV b) is applied (50% due to increased land productivity point and 50% considering derelict land area). The area of derelict land in municipalities is calculated on the basis of the data of 2003.

Conclusions

Differences in the income of agricultural subjects of various regions depend on natural and economic factors. Having created the possibilities for rational agricultural development in different regions, the state budget subsidies allocated for state land reclamation structures should be regulated considering the criteria that estimate the increased land productivity point due to water regime control, as well as considering the area of derelict land in municipalities.

New methodology of the allocation of special state budget subsidies for land reclamation activities has been developed and the algorithm for the calculation has been created. Having applied the methodology suggested, the base financing index would increase up to 1.39 in the region of Middle Lithuania where water regime control is of great importance. In regions of Eastern Lithuania and Žemaičiai Highland where water regime control is less significant, the base financing would be reduced by about 35%. For municipalities where water regime control is of medium importance (land productivity grades up by about 14.5 points) the adjustment of the base financing has minimal impact, and the base financing index is changing only by ±3%.

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INVESTIGATION AND EVALUATION OF THE STATE OF PROTECTIVE BELTS AND INFLOW OF EROSION PRODUCTS INTO DRAINAGE CHANNELS

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Abstract

As the results of the studies on the condition of protective belts of drainage channels (PB) have shown, due to improperly maintained and mechanically damaged protective belts large amounts of erosion products contained in surface water inflows the channel bed. Disorderly condition of protective belts does not correspond to the requirements of environment protection. Mechanical damages are often related to unsustainable human activity in the adjacent zone of a drainage channel. According to the principles of the type of soil occurrence in the channel bed, four groups of damages might be distinguished: soil entrance into the channel during the tillage of a protective belt; inflow of washout products from the basin; scours of protective belts and washout of turf flumes of surface water discharge. The most frequent damages enhancing the washout of flumes and inflow of erosion products are total or partial tillage of the protective belt of a drainage channel. From the point of view of erosion process, the inflow of erosion products from the basin is considered as the most dangerous damage, which is inevitable when the width of a protective belt is insufficient, particularly in places with deep turf flumes arranged.
Key words: siltation of channels, mud accumulation, protective zones.

Introduction

Even in the middle of the last century, when lots of land reclamation systems were arranged, many problems related to the deformation and siltation of operated channels occurred (Šileika, 1961). The studies on the resistance and failures of drainage network have shown that one of the main factors affecting the changes mentioned include surface water inflow from outside. When solving this problem, suitable flumes were suggested to be arranged and slopes needed to be strengthened in order not to be eroded by water. The importance of protective belts (PB) of channels from the siltation as well as ecological points of view was taken into consideration only since 1974 (Jaceris, 1986). For this purpose, until 1980 the limits of protective belts of channels and water bodies were indicated in plans of farms; in 1975–1980 the effectiveness of those protective belts was investigated and recommendations were prepared at the Lithuanian Hydraulic Engineering and Land Reclamation Research Institute and Geography Department of Lithuanian Science Academy. In 1982, the regulations of the formation and maintenance of protective belts of water bodies were confirmed (Vandens ..., 1982). In the regulations mentioned it is specified that the width of a protective belt near a regulated stream with the basin area of 10 km² (when the coastal strip at an angle is up to 5°) should be no less than 1 m. When the slope of a channel or the area of a basin is larger than the values mentioned, the protective belt was expanded to 2.5 m or 5 m respectively. The regulations also specify that in the territory of a protective belt the land tillage, turf destruction or cattle pasturage are forbidden. In the latest regulations (Valstybės ..., 2001) the width of PB of a channel is indicated the same, only the possibility of its expansion is excluded. PB of channels with the width mentioned are found in most (about 80%) of all channels and regulated streams (Jablonskis, 2001). From the functional point of view, the nearby part of a channel is necessary for

machinery to move during the mechanized maintenance of channels, while the PB of channels are necessary for the retention of erosion products inflow together with surface water from adjacent areas. Coarse particles of erosion products contribute to the formation of a sediment layer on the channel bed; chemical substances enhance the eutrophication of water bodies. Moreover, those materials induce the overgrowth of a channel bed and thus increase the water flow resistance. PB of a channel, as the final barrier for the retention of water erosion products, are particularly important in channel stretches nearby which there are cultivated and plots located with the surface slope towards the channel. In the case of unsatisfactory condition of protective belts, soil particles may be transported into the channel bed during the snow thaw period or heavy rainfalls.

PB are able to retain water erosion products washed from adjacent fields during water flow and purification processes via the vegetation of a protective belt. As Račinskas (1983) has determined, a 1-m wide protective belt of channel overgrown with grass vegetation may decelerate slow or moderate water inflow by 49.3% and may retain 82.4% of all deposits (in the case of strong water flow the values are 20.1% and 66.4% respectively). Chemical compounds concentrations contained in water do not change irrespective of water flow velocity. From the point of view of erosion process, the author mentioned above has estimated in his works the significance of the basin area determining the surface water quantity in a certain interval of the adjacent zone of channels during the period of floods or heavy rains, as well as the effect of the relief on water flow velocities and soil resistance to washout process. Moreover, on the basis of the susceptibility to sedimentation of the protective belts, the author has substantiated rational width of protective belts. Therefore, PB of channels are to be properly maintained in order to retain as many erosion products as possible and thus to reduce the siltation of channels.

The objective of the study was to estimate the condition of protective belts of channels and to determine their interrelation with inflow of erosion products into drainage channels.

Program and methodology

In 2000–2003, expeditionary studies were carried out in Kёdainiai, Raseiniai and Kaunas districts. In the territory of 2076 km², 60 random squares with the area of 1 km² each were selected and framed with lines of coordinate network in the map with the scale of 1:50000 (Fig. 1).
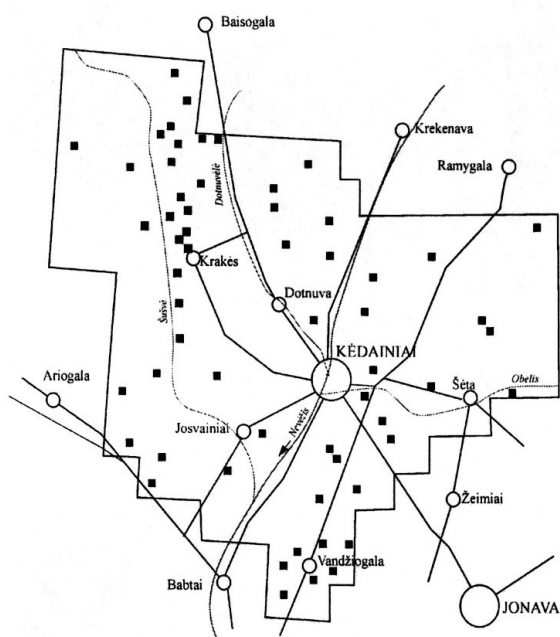
Fig. 1. Scheme of the location of random squares.

Using tables of random numbers, five stretches of channels with the length of 100 m each were selected in each separate square (in the map with the scale 1:10000 the stretches were also selected randomly).

During the studies the width of PB of channel and its comparative altitude in respect of the nearby field were measured in all stretches under investigation. Moreover, the purpose of land use plots located in the adjacent zone of channels was determined, human activity, water erosion outcomes as well as mechanical damages of PB of channel were estimated. The outcomes of surface water erosion process were estimated according to the washout in the basin as well as in PB of channel, or considering the amount of soil washed onto a channel slope or in a channel bed. The studies also included the evaluation of the dimensions of all mechanical damages observed in PB of channel. The condition of surface water discharge flumes was also estimated, as well as their width and depth in the spot where PB of channel joins the channel slope. In order to obtain obvious and unchanged results of erosion and different damages, the study data was collected during the flood period early in spring (before the growth of grass) and before the snowfall period in autumn. In all, 600 stretches of the PB with the total length of 60 km have been studied. Over half of those stretches are the adjacent zones of channels arranged in cultivated land areas (Table 1).

Table 1

Distribution of studied PB in respect of the type of land use

Type of land use	Studied trench slopes	
	Amount	%
Cultivated land	320	53.3
Grassland and pastures	157	26.2
Waste land	58	9.7
Forest	30	5
Local roads	35	5.8
Total	600	100

Results and discussion

Having analyzed the data on PB condition, it was determined that all damages caused by water erosion and anthropogenic processes that enhanced soil occurrence in channels are observed only in those channel stretches the protective belt of which have boundaries with areas of cultivated land. It was determined that soil particles appeared in channels mostly due to the damages caused by improper human activity nearby the channels and effects of water erosion process. According to the type of soil occurrence in channels, damages might be divided into four groups: entrance of topsoil ground particles into the channel during the tillage of PB; wash products from the basin; scour process of PB; and washout of turf flumes of surface water discharge (Table 2).

Table 2

Frequency of damages of PB and erosion cases and extent in cultivated land areas

Type of damage	Number of damages		Amount of eroded soil		Amount of soil (m³) for 1 case
	unit	%	m³	%	
Tillage of PB	36	54.5	69	43.8	1.9
Washout of channel basins	15	22.7	62.3	39.5	4.1
Scours of PB	12	18.2	20.9	13.3	1.7
Washout of flumes	3	4.6	5.4	3.4	1.8
Total	66	100	158.6	100	2.4

Table 3

Parameters of PB with damages observed

Type of damage	Number of damages	Geometric parameters of trench slopes					
		Width, b (m)			Height, h (cm) in respect of the field		
		$b \pm SE$	b_{maks}	b_{min}	$h \pm SE$	h_{maks}	h_{min}
Tillage of PB	36	0.15 ± 0.056	0.45	0	$+2.1 \pm 1.6$	+30	-18
Washout of channel basins	15	0.65 ± 0.45	9.5	0	-7.6 ± 1.6	+20	-18
Scours of PB	12	1.91 ± 0.65	4	0	$+2.1 \pm 3.7$	+20	0
Washout of flumes	3	1.82 ± 0.51	3	0.5	$+16 \pm 7$	+35	0

Note: abbreviation SE – standard error.

Having analyzed the reasons of the entrance of erosion products into drainage channels there was determined a particular effect made by the geometric parameters of a protective belt on different kinds of damages and their quantitative indices (Table 3).

More than a half of all damages observed are related to improper human activity nearby the channel when the whole PB or a part of it is tilled up. As the study results have shown, the ground of topsoil layer gets into the channel only when the whole PB of a channel is ploughed up and furrows are turned towards the channel. Seven cases of damages were observed when the remains of topsoil ground were found on the channel slope and the width of PB in those places of channel stretches reached from 0.15 m to 0.45 m. When PB is tilled for the first time, the topsoil layer thrown with the turf on the channel slope does not fall to pieces immediately; as the study results have show, affected by different outside factors (rain, wind, sunshine, cold) it is decreasing until the grass overgrows it completely. When PB is tilled not for the first time, the topsoil layer that gets on the slope falls to pieces and the greatest part of it gets into the channel bed immediately. In the stretches where PB is tilled from the side of the channel (6 cases of damages), no signs of the entrance of topsoil layer into the channel were observed; however, it was noticed that a furrow is left nearby the channel slope, i.e. a depression is formed equal to the depth of a topsoil layer. Later, after the cultivation, this depression is partially filled up. However, such cultivated 1–0.5–m wide stretch of the adjacent zone of channel has a 1–1.5 degree inclination towards the channel, thus here favorable conditions for water erosion processes are formed. Apart from the tillage cases specified in Table 2, 43 stretches were found with PB less than 1 m wide; however, no entrance of erosion products into the channel was observed.

The second kind of damages according to the frequency and the amount of eroded soil is considered to be washout from basin area (Table 2). This kind of damages may result in the siltation of channels; the amount of eroded ground for such damages is twice as large as for other kinds of damages. Such damages are observed only in winter crop fields during floods after snow thaw period in

spring and in land plots ploughed in autumn. It was determined that the cases of washout from the basin are more frequent in the stretches of channels where PB is fully cultivated (Fig. 2), or its surface level is lower than that of a nearby field (Fig. 3). However, eroded washout amounts, compared to the average values (4.1 m³), are lowest: on the average one washout gets about 1 m³ of soil (Table 4), often washed from the nearby areas of the channel that are situated at the distance of no more than 24 m.

Increased width of PB results in less number of erosion-related damages that tend to become occasional. However, the amount of washout products for one damage case is much larger (on the average 10 m³). When studying the conditions of soil occurrence in the channel, three principal interrelated factors were determined to be essential for the extent of erosion: relief of cultivated field, dimensions of PB and its elements, and soil resistance to washout process. The relief determines the amount of water accumulated during the snow thaw period; water flow velocity and its destructive power depend on the inclination degree of soil surface of the cultivated field. In all cases the

$$n = 1.74b^{-0.48}$$
$$R^2 = 0.72$$
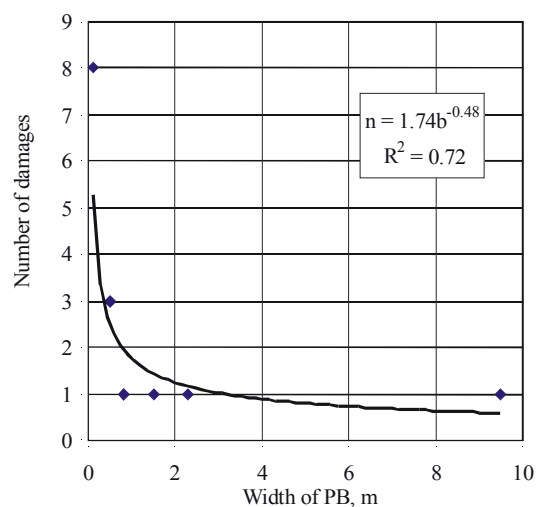
Fig. 2. Dependence of types of erosion in the basin on the width of PB.
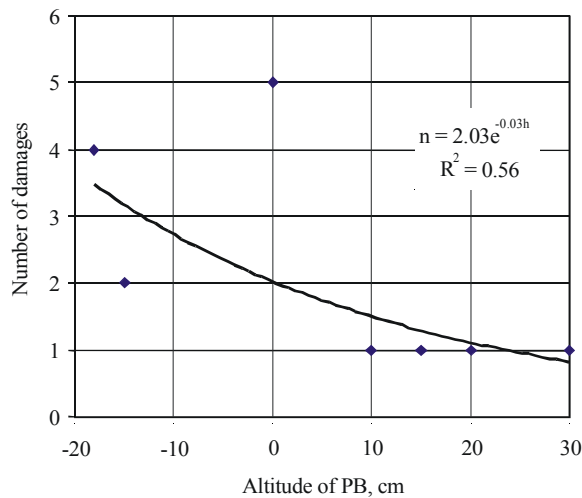
Fig. 3. Effect of the altitude of PB on the frequency of erosion
cases in respect of the field.

soil was washed from hollows with a certain inclination towards the channel. In two cases the erosion process might have been enhanced by increased inclination degree due to deep turf flumes (0.55 and 0.8 m deep). In the first case, when 24 m³ of peat soil was washed, the width of PB was only 0.8 m, which indicates that the greatest part of the flume was ploughed up. In the second case (15.1 m³ of sandy loam soil was eroded), the washed flume was nearly 5 m long and 4.3 m wide. The profile of the washout flume (width and depth) corresponded to the profile of the ravine washed during previous snow thaw periods; therefore it is possible that the erosion process has started from a flume that was too deep. Vertical edge (0.7 m high) at the end of the washout flume indicates that the profile of the channel was being formed not only by water inflow from the basin (as it was in the first case) but by the changes in water flow, which tends to the destruction of sandy loam soil at the lower part of the ravine. When studying the condition of PB it was noticed that most of turf flumes (58 cases out of 81) were too deep (0.5–0.8 m deep) and might have caused the erosion under certain circumstances. Those flumes

were arranged 40–50 years ago having excavated the channels; considering the requirements of that time, the depth of flumes was not limited (Katkevičius, 1973). Following the work technology, flumes were mostly excavated with the help of bulldozers, and the start point of the flume was at about 3–4 m away from the side of the channel.

The third largest washout (9 m³) in the basin is specific for the erosion process that occurred during the spring flood of the study period (18.03.2003) the changes of which were thoroughly observed. Due to a beaver dam existing farther away in the channel and ice accumulated in it, not only the channel with its 1.5 m wide protective belt was flooded, but also a 2.5 m wide strip of winter crop field. As it was observed, the velocity of surface water inflow from basin saturated with sediment is significantly decreasing as soon as the water flow reaches the flooded area. After the abatement of channel affluent, the balance of soil washed out of the basin into the channel was estimated. It was determined that 2.9 m³ of the total 9 m³ of light loam soil washed from winter crop field settled down in the strip of winter crops; 1.9 m³ of soil accumulated in the zone of protective belt, the rest amount of soil (4.2 m³ or 46.6% of its total amount) accumulated in the channel bed. Thus, due to decreased flow velocity more than a half of sediments (53.4%) accumulated in the flood area and did not enter the channel bed. If PB and the areas of winter crops were not flooded, it is possible that the whole amount of soil eroded from the basin (in the case if PB is at the same surface level as the field) would be washed with water flow straight into the channel bed, as it was observed in two previous cases.

Accumulation of erosion products of the basin into channels also depends on the type of soil prevailing (whether the soil is organic or inorganic) (Table 5).

The third damage according to the frequency and amount of eroded soil (Table 2) is scours of protective belt. Unlike the washout in the basin area, scours were formed a year or several years ago. However, scours also occur as a result of surface water inflow from the basin, when water flow washes out the soil in lower places of PB that are more susceptible to damages. It was determined that in half of all 12 cases, PB was at the same level as the field; in all the

Table 4

Extent of erosion in respect of the width of protective belts of trench slopes

Width (b) of PB, m	Type of erosion		Extent of erosion		Average altitude of PB, cm
	Number	%	m³	For one damage	
b=0	8	53	6.7	0.83	-13.1
0.5≥b>0	3	20	3.7	1.23	5.1
1≥b>0.5	1	7	24	24	0
2≥b>1	1	7	9	9	29
b>2	2	13	17.8	8.9	5
Total	15	100	61.2	4.08	

Table 5

Distribution of soils eroded from the basin according to their type

Type of soil	Number of damages	Total amount, m^3	Amount of 1m^3 for 1 case of erosion
Peat	6	29.1	4.9
Sandy loam	4	17.4	4.4
Sand	2	2.0	1.0
Light loam	2	10.0	5.0
Loam	1	2.6	2.6

rest cases PB was about 10 cm above the field and its average width was 1.9 m (Table 3). During the studies it was observed that most often scours occur at the joining point of PB and the slope where the erosion process is mutual due to poor vegetation and downward water flow (i.e. the length of scour is increasing on the slope as well as in PB (6 cases)). The soil of scours is rather different, it does not depend on the type of soils: most intensive washout process was observed in sandy loam (10.1 m^3, 4 cases) and loam (9.73 m^3, 6 cases) soils; in light loam and sandy soils the washout was less intensive (1 m^3, 1 case each).

From the extent of erosion as well as the number of its cases, the washout of turf flumes is less dangerous. Only three turf flumes out of 81 case were found to be washed out (Table 2); on the average 1.8 m^3 of washed soil for each separate washout. It was determined that sandy loam soils were prevailing in the vicinity of all three washout cases of flumes; the width of PB were 1, 0.5 and 1.6 m respectively; the depth of flumes were 0.8, 0.6 and 0.4 m respectively. In the first two cases hollows were noticed (0.35 and 0.46 m deep) in the cultivated land nearby the flumes; therefore, it is assumed that a certain part of flumes has been ploughed up, and the surface water flow of flood has washed out the topsoil layer as well as the flumes.

The summarized study results show that erosion products have accumulated in channels due to the following reasons:

1) due to the ignorance or misunderstanding, land users tend to plough up the PB, or leave it too narrow;
2) too deep turf flumes for surface water discharge, when the width of PB is insufficient, which may create favorable conditions for the accumulation of erosion products from the basin;
3) the scours of PB may appear due to the absence of flumes for surface water discharge.

According to the existing requirements, arranging turf flumes there must be a certain inclination in the PB and a 30 cm deep hollow at the side of the channel (Melioracijos …, 1998). When surface water flows through the flumes of such construction, flow velocity remains stable, it does not decrease and sediment does not settle down in the channel bed. However (as one analyzed case of basin erosion has showed) before the surface water enters the channel, wash load might be at least partially removed. This is particularly important from the environment protection point of view; as the analysis results obtained by Račinskas (1990) show, sediment contains much higher nutrient concentrations (nitrogen, phosphorus and potassium) (up to 90–95%) than the inflow surface water itself. To retain sediments (Balsevičius, 1968), it is suggested to arrange flumes along the PB. Proper construction of flumes is essential from the functional point of view of a channel, as most of the existing turf flumes are too deep and impede the efficient fulfillment of mechanized channel maintenance works.

Conclusions

1. The studies have determined that field erosion (wash) products have entered the channels only in the stretches the PB of which has boundaries with the areas of cultivated land.

2. It was determined that soil has accumulated in the channel bed due to the following reasons:
   a) When a part of ploughed PB and topsoil layer gets into the channel immediately;
   b) From the basin with inflowing surface water when PB is fully or partially ploughed (up to 1 m wide);
   c) From the basin due to improperly arranged turf flumes of surface water discharge;
   d) From PB due to non-arranged surface water discharge flumes.

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P-LOAD IN DRAINAGE WATER WHEN SLURRY IS APPLIED

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Abstract

The paper presents study results on nutrient leaching in crop rotation fields where slurry was applied. The studies were carried out within the period of 2001–2003.

As the study results have shown, phosphorus (P) concentrations much depend on drainage runoff. Increasing drainage runoff resulted in decreased P concentrations (r = 0.7).

P leaching also depends on the precipitation amount (r = 0.83). Higher precipitation rates resulted in more intensive P leaching.

P leaching more depended on the drainage runoff and the type of cultivated crops rather than on fertilization rates. P leaching decreased when higher amounts of phosphorus were accumulated in crop yield; the mineralization process of vegetative residuals that were left in the test field enhanced more intensive P leaching.

When slurry was applied on crops of the test field, P concentrations never exceeded maximum allowable rates determined in normative documents of the Environment of Lithuania.

From the point of view of the environment protection, it is more expedient to apply slurry in spring because in this season of the year the leached amount of total P input into the soil is 37.5% less compared to its leached amount when slurry is applied in autumn.

Key words: slurry, phosphorus concentration, phosphorus leaching.

Introduction

As it is known, P compounds are vitally important for all living organisms. It was proved that not only plants, but even simple microorganisms are not able to exist without phosphorus. This element is essential to maintain the synthesis of organic matter and metabolism in plants. Due to the stability and poor dissolubility in soil, a lack of phosphorus is often experienced in the soil. As a result of the decomposition of initial P-rich materials, mineralization process of vegetative residuals and application of organic and mineral fertilizers, phosphorus contained in the soil turns into a soluble form (Томпсон и др., 1982).

This element contained in the soil is a plant available nutrient, however excess amounts of phosphorus may adversely affect the quality of drainage water as well as ground water. Rivers flowing via farming fields collect water rich in nutrients. The most significant P input (70%) is that with river water. About 200 rivers inflow into the Baltic Sea; the Vysla, the Oder, the Neva, the Dauguva and the Nemunas are considered as most heavily polluted. Considering the pollution of the Baltic Sea with P compounds, the Nemunas is the third river from all the five mentioned here (Grimvall et al., 2001).

Due to the isolation of the Baltic Sea, the process of the interchange of its water with the Atlantic Ocean is very slow. Therefore biogenes accumulating in the sea may cause different eutrophication problems. The farming activity of humans may enhance natural eutrophication process during which waters of low productivity become productive enough as a result of continuous inflow of nutrients into the hydroecosystem. Constant inflow of biogenes may cause the lack of oxygen on the sea bottom where the decomposition process of all kinds of organic matter formed on the sea surface is observed. That is why in certain areas of the sea bottom fauna has been damaged and the number of fish has significantly decreased (Pleijelis, 1994).

In many countries (Denmark, France, Germany) nitrogen amount allowable for the fertilization of agricultural land areas is determined in the regulations. However, in countries like the Netherlands and Belgium the fertilization is restricted in respect of P amount because soils in most European countries are overloaded with this element, which may result in significantly higher P losses due to the leaching and soil erosion (Sibbesen et al., 2003).

Although leached amounts of this element are comparatively small, even 0.03–0.05 mg l^{-1} of P concentrations may enhance the eutrophication (Sharplus et al., 1997).

Low mobility of phosphorus determines small leached amounts of this element, however according to the classification of surface water quality necessary to maintain living conditions determined by the European Union, P_{total} concentration should not exceed 0.025 mg l^{-1} (The Harmonised…, 1996). However, due to the intensive development of agricultural activities, such concentration is extremely difficult to be reached therefore Swedish researchers are suggesting maximum allowable concentration to be 0.05 mg l^{-1} (Gustafson et al., 1995).

According to the data of 2000, the river Nevėžis flowing via land areas of intensive farming activities is more heavily polluted than the Skroblus, a river of natural background, because the average P_{total} concentrations contained in water of those rivers were 0.39 and 0.08 mg l^{-1} respectively (Lietuvos upių …, 2000).

Thus, to reduce P leaching from farming fields and its adverse effect on the natural environment, the optimal time of the application of slurry on crops was being determined.

Study conditions and methods

In 2001–2003, the investigations were carried out in Juodkiškis study object of Water Management Institute of Lithuanian University of Agriculture. During the studies, the effect of slurry on nutrient leaching in light–textured soils of crop rotation fields was estimated. The experimental
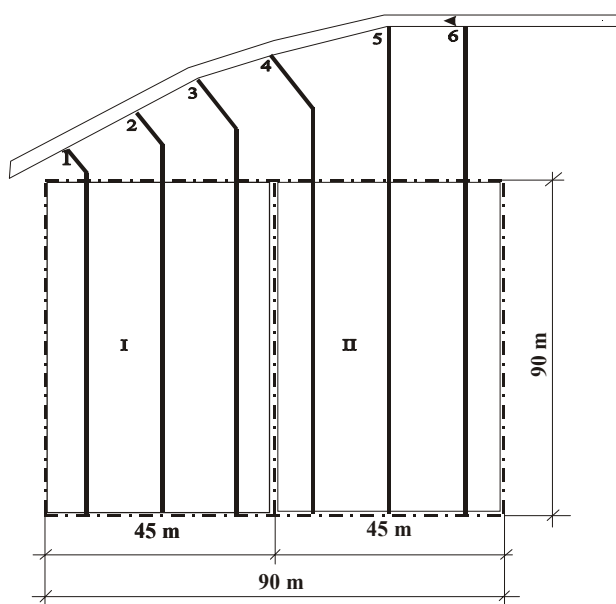
Fig. 1. Experimental scheme:
treatment I – slurry applied in spring; treatment II – slurry applied in autumn;1–6 – drains.

scheme comprises treatments I–II in three replications (Fig. 1).

The area of the study object (0.81 ha) is drained with drainage, drain spacing is 15 m, draining depth is 1.2 m. Three replications of each treatment are arranged on separate drains. In-between two adjacent drains there are polythene screens arranged in order to separate one drain from the other and avoid nutrient leaching from one drainage system into the other. Each separate drainage system covers the area of 0.135 ha.

The following crops were grown in the test field:

1. Red clover, 2nd year (20 t ha^{-1} of slurry; P_{43} in spring and P_{20} in autumn);

2. Sugar beet (60 t ha^{-1} of slurry; P_{76} in spring and P_{73} in autumn);

3. Spring rape (20 t ha^{-1} of slurry; P_{32} in spring and P_{35} in autumn).

Soil of the study object is calcareous gley brown soil (RDg4-k2) (Buivydaitë et al., 2001). According to grain-size composition, the soil is attributed to sandy loam soils.

Surface layers of the soil contain lower amounts of carbonates (1.7–4.7%), while at the depth of 40 to 100 cm their amounts are fluctuating from 18 to 22%. The soil is of alkaline reaction (pH>7), low in humus content (on the average 1.82–1.90% of humus in the arable layer), contains low nitrogen concentrations (36.0 kg ha^{-1} dissolved inorganic nitrogen at a 0–40 cm deep layer). The soil is not rich in phosphorus and potassium concentrations as its arable layer contains only 93.0 kg ha^{-1} and 88.0 kg ha^{-1} of plant available P_2O_5 and K_2O respectively.

Samples for the determination of drainage water chemical composition were taken once a month. Meteorological conditions were estimated on the basis of the

data collected in the measurement post of Vilainiai. The data was checked with the help of a rain gauge arranged in the study area. Analysis of water samples were done in the Chemical Analysis Laboratory of Water Management Institute on the basis of the methodology described in literature (Unifikuoti…, 1994).

Concentrations of total phosphorus (P_{total}) contained in water samples were determined by a spectrometric method after mineralization with potassium persulphate.

Concentrations of phosphorus (P) contained in slurry are determined from a single extract burnt with a concentrated sulphuric acid (H_2SO_4) and selenium (Se) catalyst. P concentration is measured by a molibdenum method.

Drainage runoff was measured every five days. During the periods of spring and autumn floods, the runoff measurements were taken every day in a volumetric way. Discharges were calculated on the basis of linear interpolation, drainage runoff heights were estimated according to everyday discharges.

The study period covers the whole period from the spreading time of slurry in autumn in one year until its spreading time in the following year.

Results

The average P concentrations contained in drainage water were only 0.02-0.03 mg l^{-1} within the study period (maximum allowable P concentration is 2 mg l^{-1}). Figure 2 shows the fluctuations in P concentrations.
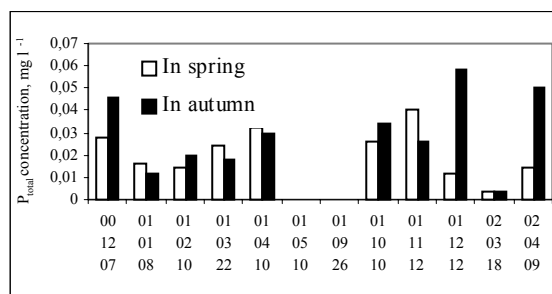
Fig. 2. Dynamics of phosphorus concentrations in drainage water.

However, in 2001, when red clover (2nd year of use) was grown, a sharp increase in momentary P_{total} concentrations up to 0.044-0.066 mg l^{-1} was observed. As the literature refers (Блацк, 1973), the increase in P concentrations is related to the type of cultivated plants, such as perennial grass or other plants with a strong root system. Roots of such plants uptake and dissolve hard-dissoluble calcium phosphates contained in the soil. During this process calcium is used and phosphorus is released. Although leached phosphorus amounts are not very large, even 0.03-0.05 mg l^{-1} of P may enhance eutrophication of water bodies (Sharplus et al., 1997). In the treatment where slurry was applied in autumn, P_{total} concentration was higher (0.066 mg l^{-1}) than in the treatment with slurry applied in spring (0.05 mg l^{-1}).
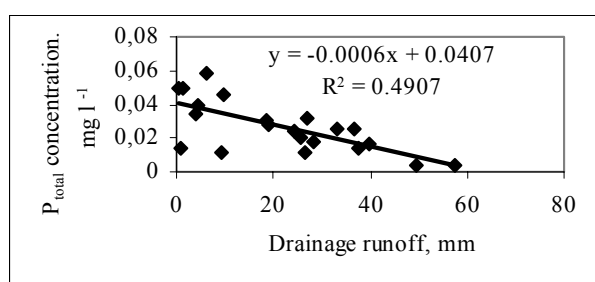
Fig. 3. The dependence of P_{total} concentration (mg l^{-1}) on drainage runoff/month (mm).

As the study results have shown, there is a close relationship between P concentrations contained in drainage water and the drainage runoff (Fig. 3).

The results of correlation analysis have shown that under the conditions of higher drainage runoff the concentration of total P contained in drainage water is decreasing (r=0.7, n=21, t_{actual}=5.99>$t_{theor95\%}$=2.1).

As the analysis results of drainage water of the period 2001–2003 show, the average P concentrations did not exceed the maximum allowable concentrations (MAC) for drainage water: P 0.019–0.034 mg l^{-1} (Dėl aplinkos…, 2002) (Fig. 4).
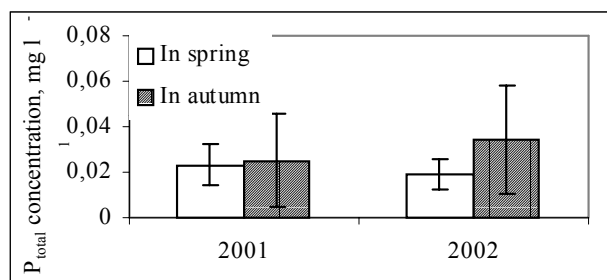
Fig. 4. Average, minimum and maximum P_{total} concentration in drainage water of the period 2001–2003.

A higher P_{total} value was determined in the treatment where slurry was applied in autumn (0.066 mg l^{-1}) but it still was even 30 times lower than the MAC.

Under the climatic conditions of Lithuania, the leaching of certain nutrients from the soil is considered as a natural phenomenon. However, the amounts of leached nutrients depend on many factors, the main of which is meteorological conditions (Table 1).

Table 1

Meteorological conditions of the study period

Index	2001	2002	2003
Precipitation, mm	580.5	461.8	451.4
% from perennial rate	98.4	78.3	76.5
Average air temperature, °C	7.3	8.2	7.1
% from perennial rate	117.7	132.3	114.5

During the vegetation period, the study object experienced the largest amount of precipitation that made up 72.8% of annual precipitation rate.

According to yearly precipitation amount, the years 2002 and 2003 were driest (461.8 mm and 451.4 mm, which is 21.7% and 23.5% below the perennial rate respectively).

Losses of P_{total} in the soil much depend on the precipitation amount (Fig. 5).
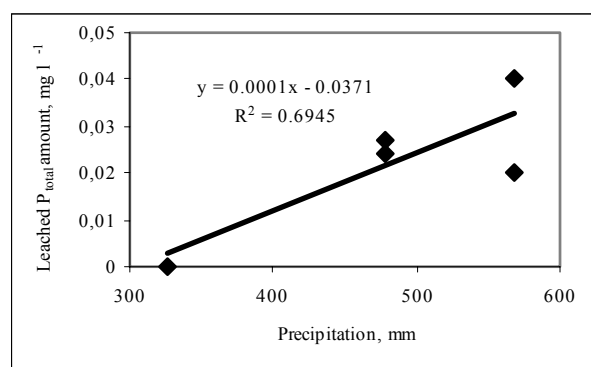
Fig. 5. Relationship between precipitation and P amounts leached by drainage per year.

In the years abundant in precipitation, large amounts of infiltration water are observed. Nutrient concentrations contained in the infiltrated water might be lower than those contained in smaller amounts of leachate, however total leaching losses are increasing (Tyla et al., 1997).

Precipitation amount was different within the whole study period. Larger amounts of precipitation determined larger amounts of leached P_{total}. Strong linear relationship was observed between the precipitation mm (*x*) and P_{total} loading kg ha^{-1} (*y*) (correlation coefficient r = 0.83) Stjudent's criterion $t_{theor95\%}$ = 3.2 when n = 5, then t_{actual} = 4. 7.

As the literature refers (Švedas, 1990), one of the factors enhancing nutrient leaching is fertilization of soil with mineral and organic fertilizers. The study results have shown that under the agroclimatic conditions of Middle Lithuania, slurry applied in separate treatments has different effect on nutrient leaching. As different rates of fertilizers were applied on the test field of the study object, it is obvious that large input rates of P determine more intensive leaching of this element. Statistical characteristics of the dependence of leached P amount (y) on fertilization rates (x) of the study period 2001–2003 are given in Fig. 6.

P leaching from the soil is less intensive and thus more even. No major relationship between P leaching and fertilization was determined. Significantly increased fertilization rates resulted in slightly higher amounts of leached phosphorus, as this element is less soluble and less mobile than nitrogen (Tumas, 1992).
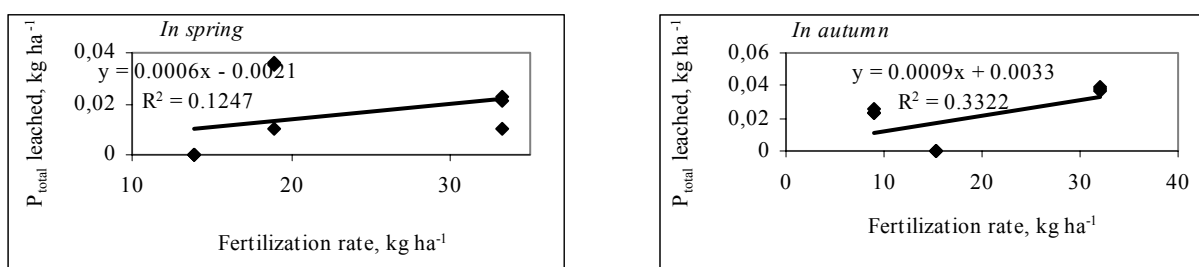
Fig. 6. Characteristics of the relationship between fertilizers and leached phosphorus amounts.

The results of correlation analysis have shown that the relationship between P leaching and fertilization rates is not reliable because the theoretical value of Stiudent's criterion is less than the actual one (r=0.35, n=7, $t_{theor95\%}$ =2.6>t_{actual}=0.9 with fertilization in spring; r=0.58, n=7, $t_{theor95\%}$ =2.6>t_{actual}=1.9 with fertilization in autumn).

During the study, period different fertilization rates were applied on crop fields. Moreover, the study fields experienced P input with precipitation and plant residuals, but the leaching of the element was changing insignificantly and depended on the drainage runoff rather than on the amount of P input in treatments of trials (Fig. 7).

In the variant where slurry was applied in spring the drainage runoff was 148 mm in 2001. At that period the leached P amount was 0.027 kg ha^{-1}. In the following study year the drainage runoff was 39 mm less therefore the leaching of phosphorus was 0.009 kg ha^{-1} less intensive. Similar P leaching results were observed in the variant with slurry applied in autumn: a 7-mm higher drainage runoff resulted in 0.014 kg ha^{-1} more intensive P leaching.

In 2003, no P leaching was observed as no drainage runoff occurred due to small amount of precipitation.

The soil is a source of nutrients, however the supply of plants with nutrients is not similar. Amounts of plant avail-able nutrients such as mobile phosphorus contained in the soil are different. Moreover, fluctuations in the amounts of the elements depend on meteorological, agrochemical and other factors.

Soil samples for the determination of mobile phosphorus (P_2O_5) were taken in spring before slurry was applied and in autumn after the harvest time. As the analysis results have shown, concentrations of those elements contained in the soil were very low during all the years of the study period.

The greatest amounts of those elements were determined in a 0–40 – cm deep soil layer. This is because nutrient input into this layer is mainly from fertilizers and vegetative residuals; the migration of P in the soil is rather slow, which results in small leached amounts of those elements.

Phosphorus content in the soils of the study object was moderate (except for the spring of 2003, when P content increased due to ploughed up residuals of sugar beet). In spring of the year 2003, the average amounts of mobile P contained in the soil was 112 mg kg^{-1}, i.e. almost did not change (moderate P content).

The amount of mobile P contained in the soil made a strong effect on the yield of crop rotation plants (Fig. 8).
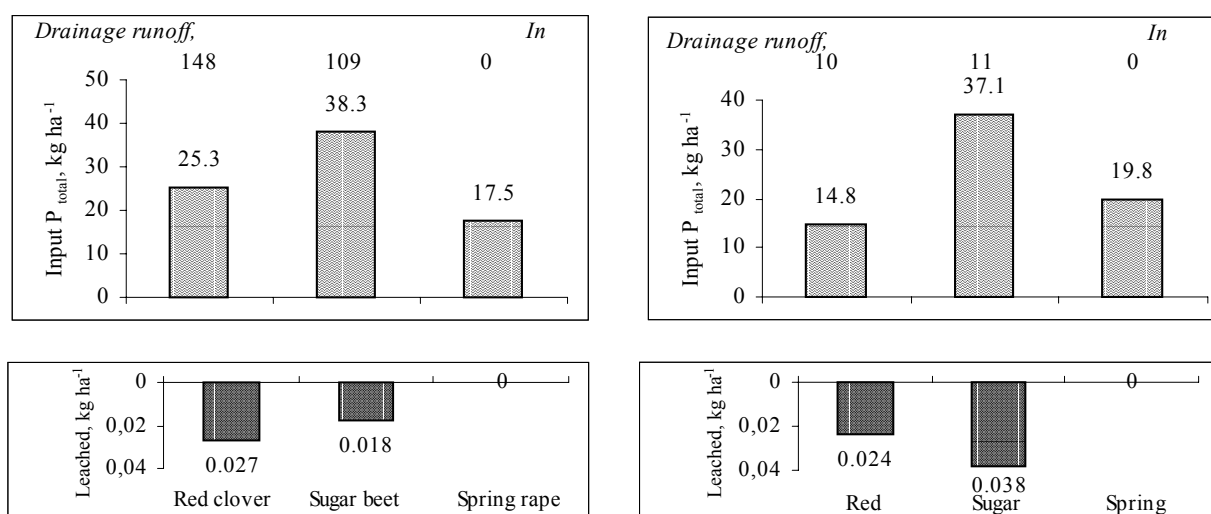
Fig. 7. Dependence of P leaching (kg ha^{-1}) on drainage runoff.
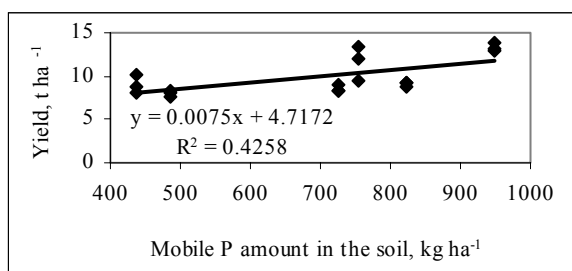
Fig. 8. Dependence of the crop yield on the amount of mobile P contained in the soil (0-40-cm deep soil layer).

Higher amounts contained in the soil determined a higher yield of cultivated crops (r = 0.65, n = 15, $t_{theor95\%}$ = 2.2<t_{actual} = 4.08).

Certain amount of phosphorus is accumulated in the crop yield and thus is eliminated from farming fields (Table 2).

In such a way, the possibility of P leaching is reduced. The content of phosphorus that remains in the soil with plant residuals is also essential. Higher amounts of P contained in vegetative residuals increase the possibility of P leaching (Fig. 9).

In the treatment where slurry was applied in spring, the crop yield accumulated 44.3 kg ha^{-1} of P; in treatment with slurry applied in autumn, P uptake with crop yield was 36.45 kg ha^{-1}. Thus, leached P amounts were 0.02 kg ha^{-1} less in the first treatment of trial. P input with plant residuals was also 0.04 kg ha^{-1} less in the first variant where slurry was applied in spring, therefore leaching of this element was 0.02 kg ha^{-1} less.

P input and leached P amounts were different in all treatments of trials within a three-year study period: in the variant where slurry was applied in spring P, input was 81.1 kg ha^{-1} and leached P amount was 0.05% of total P input; in the variant with slurry applied in autumn, P input was 71.7 kg ha^{-1} and its leaching was 0.08% of total P input. Having compared the leached P amount in both variants it was determined that 37.5% less intensive leaching of this element occurred in the variant where slurry was applied in spring rather than in autumn.

Conclusions

1. As the study results have show, P concentrations mostly depend on the drainage runoff (r=0.7).
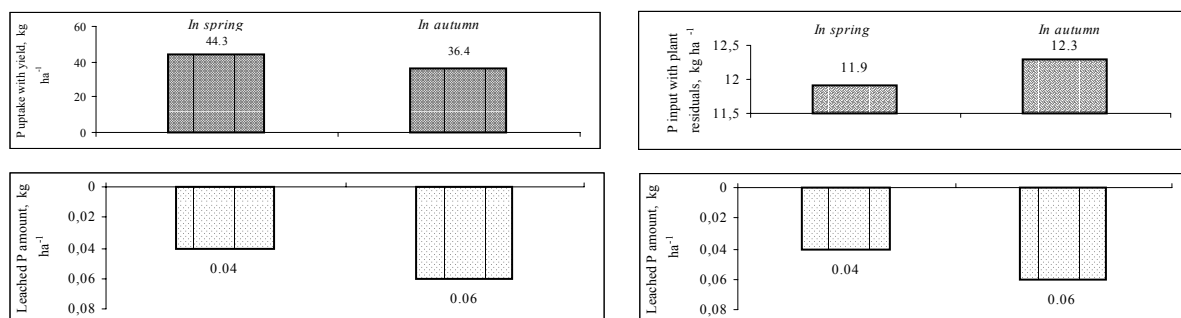
Fig. 9. P uptake with crop yield, P input with plant residuals and leached P amount, kg ha^{-1}.

Table 2

The yield of field crops, t ha^{-1}

Year	Treatments	Yield, t ha^{-1} (abs. dry matter)		P amount in the yield, %	
		Red clover 2nd year			
		1st haymaking	2nd haymaking	1st haymaking	2nd haymaking
2001	In spring	5.86	3.19	0.12	0.23
	In autumn	5.35	3.22	0.11	0,19
		Sugar beet			
		Roots	Leaves	Roots	Leaves
2002	In spring	7.2	1.8	0.102	0.15
	In autumn	5.2	2.6	0.095	0.123
		Spring rape			
		Seeds	Haulms	Seeds	Haulms
2003	In spring	2.6	4.5	0.62	0.087
	In autumn	2.1	4.1	0.68	0.044

2. P leaching mostly depends on the amount of precipitation (r=0.83).

3. P leaching depends on the drainage runoff and cultivated crops rather than on fertilization rate.

4. P leaching decreased when larger amounts of this element accumulated in the yield. P leaching was more intensive when larger amounts of plant residuals remained in fields.

5. From the point of view of the environment protection, it is more expedient to apply slurry in spring rather than in autumn because then 37.5% less amounts of phosphorus of total P input are leached.

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HYDRAULIC CAPACITY OF VEGETATED DRAINAGE CHANNELS

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Abstract

The studies were carried out in two control profiles of the Graisupis ditch excavated 40 years ago and situated at the distance of 2.4 and 4.8 km from the outlet in the land of intensive farming in Kedainiai district. The study object contained mineral loam/sandy-loam soils on the flat relief. The areas of catchments in control profiles were 12.1 and 5.9 km^2, the largest discharges of spring floods were 3.4 and 1.6 m^3 s^{-1}.

Cross-sectional parameters, grass characteristics and flow parameters were measured under the conditions of different discharges (6 replications in each control profile during the vegetation period and 4 replications in spring when the channel bed is clean).

As the study results show, roughness coefficient of the grass-covered channel bed increased up to 21 times, water tables were observed to be 20-40 cm higher, the outlets of the drainage were flooded up.

Considering the average grass indices determined in control profiles, grass hydraulic resistance was calculated according to 4 formulas based on the scheme when grass cover resistance is estimated as the total resistance of separate obstructions.

The difference of 22.3% between calculated results and natural measurements was determined. The formula estimating grass cover parameters as well as flow regime was determined to be most suitable.

Key words: bed, overgrowth, roughness, coefficient of hydraulic resistance, average velocity.

Introduction

In Lithuania, total number of drainage channels and regulated small streams is over 53 thousand km. They make up about 70% of the whole hydrographic network. Most of the channels were arranged 15–55 years ago therefore their bottom and slopes contain a comparatively deep layer of soil and deposits suitable for grass and bushes to grow. Intensive growth of grass vegetation in drainage channels, particularly on their beds, is a natural process making the most significant effect on a channel. As the study results show, grass vegetation growing in channels and riverbeds tends to increase their roughness, reduce water flow velocities and thus to enhance the deposition process of sediment. When grass roots penetrate into a sediment layer, the sediment cannot be washed away even by a strong floodwater flow, therefore a continuous sediment deposition process is observed in channels. Recently, those problems have become particularly urgent as no regular annual maintenance of drainage channels is performed nor the growth of grass vegetation is controlled anymore. In larger areas of arable land such drainage channels would be even useful, because they could reanimate the landscape and maintain the biodiversity; but on the other hand, grass vegetation impedes the flowing of water, adversely affects the water discharge process from drainage systems, increases water depths and thus causes the possibilities for the drainage outlet to be clogged.

Water flow processes in riverbeds and large channels overgrown with grass have been studied in detail. Many authors have suggested different scheme-based and calculation methods.

When aquatic vegetation is growing only on the bottom and does not take up the whole cross-section of the water flow, it is considered that in such case the flow consists of the part of the flow in a grass layer and another part of the flow over the grass layer (Borovkov, 1989). Such water flow conditions are observed in large rivers.

When strong river flow flattens the grass growing on a channel bed and slopes, it is recommended to reduce the cross-section by a certain equivalent depth of a grass layer, and water flow above the grass layer is suggested to be calculated as in the case of the channel bed of common roughness (Rimkus, 1999). It was determined that the layer of flattened grass is decreasing with increasing water flow velocities; thus the method is optimal under the conditions of different degree of flattened grass. However in channels such conditions are observed only during spring floods when grass stems are slightly decayed, broken and bent by a snow cover.

V. N. Goncharov has analyzed certain cases when the roughness of the overgrown channel bed increased about 30 times compared to a clean channel bed (Goncharov, 1954). To calculate the roughness coefficient, a theoretical scheme is used when horizontal suppressive obstacles are introduced into the water flow.

Methods estimating grass stems as a whole of separate obstacles of water flow are considered as a separate group (Karasev et al., 2000; Borovkov, 1989). Those methods are based on the idea that when water flow is impeded by a cylinder bodies the friction makes up only several per cents, while all the rest part of the resistance is the resistance of the form (pressure). This principle was used when developing the methodology for the calculation of the conductivity of channels overgrown with bushes (Rimkus et al., 1999) as well as for the calculation of the drag force when modeling the distribution of velocities and shear stress between the overgrown and non-overgrown parts of the flow (D. Klopstra et al., 1997, Sung-Uk Choi et al., 2004).

The objective of the studies was to determine the effect of grass vegetation intensively growing in drainage

Table 1

The overgrowth of channels and distribution by catchment area (F) and gradients (i)

Overgrowth			F, km^2			i, ‰		
Type	n	%	Size	n	%	Size	n	%
Grass	66	21.6	0.1 - 3	201	65.7	0.5 - 1	169	55.2
Grass and single bushes	100	32.7	3.1 - 10	86	28.1	1.1 - 3	97	31.7
Grass and scarce bushes	48	15.7	10 - 20	12	3.9	3.1 - 5	17	5.5
Thick bushes	92	30.1	>20	7	2.3	>5	23	7.5
Total	306	100	4.0 ± 0.40	306	100	1.6 ± 0.09	306	100

Note: n – number of surveyed stretches of channels, % – distribution in % of surveyed ones

channels on the hydraulic regime of the channels, based on natural measurements and calculation methods.

Study object and methodology

The size and condition of channels of the Middle Lithuanian Plain might be characterized by the data obtained from randomly selected 306 stretches of drainage channels.

Intensive grass cover is also observed in stretches of channels with scarce bushes as well as in the part of channels with thick low bushes that create no shadow. Thus it might be stated that grass vegetation is observed in more than 70% of drainage channels.

For the studies of hydraulic conductivity, the channel Graisupis in Kėdainiai district has been selected. The channel was arranged 40 years ago in landscape of clayey moraine plain. The channel Graisupis is attributed to the basin of the river Smilga (the Nevėžis tributary); its length is 8.0 km, catchment area – 16.4 km^2, wooded part of this area – 26%, prevailing soils are mineral loam and sandy loam. The studies were carried out in two control cross-sections (profiles) located in fields of intensive farming at the distance of 2.4 km and 4.8 km from the outlet of the channel respectively. The area of basins nearby those cross-sections is 12.1 km^2 and 5.9 km^2 respectively; maximum 10% probability discharges of the spring flood are 3.4 and 1.6 m^{3}s^{-1} accordingly. The channel profile was designed as trapezium-shaped with slope coefficients m = 1.5 and width of the channel bed 0.6 m, the channel gradient at the spots of control cross-sections is 2.4 and 1.6‰ respectively.

At the control profiles the form of each cross-section was measured having graded the points at each 0.5 m on the slopes and at each 10 cm on the lower flooded part of the channel. Considering the data of cross-sectional measurements, with the help of grapho-analytical method the wet perimeter and the area of cross-section have been determined as well as the hydraulic radius for each measured water level has been calculated.

Water levels were measured during the high water periods caused by spring floods and intensive rainfall. Water discharge was measured at the water measuring post containing a thin shield of combined profile; the measuring

post was located below the control cross-sections. When water level in the post was measured to be within the limits of a triangle 120° cut (up to 0.6 m), water discharges were calculated in respect of the measured water levels using special tables (Solomencev, 1957), in the case of higher water levels the discharges were calculated based on the data collected at this post by dr. K. Gaigalis. The discharges in measured cross-sections were corrected according to the channel basin areas, and were verified having performed control measurements of velocities using a computerized micro-propeller water flow meter. The average hydraulic gradient was calculated according to water levels in the measuring cross-section and the cross-section below. Using this data, a roughness coefficient of the channel was determined in the order described below.

Having calculated the average velocity in the control profile $v = \dfrac{Q}{\omega}$, the coefficient C was calculated according to Chezy equation $C = \dfrac{V}{\sqrt{RI}}$, and the roughness coefficient n was calculated according to Manning equation $n = \dfrac{R^{1/6}}{C}$.

In June, when grass is high but still not flattened, the density, height and diameter of grass stems were measured in the control cross-sections. As there is a great diversity of grass, only the indices of the most common grass species were measured within a 10-m long stretch. Having grouped and generalized the indices, they were used for the calculation of hydraulic resistance.

Figure 1 presents a calculation scheme that is closest to the flow conditions observed in the channel Graisupis, when the channel bed is overgrown with grass, water levels are less than the height of grass stems and thus the grass is not bent down by the water flow.

Using several authors' formulas based on this scheme, the hydraulic resistance coefficients of grass and its average velocities have been calculated and the results were compared with those obtained from direct measurements. The values of grass density, its height and diameter as well as natural water depths measured in control cross-sec-
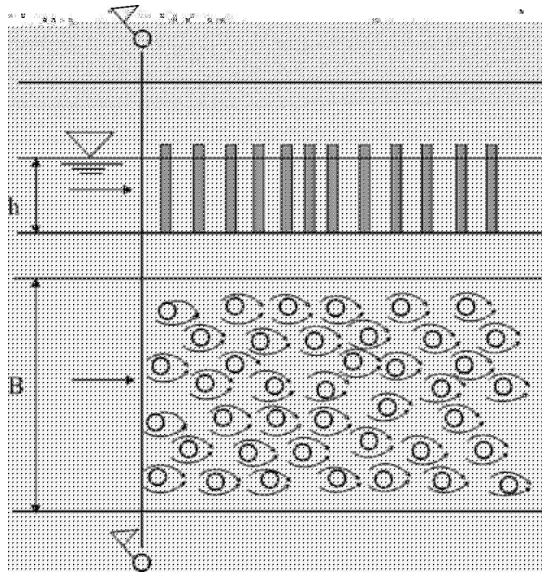
Fig. 1. Calculation scheme of the hydraulic resistance of grass-covered channel bed.

tions and indicated in Table 2 were used for the calculations. Hydraulic resistance coefficients of whole grass stems λ_3 and x were calculated according to the following equations:

a)

$$\lambda_3 = \lambda_o\left(1 - da\sqrt{a}g\right) + Klagd_aha,\qquad (1)$$

(Karasev et all, 2000, (6)), where d_a – stem diameter, a_g – density of stems, units/m^2; h_a – height of the part of stem under water (in our case it was equal to water depth as the stems were not fully submerged); λ_0 – channel bed resistance coefficient (considered as $\lambda_0 = 0.13$); K_l – grass stem resistance coefficient (considered as $K_l = 1.2$ for cylinder-shaped stems);

b)

$$\lambda_3 = 4S_mC_dk_b\frac{1}{M_a^2},\qquad (2)$$

(Borovkov, 1989), where S_m – stem resistance area, C_d – stem resistance hydrodynamic coefficient (considered for cylinder-shaped stem as $C_d = 1.2$); k_b – coefficient of the interaction of stems determined from the dependence

$k_b = 1 - \dfrac{1.5d}{l}$, where d – stem diameter; l – distance between two adjacent stems in the direction of flow; M_a^2 – the average dimension of the area where one vegetation unit is growing;

c)

$$\zeta = 1.32\frac{d}{l}\left(1 - 1.5\frac{d}{l}\right),\qquad (3)$$

(Rimkus et al., 1999), formula for the hydraulic calculations of channels, overgrown with bushes, where d - stem diameter; l – distance between adjacent stems. Common feature of those formulas is that stem resistance is estimated with a constant coefficient irrespective of the flow regime (depth, velocity);

d)

$$\lambda_3 = \lambda_o\left(1 - da\sqrt{a}g\right) + \frac{182agd_aha}{\left(Re\cdot 10^{-3}\right)^{1.2}},\qquad (4)$$

(Karasev et all, 2000; (8)), where values of all elements are the same as in formula (1), only the constant value

$K_l = 1.2$ is replaced by the dependence $K_l = \dfrac{182}{\left(Re\cdot 10^{-3}\right)^{1.2}}$,

where Re should be related to the diameter of stems because the water is flowing round separate stems. As water flow processes are much more complicated in a natural bed, stems tend to intertwine making various non-defined forms. The degree of water flow round those forms is close to the dimensions of the flow itself and thus it is considered

that $Re = \dfrac{Vh}{v}$, where v – average velocity, h - water depth and v - kinematic viscosity.

Due to the different methodologies, it was impossible to make a direct comparison of resistance coefficients. Therefore the average velocities needed to be calculated. Having calculated the resistance coefficients according to equations (1) and (4), the average velocities are calculated

according to Chezy formula $V = C\sqrt{RI}$, where $C = \sqrt{\dfrac{8g}{\lambda_3}}$,

R – hydraulic radius, I – hydraulic gradient, g – acceleration due to gravity.

When coefficients are calculated according to formula (2), the average velocity is calculated by the equation

$V = \sqrt{2ghI}\cdot j$, where $j^2 = \dfrac{M_a^2}{S_mC_dK_b}$, i.e. it is the same as in

formula (2).

Having calculated ζ according to formula (3), the aver-

age velocity is calculated as follows: $V = \sqrt{\dfrac{2gi}{\dfrac{1.15\zeta}{l} + \dfrac{\lambda}{4R}}}$, where

i is hydraulic gradient and λ – channel bed resistance koefficient.

Study results

The channel was cleaned with the help of an excavator in 1995, the studies were started in 2000; thus the channel bed is covered with unvaried grass vegetation. The grass of previous year is usually flattened during the spring flood, which results in a relatively clean channel bed (depending on the size of flood and other conditions). At the onset of grass vegetation period, the most intensive growing of grass is observed on the sides of a channel bed and lower parts of channel slopes. Here usually high grass veg-

Table 2

Characteristic of grass most frequent in control profiles

Name of grass	Density, unit m^{-2}	Height h, m	Diameter d, mm
Upper slope			
Wheat grass (*Elitrigia Desv.*)	2650	0.65	1.5
Middle of the slope			
Various meadow grass	3925	0.4	0.8
Lower slope			
Reed grass; sedge (*Typhoides urundinacea, Carex gracilis*)/	900	1.0	2.1
Reed grass (*Typhoides urundinacea* L.)	1938	1.2	2.3
Meadow sweet (*Filipendula ulmaria* L.)	975	0.8	5.0
Other heavy-stem grass	875	1.1	6.0
Sedge (*Carex gracilis, Carex cespitosa*)	1950	0.7	2.2
Yelow iris (*Iris pseudacorus*)	1100	1.2	12.0
Average	1429	0.96	3.32

etation easily supporting moisture is prevailing: certain species of reed (e.g. *Thypoides arundinacea L.*), marsh dropwort (*Filipendula ulmaria L.*), sedge (*Carex gracilis, Carex cespitosa*), etc. When the channel gets dry, those species of grass are growing in the channel bed. The species of grass vegetation dominant in the channel bed include: marsh marigold (*Caltha palustris L.*), marsh forget-me-not (*Myosotis scorpioides L.*), ivy bent (*Agrostis stolonisans*), etc. Those and other kinds of grass vegetation grow very thick in the channel forming a real all-over carpet. Their stems are growing and divaricating in a horizontal position therefore it was impossible to calculate directly their hydraulic resistance by the selected calculation methods. The effect of those grass stems was estimated having measured the profile of the channel bed and calculated the average velocity. The main indices of grass species growing in control profiles are given in Table 2.

For the calculations of hydraulic resistance the average values of grass were calculated having estimated the characteristics of all species of grass growing on the lower part of the slope, except for the indices of yellow iris that was less frequent. To make the comparison, indices of the most frequent grass species (i.e. reed grass and yellow iris) that make the thickest cover in the channel were selected.

Within the study period of 2000–2004, during the vegetation period when the channel bed was covered with grass, high water levels that were enhanced by 25–40% probability of summer flood occurred only in July-August in 2000 and in August-October in 2001, when the height and density of grass reached its maximum rate and the grass vegetation on channel sides started to bend down intertwining with grass vegetation growing on the channel bed. Not all maximum water levels were fixed as they lasted for a rather short period of time. Spring floods occurred in January-March periods, when channels were full of snow and thus were not suitable for our studies due

to their uneven profiles. Those reasons determined a comparatively small number of natural measurements taken in each control profile.

When grass vegetation fills up the whole profile of the water flow, the concept of roughness becomes relative because it does not define the roughness of the channel bed and slopes but specifies the reduced hydraulic conductivity of the whole profile.

In all studied cases the flowing of water under the conditions of high water levels during the vegetation period occurred between grass stems. Occasionally, short rifts of non-continuous open water flow were observed; the rifts did not cover the entire width of the channel bed, although water depth reached 1 m and even more. During the studied periods of high water levels the grass was not flattened. This is the main difference between water flow in small channel beds and large riverbeds. For example, the overgrowth of a large 17–19-m wide and 3.4–4.5-m deep channel starts from the banks of the channel, then free water flow gets narrower, occasional zones of stagnant water occur, and the roughness coefficient of such channel increases about 3.4 times (from 0.025 to 0.084), which results in increased water level only by 25% (Zhuk et al., 1984). In our studied cases the roughness coefficient n calculated by Manning equation was from 0.096 to 0.290 in control profile 1 during the vegetation period, while in control profile 2 it was from 0.130 to 0.637, i.e. exceeded the designed roughness coefficient (0.030) about 21 times.

Differences of water levels in overgrown and relatively clean channel beds are best illustrated by the graphs in Figure 2, where the dependence of depths on water discharges that were obtained having expressed natural measured values by logarithmic dependences are shown.

In both control profiles more significant differences in water depths were observed under the conditions of lower discharges. When discharge is 0.1–0.2 $m^3 s^{-1}$, the differences in water depths are up to 0.4 m. As we know, the
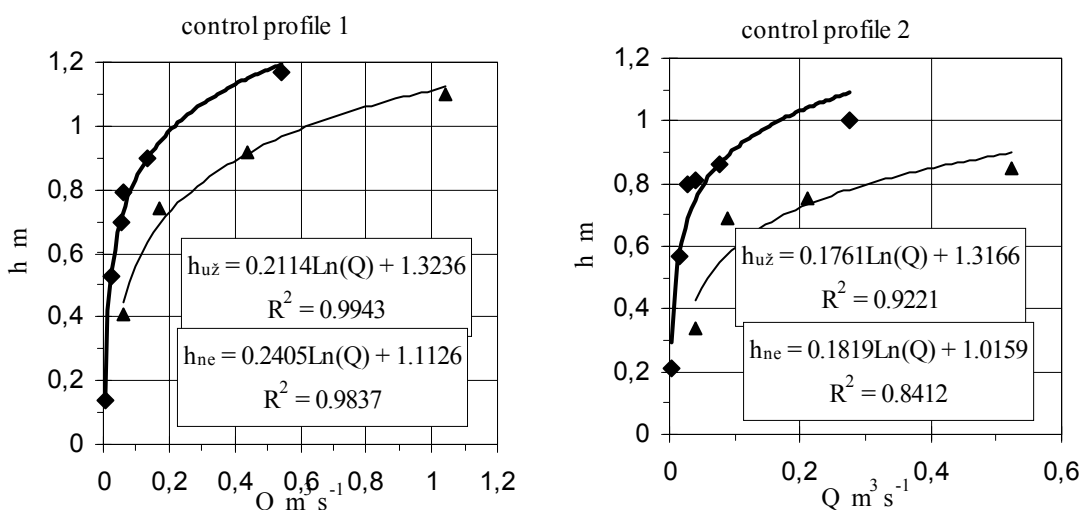
Fig. 2. Dependence of water depths on water discharges under the conditions of overgrown (upper curves and dependences) and relatively clean channel beds (lower curves and dependences).

drainage outlet is usually constructed at this level; obviously, most of drainage outlets will experience the affluent in the intensively overgrown channel bed. Such affluent may significantly reduce the efficiency of drainage functioning only in certain cases when channels are shallow and the gradient of drained areas is insignificant. The effect of the affluent on the state of drainage and its outlet was not the objective of our studies and thus it was not investigated.

According to the selected four formulas, the average velocities were calculated for all depths measured in control profiles, when three different bed overgrowth indices were chosen. Due to a rather extensive data, Table 3 gives only a certain part of average velocity values calculated in control profile 1. The values given in Table 3 illustrate the results obtained by calculations with different formulas.

Calculated average velocities for different water depths (when the grass cover on the channel bed is moderate) differ from the measured ones more than 70%, but average deviations do not exceed 23%. Average velocities calculated by all the four formulas are 29.8% higher than the measured ones when reed grass is prevailing in the channel bed (less frequent than moderate overgrowth) and 30.8% lower than the measured values when yellow iris is prevailing (Table 2). All the discussed formulas well enough evaluate the indices of grass vegetation. The differences of the results of average velocities obtained using different formulas are better presented in graphs.

As it is seen, the average velocities calculated by formulas (1)-(3) do not depend on water depths, while the measured velocities and those calculated by formula (4) show a tendency to increase with increasing water depth. It was also determined that average velocities calculated by the first three formulas correspond to the calculated ones

Table 3

Comparison of calculated average velocities with the measured ones, under average conditions of the grass cover of the bed

Depths, m	Measured, m s⁻¹	Average velocities v, m s⁻¹							
		Calculated by formula 1 (Karasiov et al., 2000)		by formula 2 (Borokov, 1989)		by formula 3 (Rimkus et al., 1999)		by formula 4 (Karasiov et al., 2000)	
		Value, m s⁻¹	± %	Value, m s⁻¹	± %	Value, m s⁻¹	± %	Value, m s⁻¹	± %
0.14	0.088	0.126	43.2	0.115	30.7	0.088	0.0	0.049	-44.3
0.53	0.069	0.108	56.5	0.12	73.9	0.091	31.9	0.077	11.6
0.70	0.085	0.113	32.9	0.125	47.0	0.095	11.8	0.107	25.9
0.79	0.077	0.114	48.0	0.126	63.6	0.096	24.7	0.109	41.6
0.90	0.124	0.117	-5.6	0.128	3.2	0.098	-21.0	0.159	28.2
1.17	0.284	0.12	-57.7	0.129	-54.6	0.098	-65.5	0.302	6.3
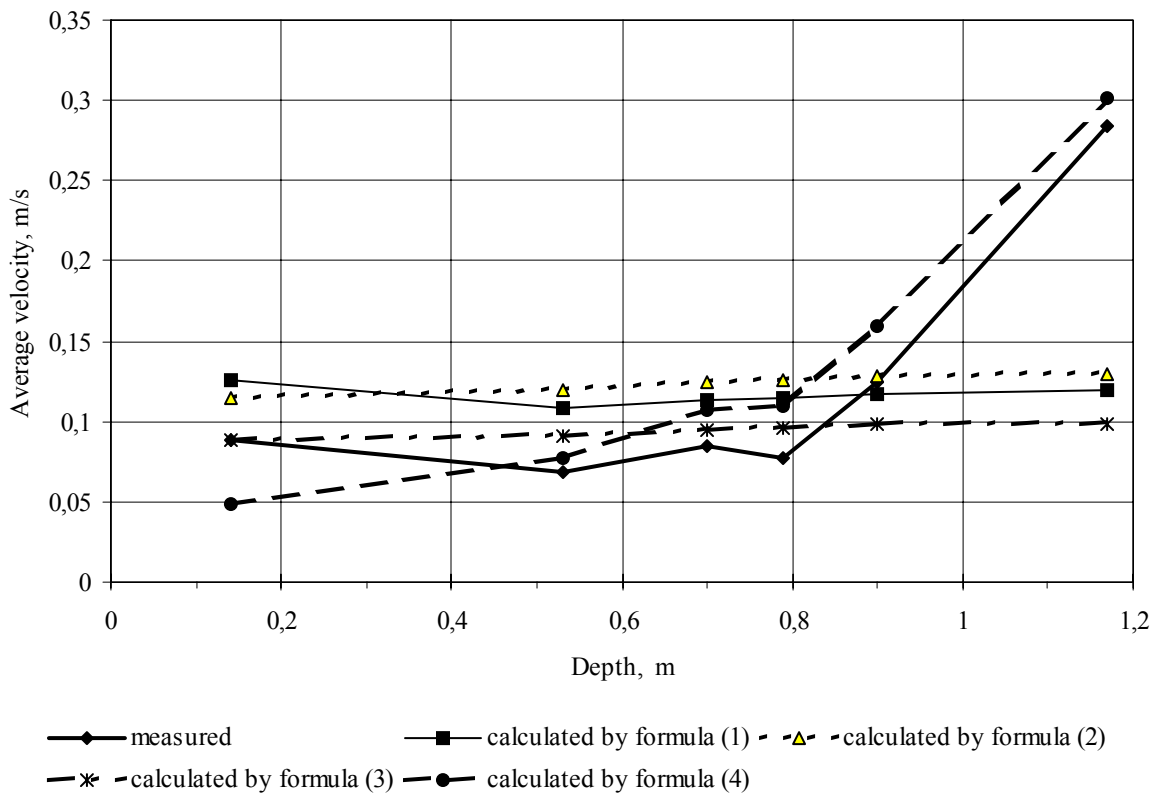
Fig. 3. Comparison of measured velocities and those calculated by different formulas in control
profile 1.

until a certain depth, but with further increasing depth the results become different. Such shortcoming is not observed in formula (4) that estimates not only the indices of channel overgrowth, but the flow regime (*Re*) as well. Having made the regression analysis of the range of measured average velocities and those calculated with different formulas, it is obvious that only the formula below gives statistically reliable (F_{actual} 41.28 > $F_{critical}$ 7.71) regression dependence (r = 0.95):

$$v = 1.05 v_{measured} + 0.006.$$

This formula is less suitable for practical usage because the output data must contain not only the indices of channel overgrowth but the values of flow velocities as well.

Due to the limited number of natural measurements, the study results show only approximate possible changes in the hydraulic conductivity of channels covered with thick grass vegetation. For the application of practical calculation methods, the studies are to be continued, suitable methods are to be reliably based and data bases of the indices of channel overgrowth are to be created.

Conclusions

1. Roughness coefficient of the channel bed covered with grass vegetation increases 20 times compared to the designed one therefore water depths are 20–40 cm higher and most drainage outlets may experience the affluent.

2. Considering the indices of grass density and its stem thickness and hydrological data, the hydraulic conductivity of overgrown channel beds might be calculated by formulas created for riverbeds. When grass vegetation is not flattened, the formulas estimating grass stems as a whole of separate obstacles impeding water flow process are most suitable.

3. The results obtained by the formula 4 estimating grass vegetation indices and water flow regime most exactly correspond to the natural measurements.

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THE INVESTIGATION OF SAFE WATER SUPPLY TO RIGA CITY

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Abstract

The studies were made on the surface water and groundwater sources, the existing and future water production yields of the Riga city. The forecasts about water demand in Riga by year 2010 are estimated as 200 000 m^3 d^{-1}, with a variation coefficient of 1.13. Total water yield is estimated as 410 000 m^3 d^{-1}, with a storage coefficient of 2.05, which is considered as sufficient. It is proposed that in future 50% of drinking water for Riga will be abstracted from groundwater and 50% will be produced in the Daugava surface treatment plant.

Introduction

Riga was founded in the 13th century and was developed on the eastern and western banks of the Daugava River next to the gulf of Riga (Fig. 1). Today the territory of Riga is approximately 302 km^2 and its population exceeds 750 000. The number of population living in the cities has dropped over the last years, however it still makes over a third of the total population of Latvia. Sharp changes have occurred within the production structure after Latvia regained its freedom in 1991.

Today centralized water supply is available to 94% of the city's permanent residents. According to the law, the responsible institutions have to supply drinking water also to the neighboring residential areas: Adazi, Baltezers, Upesciems, Bergi and Titurga.

From 1904 to 1967, the underground water collected in the Baltezers region was the only source of water supply for the city of Riga. A portion of the city water supply begun to decrease starting from 1967 and in particular from 1978 when water was supplied from Lake Jugla and the Daugava River.

In 2001, a quantity of collected water was a thousand m^3, collected from the following water sources in following proportions: the Daugava – 31839.9, Baltezers – 13527.3, Baltezers-I – 2712.6, Baltezers-II – 1819.1, Rembergi – 1831.7, Zakumuiza – 8753.4, Vencu wells – 25.1, Katlakalns – 3336.3 and Spiedudens wells – 41.2.

Water consumption in Riga in 1996 was 360 thousand m^3 d^{-1}. Since 1996, total water consumption in the city is constantly dropping, even more rapidly than the prognosis of 1995 had predicted. According to the prognosis of 2000, the average daily water consumption from the water sources in the Riga city had to amount to 236 thousand m^3 d^{-1} of drinking water. In reality, the amount of the consumed water in Riga in 2000 was only 200 thousand m^3 dnn^{-1}, which is 18% lower than the predicted (Fig. 2).

Productivity of the existing water sources in 2000 was considerably higher than the needs of city, which to a certain degree improved the quality and safety of water. The consumption of that part of the distributed water had increased from 1995 to 2000 that was accounted for by the
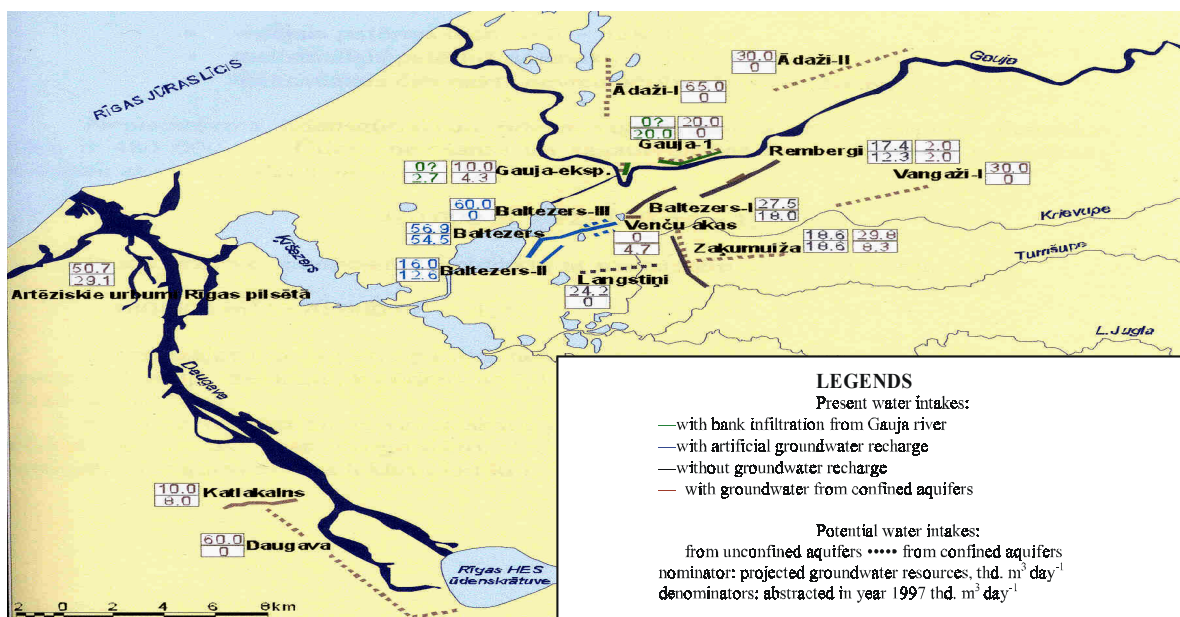
Fig. 1. The existing and potential ground abstraction plants used for drinking water supply in Riga.
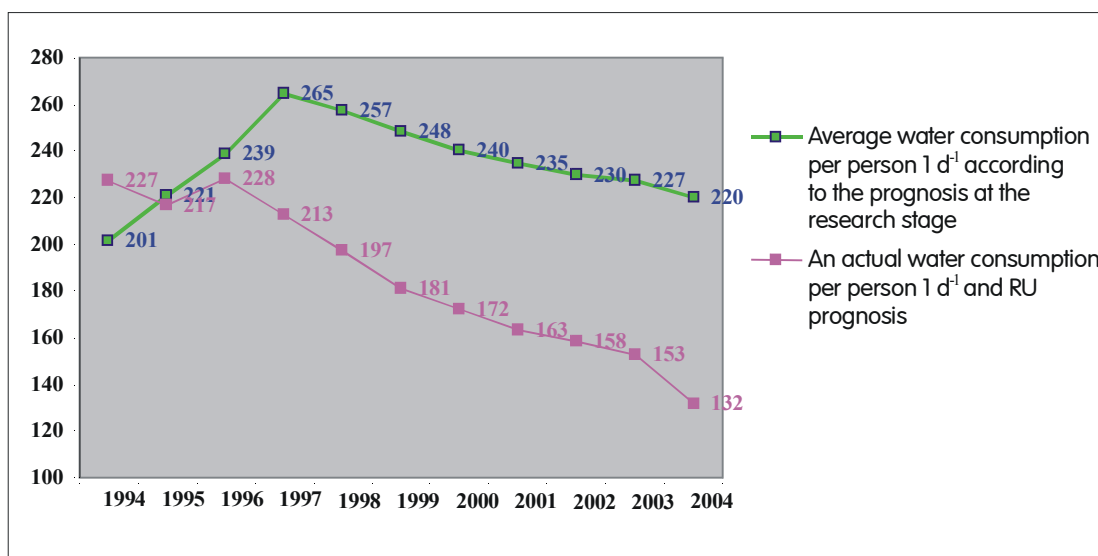
Fig.2. Comparison between water consumption quantity and its prognosis at the research stage (1 d⁻¹).

water meters and this had big influence on the water consumption. In 2001 the average water consumption in one household was 163 liters per person daily, which was significantly lower than the predicted 235 liters per person daily. Combined with the decrease of the population in Riga and a large drop in the non-household water consumption this lead to the significant drop in the total water consumption.

Although the consumption of the drinking water in the city had dropped, still it is essential to evaluate the possibilities of the development of the water sources in future with a goal to improve standards of the services and to increase safety of the water supply.

Study Goal

Recognizing the necessity of improving water supply services and environment protection standards using the available data, the goal of the study was to find out the following:

- the amount of consumed drinking water in the Riga city in 2010 (enlist losses);
- the ways to protect safety and high quality of the city's water;
- capability of the water sources systems to provide the necessary level of production;
- possibility of the underground water sources in Baltezers region to ensure provision of 50% of the drinking city's water requirement;
- compliance of the quality of produced drinking water with the EU water requirements.

Study Methodology

The revised materials issued by the "Rigas Udens" Ltd in between 1997 – 2004 were used in the study. The "Rigas Udens" laboratory data was used for the observations of a drinking water quality; analysis was carried out according to the standard methods.

This study is based on the collected and processed data. In this study were used materials of the scientific research that were carried out at the Society's request by various scientific organizations together with the client's specialists.

The experience of the protection of water sources in Vilnius, Tallinn and Stockholm experience of the water sources protection has been used.

Results

The population in the city of Riga has dropped from 911 830 in 1990 when it was the highest, to approximately 750 000 in 2002; and this drop occurred more rapidly than it was anticipated. Drop of the population and of the production activities in Riga as well as the water rates' determination and installation of the water meters in the apartments lead to significant drop in the water consumption, which exceeded all the prognoses made.

The available data shows that the tendency of the population to decrease is changing and it will start grow gradually in the period from 2010 to 2015.

Planning of the development of the city of Riga outlines few areas that will be used in future for the housing construction and commercial development. However, taking into consideration the available information, one cannot expect a big rise of the water consumption in a period before 2010, as residents will continue moving away from the city center to the closest living suburbs across the Riga borders.

In this period of time attention should be paid mainly to the improvement of level of a water supply services, securing the system of water sources and its quality complies with the EU drinking water directives. The centralized network should be widen up to provide access to the centralized waterline for 95% of the residents, however it should be achieved that to 2015 the water supply services would

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Table 1

Specifics of the water consumption (liters consumed by one consumer in 24 hours)

Year	ACTUAL									PROGNOSIS	
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Household	228	213	196	153	137	130	125	121	118	115	115
Institutions	31	30	25	24	19	17	16	15	15	15	15
Production	37	32	33	30	32	32	32	32	32	32	32

cover up to 100%. If the program that counts for and registers an active loss of the water will be installed then a quantity of the water that is not accounted for can be brought down to approximately 23%.

It can be concluded that there are reasons to suppose that in the period from 2003 to 2010 the daily and the average water consumption in the city will reach 200 thousand m³ similarly as it was in 2000. The city will consume 280 thousand m³ in 24 hours with the 24 hours maximal water consumption. To ensure fairly safe water supply in the city, the capability of the water source and preparation should be 45-50% higher than the average daily consumption. Because of that the capabilities of the water sources will reach 300 thousand m³ of water in 24 hours. Specifics of the water consumption in liters consumed per one consumer are shown in Table 1.

Researches of the underground water sources of Riga and the development of these until 2010 (3) that were carried out by the "Rigas Udens" Ltd and the State Geology Service attest that there are sufficient reserves of the underground water and these are significantly higher than the required by the city quantities of water for 2010.

Other water sources are supposed to have iron and manganese reduced at a period after 2008.

Prescribed capability of the "Daugava" drinking water production complex is 240 thousand m³ dnn⁻¹, of which 9% are utilized for technological needs of the complex, mainly for filter flushing. Due to of the production capability of the complex of drinking water the supply for the city is 220 thousand m³ dnn⁻¹. The purifying complex had

achieved a total capability of 220 thousand m³ in the process of its realization in Riga in 2001. The water source "Baltezers" has an intensive underground water supply and still can increase its capability 1.5 times thus achieving the level of production of 80 to 85 thousand m³ dnn⁻¹.

The water source "Baltezers-I" is able to increase its productivity up to 27 thousand m³ dnn⁻¹.

The planned productivity of the water source "Baltezers-II" used to be 30 thousand m³ dnn⁻¹. Research will be carried out in relation to the renovation of the well activity facilitation, and the essential rehabilitation works will be accomplished. Capabilities of only such water sources should be increased where it would be economically beneficial.

The capability of the water source "Zakumuiza" can be increased up to 48 thousand m³ dnn⁻¹.

The underground water wells equipped with a deep pump and connected to the pressure wires allow flexibly to increase or decrease the supply of water in the city in morning or evening hours when the level of consumption is changing. It would be efficient to increase quantity and capacity of such wells.

Conclusions

The desirable working regime of the Riga water supply system to 2010 would be when 50% would be catered from the underground water sources and 50 % from the drinking water preparatory station "Daugava".

Extension of the water supplier "Zakumuiza" would increase from 72% to 85% that fraction of the distributed water that complies with the EU drinking water directives.

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ECONOMIC SCIENCES

EU-STRUCTURAL FUNDS FOR RESEARCH IN LATVIA

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Abstract

Latvia has become a fully-fledged Member State of the European Union (EU) and now is a part of the global integration processes. The EU has set a goal to form a knowledge-based society and to become a region with a dynamic economy. For this reason it is necessary to increase scientific research and innovation capacity. The scientific potential is characterized by adequate supply of materials, facilities and equipment. It is a precondition for any kind of productive scientific activity. It must be noted that equipment, along with materials and resources necessary for their maintenance and operation in scientific institutes and by groups of scientists, has not experienced any significant improvement since the Soviet period. Since 1990, budgetary funding for science has been sufficient to ensure a mere survival. In 2004, Ministry of Education and Science, together with scientific institutions, drafted the National Programme "Support for Modernization of the Scientific Infrastructure in the State Research Institutions". The funding made available through the EU Structural Funds can be used for purchasing new scientific equipment for the state research institutions.

Key words: EU Structural Funds, National Programme, scientific infrastructure.

Methods

The information for this report is compiled by the National Development Plan (Single Programming Document) and the Programme Complement, by the information of the National Programme, scientific sources related to the set aim and tasks, as well by sources of Web sites.

Introduction

Presently, insufficient funding prevents the research institutions to purchase modern equipment. Deterioration of the resource base in universities and research institutes causes a rapid degradation in the effectiveness of their operations. Because of low industrial activity, in industry the development of research and technology is weak. The operating enterprises that are developing sectors with a substantial share of high technologies, are not receiving support from the Government [2].

From 2004 the EU Structural Funds have been used in Latvia and the use of the Structural Funds is guided by the National Development Plan (Single Programming Document) and the Programme Complement both of which are documenting the implementation provisions for Latvia's 2004–2006 EU Structural Funds Programme [3, 5]. Taking into account the current social and economic situation, the National Development Plan sets out development strategy for Latvia. The EU Structural Funds are making an effective

Source: http://www.esfondi.lv
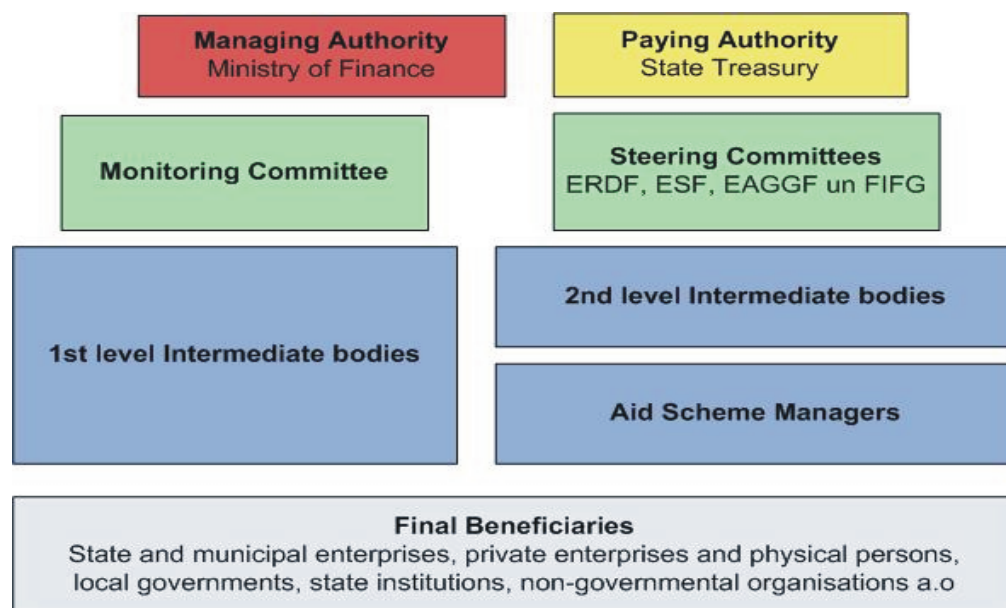
Fig. 1. The Institutional Framework of the EU Structural Funds in Latvia.

contribution for research in Latvia. A modern research infrastructure is a prerequisite for the development and the use of future-oriented technologies.

Institutional Framework of the EU Structural Funds

In figure 1 is shown the Institutional Framework.

The *Managing Authority* of the EU Structural Funds in Latvia is the *Ministry of Finance* and it ensures: 1) Elaboration of the National Programme; 2) Overall management, implementation, control, monitoring and evaluation of the National Programme; 3) Secretariat for the Monitoring and Steering Committees.

Under the Ministry of Finance is the *Central Finance and Contract Agency* (*2nd Level Intermediate Bodies & Aid Scheme Managers*) – which functions are:

1) ensure technical, administrative and financial management in respect of final beneficiaries;

2) call for proposals;

3) receive project applications and ensure administrative assessment;

4) enter into contract with Final Beneficiaries or bodies/firms carrying out operations;

5) carry out controls.

The paying Authority is the *State Treasury*.

There are four *Steering Committees* – one for each Structural Fund. The functions are the following:

1) approve guidelines for applicants (including project application form);

2) approve Standard Contract between 2nd Level Intermediate Bodies/Aid Scheme Managers and final beneficiary/body or firms carrying out operations in case of Structural Funds National Programmes;

3) open call for applications and Aid Schemes;

4) give + opinion to list of projects of open calls for applications;

5) give + opinion to EU Structural Funds National Programmes and their projects;

6) give + opinion to Aid Schemes;

7) monitor on a regular basis implementation of priorities and measures on each EU Structural Funds level.

The *1st level Intermediate Bodies* are ministries involved in the implementation of EU Structural Funds. The 1st level Intermediate Body/Line Ministry is responsible for development of the National Programme and submission for consideration to the Steering Committee. The 1st level Intermediate Body / Line Ministry develops project selection criteria for projects and submits the criteria to the Monitoring Committee for approval. In case of positive opinion of the Steering Committee, the 1st level Intermediate Body / Line Ministry approves the projects of the National Programme.

Final Beneficiaries are State and municipal enterprises and physical persons, local governments, state institutions, non-profit organization.

Monitoring Committee –

1) confirms the Programme Complement;

2) confirms project specific selection criteria;

3) monitors implementation of the Single Programming Document and achievement of its objectives;

4) considers and approves annual and final implementation reports (National Development Plan).

EU Structural Funds for Latvia

At present all four EU Structural Funds are available for Latvia, which allows Latvian government to grant financial assistance to resolve structural economic and social problems. Each of the four existing Structural Funds has its own specific thematic area. *The European Regional Development Fund* (ERDF) finances infrastructure, job-creating investment, local development projects and aid for small firms. The ERDF primarily supports productive investment, infrastructure and Small and Medium Size Enterprises development [6].

The ERDF has five priorities. The Priority 2 *"Promotion of Enterprises and Innovation"* is oriented towards entrepreneurship and promotion of science. It supports formation of new enterprises and increasing competitiveness of the existing enterprises by creating a beneficial environment for knowledge based economy. There are five Measures associated with the Priority 2.

1. Support to Development of Innovation.

2. Business Infrastructure Development.

3. Enhancing Business Support Measures for Small and Medium Size Enterprises.

4. Access to Finance for Small and Medium Size Enterprises.

5. Development of Public Research.

To the Research and Development (R&D) relates Measure 2.5 *"Development of Public Research"*. There are two activities:

- 2.5.1. Support to the implementation of the targeted applied research projects – the Open calls for Projects;

- 2.5.2. Provision of modern research equipment and infrastructure to the state research institutions - the National Programme *"Support for the Modernization of the Scientific Infrastructure in State Research Institutions"*.

As it is shown in Table 1, the final beneficiaries are state research institutions – the higher education institutions and state research institutions, which perform research activities in the relevant research field.

The National Programme is applied in cases where it is necessary to create a package of projects that are mutually linked and have a common objective. These packages of projects are elaborated in accordance with specific national sector strategy [1]. The projects in National Programmes are fixed by implementing ministry and between projects is no competition.

To start project implementation, the 2nd level Intermediate Body concludes the agreement with the Final Beneficiary on project implementation and ensures operational monitoring of the implementation.

Table 1

Implementation and Monitoring Arrangements

Priority/ Measure/ Activity	Implementation Procedure	1st Level Intermediate Body	2nd Level Intermediate Body	Final Beneficiary	Total cost (LVL)
2.5.1	Open calls for Projects	MoES*	CFCA**	State Research Institutions	4,8 mill
2.5.2	National Programme	MoES	CFCA	State Research Institutions	10,5 mill

Source: Programme Complement for Latvia Objective 1 Single Programming Document.
* The Ministry of Education and Science
** The Central Finance and Contract Agency

Research Priorities

The support for projects is tailored to applied research activities performed in accordance with the research priorities adopted by the Decree No.548 of the Cabinet of Ministers for the period 2002–2005:

- **Information technologies** (telematics, systems of multimedia and telecommunications, new technologies of systems and software engineering);
- **Biotechnology, bio-medicine and organic synthesis** (gene therapy, new technologies for synthesis of biologically active compounds);
- **Material sciences** (nanomaterials, new materials in microelectronics, photonics and optoelectronics, biomaterials and other composite materials) and engineering;
- **Forestry and wood sciences** (sustainable forestry development, rational usage of wood biomass, wood processing technologies).

The National Programme *"Support for the Modernization of the Scientific Infrastructure in State Research Institutions"* is closely related with the above mentioned research priorities.

Results and Discussion

The National Programme *"Support for the Modernization of the Scientific Infrastructure in State Research Institutions"* is targeted at the provision of research institutions with modern scientific equipment with the aim to commercialize research [1, 4]. The cause of included projects in the National Programme involving with the strategic goal of the research – to develop the competitiveness for National Research Institutions – and tasks to achieve that goal:

- to establish conditions for innovative entrepreneurship development;
- to modernize the infrastructure for the research and development.

The National Programme is coordinated by the Ministry of Education and Science (MoES) and the project implementation period is 2004–2006. The target group is state research institutions:

- **State research institutes** (e.g. Latvia Institute of

Organic Synthesis, State Institute of Wood Chemistry);
- **Universities** (e.g. Riga Technical University, University of Latvia, University of Agriculture of Latvia, Riga Stradin's University, Daugavpils University, Ventspils University College);
- **University Research institutes** (e.g. Institute of Solid State Physics, Institute of Atomic Physics and Spectroscopy, Institute of Mathematics and Computer Science).

The process of the approval of the National Programme is:

- draft plan for the National Programme (November, 2003–March, 2004);
- approval at the Programme and project evaluation commission of the MoES – April 7, 2004;
- approval at the Steering Committee of the ERDF–June,17 2004;
- MoES Decree No. 523 of the approval of the National Programme – September 10, 2004;
- signed triangular agreements (6) between MoES, CFCA and research institutions – during September 29 and October 7, 2004 for implementation of ERDF funds;
- signed triangular agreements (2) between MoES, CFCA and research institutions – March 15, 2005;
- to design signed triangular agreements (8) between MoES, CFCA and research institutions – June 30, 2005.

Financing of the National Programme

The total amount for implementation is LVL 10 522 107 (22 projects), int.al., ERDF financing – LVL 7 891 580; MoES co-financing – LVL 2 630 527:

- *2004 – LVL 4 077 927 (6);*
- *2005 – LVL 4 313 180 (10);*
- *2006 – LVL 2 131 000 (6).*

(Without ERDF and MoES financing there are research institutions financing – LVL 101 113).

Eligible Activities of the National Programme

The National Programme (within 22 projects) includes the following main activities:

- purchasing of new equipment;
- renovation and adjustment of laboratories for the placing of the new equipment;

Table 2

Implementation of the National Programme Projects in 2004

Project Applicant	Title of the Project	Total budget (LVL)	Financing Sources of the Project (LVL)
Institute of Solid State Physics (ISSP)	The Modernization of Infrastructure in the Institute of Solid State Physics of the University of Latvia	1 193640	ERDF: 856 895 MoES: 285 632 ISSP: 51 113
Biomedical Research and Study Centre of the University of Latvia (LU BMC)	Equipment for Development of Latvian Genome Database	422 500	ERDF: 316 875 MoES: 105 625
University of Latvia	Modernization of Infrastructure for Material Sciences and Astronomy in the University of Latvia	885 300	ERDF: 663 975 MoES: 221 325
The Latvian Institute of Organic Synthesis (IOS)	The Improvement of the Scientific Infrastructure in the Latvian Institute of Organic Synthesis (IOS)	828 500	ERDF: 621 375 MoES: 207 125
Riga Technical University	Support of Equipment and Infrastructure of Research Centers of Engineering Sciences in Riga Technical University	708 100	ERDF: 531 075 MoES: 177 025
Dobele Fruit and Berry Experimental Processing Centre	Modernization of the Fruit and Berry Experimental Processing Centre and Fruit Storage Facilities	91 000	ERDF: 68 250 MoES: 22 750
		Total:	4 077 927

Source: Nacionālā programma "Atbalsts zinātniskās infrastruktūras modernizēšanai valsts zinātniskajās institūcijās" 2004.–2006.

- installation of equipment;
- personnel training for the work with the equipment;
- project management costs.

Table 2 shows that in 2004 there were implemented sixth projects of the National Programme with the total budget – LVL 4 077 927.

Description of implemented projects

Project "Modernization of Infrastructure in the Institute of Solid State Physics (ISSP) of the University of Latvia" http://www.cfi.lu.lv/

Objectives of the Project:
- to provide the possibility for preparing the staff with the highest qualification;
- to update the research equipment.

The result of the Project is purchased technological equipment (26) for nanomaterials and nanotechnologies, incl.: microscopy, electronics measuring equipment and optoelectronic equipment and lasers, as well trained personnel (11) for the work with the modern equipment, renovated and adjusted 5 of laboratories (178 m^2) for the placing of the new equipment.

This project will give a great opportunity to work on modern equipment, to train people in work with new technologies, to develop new inorganic materials and new technologies for psycho-physical testing and primary vision care.

Project "Equipment for Development of Latvian Genome Database"

Objectives of the Project

An objective of the project is to provide Latvian genome data base with advanced infrastructure. Project is aimed to ensure recourses for gene analysis and genotyping within the framework of Latvian population genome database. Created infrastructure modules are available for Latvian research organizations and will improve developing high level medical and scientific research.

Contents and results of the project

Serious and modern equipment is needed to create functional genome analysis centre. Even though there is high level scientific potential in Latvian biomedical research, this area lacks serious investments in modern technologies which are based on use of high level equipment. The project is aimed at improving this situation. The result of the project is a fully functioning genotyping centre at LU BMC. The infrastructure obtained by support from the EU Structural Funds raised the quality level and productivity of genotyping necessary for fully functioning genome data base.

1. Two robotic workstations Freedom EVO 100/4 (Tecan) for liquid handling, reaction setups and purification of biomolecules.
2. Autoflex MALDI-TOF mass spectrometer (Bruker daltonics) for high throughput genotyping and proteomic analysis.

3. Real time PCR 7500 (Applied Biosystems) for quantitative gene expression analysis and genotyping.
4. Centrifuge Avanti J-30I (Beckman Coulter) for preparative separation of macromolecular components of the cell.
5. Akta FPLC system including fraction collector for preparative protein purification.
6. Fluorescence microscope Leica DM 6000 (Leica Microsystems) for fluorescence imaging of cells.

Technological improvements and developments made by the project will be used for genome and medical research in Latvia at least within next ten years. Development of high level genomic research and biobanks is one of the most perspective directions in modern biomedical research and health care. Latvian genome database will effectively improve knowledge – based economy in the field of medicine and pharmacy.

Project "The Improvement of the Scientific Infrastructure in the University of Latvia in Field of Material Science and Astronomy" http://www.lu.lv

Reason why the Project was set up

Scientists working in the University of Latvia and its institutes can successfully compete or be leaders in the field of material sciences thanks to scientific potential, experience and existent resources accumulated in Latvia. However, the lack of the up-to-date equipment and infrastructure, particularly the usage and development of modern technologies that dominate in Europe and the world, prevent the competitiveness. As a result, the accomplishment of a high level research and the production of specialists with the highest qualification are prevented, young scientists don't wish to work in Latvia and foreign researchers cannot be attracted.

Objectives of the Project
- To update the research equipment in the field of material sciences in the University of Latvia.
- To provide the accomplishment of the basic research functions of material sciences at the world level, as well as to develop technologies and new products with practical application.
- To provide the possibility for preparing the staff with the highest qualification using modern research equipment, to ensure the wish of young scientists to work in Latvia, as well as to attract foreign researchers.

Results of the Project
- Promotion of the competitiveness and employment: the project will promote the competitiveness, development and commercialization of products with high added value.
- Development of human resources: the project will promote the research work and where with the quality of knowledge and skills of education workforce.
- Development of infrastructure: the research infrastructure (equipment – 23 pieces) will be purchased within the framework of the project. Purchased equipment

will be the most perspective in the development of new investigations and products.

Perspectives for the Future

The modernization of the resources of the University of Latvia and its institutes will let to successfully develop more perspective scientific disciplines such as material sciences, int.al., nanotechnologies and magnetic hydrodynamics, will promote the transfer of technologies and development of the national innovation system in research and industry, as well as will contribute to the development of human resources. As a result, gradual reorganization of national economics towards up-to-date technologies and generation of knowledge intensive production with high added value will be possible. EU Structural Funds enabled the University of Latvia and its institutes receive additional funding for the modernization of scientific equipment in material sciences and astronomy that was not possible with existing funding from the national budget and other Latvian or foreign resources.

Following indices related to the fulfillment of the Lisbon strategy will be achieved as a result of the project.

- Achieved average EU indices for one resident: by encouragement of scientific elaboration and development of products with high added value Latvia will be capable of ensuring comparatively fast economical growth and cohesion.
- Promoted sustainable territorial development: the development of research will be promoted in the framework of the project. It will create a positive spill-over effect promoting the development of regional economics via introduction of new products and elaborations.

Project "The Improvement of the Scientific Infrastructure in the Latvian Institute of Organic Synthesis (IOS)" http://www.osi.lv

Reason why the Project was set up

The project was set up to upgrade the equipment of the Latvian Institute of Organic Synthesis (IOS). Currently the potential of the Latvian pharmaceutical companies to develop new drug candidates is impaired by the fact that none of them possess necessary resources to create full pharmaceutical R&D cycle. By concentrating the necessary up-to-date equipment and scientific knowledge base in the institutes, and making it available to pharmaceutical companies, the capacity of the whole industry to create new high value added pharmaceutical products can be substantially increased. The IOS collaborates in several stages of development of new medical substances with Latvian pharmaceutical companies *Grindex* and *Olainfarm*, as well with companies from US, Japan, UK, Germany, Sweden, Denmark, and Finland.

Objectives of the Project

The goal of the project is to improve the scientific infrastructure in IOS, namely, to procure the unique scientific research equipment necessary for the medical, pharmaceutical and organic chemistry industries to conduct research on the analysis of biologically active compound

structures. The highly qualified personnel of IOS, its scientific research knowledge as well as laboratory space of IOS will provide excellent basis for the exploitation of the equipment procured within the scope of the project.

Activities of the project

The following activities were made within the scope of the project.

- Organising the tender for procurement of the equipment according to the Latvian laws regulating public purchases.
- The procurement of the following equipment:
  - Multinuclear 600 MHz NMR Spectrometer;
  - Liquid Chromatography System with Mass Selective Detector.
- The installation of the equipment and personnel training.

Results of the project

Due to the support provided by the EU Structural Funds, IOS obtained a potential to offer Latvian pharmaceutical companies scientific services of substantially higher quality as well as design new services to meet the needs of the industry. Moreover, due to the character of the support, new services can be provided with maximum cost efficiency.

In the future IOS plans to apply for the EU Structural Funds to finance the applied research. The project facilitates the development of high value added pharmaceutical products and knowledge intensive technologies, thus contributing to the competitiveness and sustainable growth of EU economy.

Project "Support of Equipment and Infrastructure of Research Centers of Engineering Sciences in Riga Technical University" http://www.rtu.lv

Objectives of the Project

Project aim is to support purchase of modern equipment and modernization of research laboratories in engineering sciences. This, in turn, will create necessary preconditions for Latvian specialists to increase their competitiveness and participate in development of knowledge intensive technologies at European and world level, as well as to commercialize research and develop high added value production in Latvia. The project is also promoting new contact development with foreign universities.

Activities of the project

- Preparation of tendering documentation.
- Tenders for equipment supply contracts.
- Supply and installation of scientific equipment.

Results of the project

Within the project, 237 units of new scientific equipment were purchased, thus supporting 19 scientific laboratories in fields of machine building and electrical engineering. New equipment will facilitate development of human resources, as many new scientists will use the equipment. At the same time, project results are directly targeted at improvement of competitiveness of Latvian industries through development of new products and more competent problem solving capacity for industrial processes.

Project "Modernization of the Fruit and Berry Experimental Processing Centre and Fruit Storage Facilities" http://www.ddsis.lv

Reason why the Project was set up

At present only 10% of the Latvian market is supplied with local fruits. Therefore research about suitable storage regimes for commercial varieties is very important. In 2003, such research was already started at the Dobele Fruit and Berry Experimental Processing Centre (Dobele HPBES). Yet, in Europe, the ULO type modified atmosphere storage comes into use more and more, because it makes possible better maintenance of fruit quality for a significantly extended period of time. It is necessary still to find the most suitable gas mixtures for each fruit crop and variety, as well as their length of storage and other parameters. For this reason it was planned in this project to purchase experimental ULO type storage facilities with 4 chambers, to perform simultaneous research in different regimes.

Another important issue linked with the increase of the amounts of processed local fruits and berries, is research concerning fruit and berry processing. An experimental Fruit and Berry Processing Centre has been established at the Dobele HPBES, which includes a processing unit, biochemical laboratory, facilities for deep freezing and cold storage. For 4 years research is done for a wide range of fruit varieties, which will allow the growers to select the most suitable varieties and provide processing enterprises with new technologies. For extended and more precise research, universal equipment for making experimental lots of fruit and berry additives and special press for pure juice were necessary.

Taking into view the expected joining to the EU, the processing facilities were necessary to adapt according to the EU Standards and Latvian Cabinet of Ministers Rules. This demanded repairs and reconstruction.

For the improvement of the fruit and berry biochemical laboratory, purchase of a spectrometer was included in the project, which will allow to solve the problem of rapid and low-cost quantitative analysis of simply isolated and stained components. The experience obtained during the work, demand from the producers, participation in several international projects, as well as the current trends of research in the world make it necessary to work on the analysis of complex, biologically active substances (vitamins, polyphenols, etc.). One of the most widely used methods here is high performance liquid chromatograph (HPLC), so the purchase of a high pressure liquid chromatograph was planned.

Objectives of the Project

To create, during the implementation of the project, a possibility for essential expansion and modernization of fruit and berry processing research, necessary for the development of commercial fruit growing in Latvia, aiming first of all at the development of healthy, functionally active products. The results of the research will be used by the processing enterprises in this field, so increasing their com-

petitiveness after joining to the EU. Carrying out of the project will allow to begin research about the storage possibilities of Latvian-grown fruit and berries in ULO type storage, to introduce its results in specialized farms, so providing the local market with fresh locally grown fruits and berries during the whole season.

Activities of the project

The project activities can be roughly divided into 4 packages.

1. Organizing of price polls and competitions linked with purchase procedures.

2. Renovation and adjustment of the premises for the placing of the new equipment.

3. Purchase of the experimental equipment.

4. Training of the personnel for the work with the equipment.

Results of the Project

- The project will stimulate the development of competitive, high added value products and their commercialization.

- The project will facilitate research and, as a by-product, the quality of knowledge and skills of the education employees.

- In the framework of the project there is purchased scientific equipment most promising for the development of new research and products, along with the improvement of the infrastructure of the research facilities:

  • equipment for fruit and berry biochemical laboratory – high performance liquid chromatograph (HPLC) "Shimadzu HPLC VP System", spectrophotometers "Shimadzu UV 1650 PC";

  • equipment for fruit and berry processing centre – universal equipment for production of fruit and berry additives (also jams, jellies, etc.); juice press "VORAN 60 Hydraulic Basket Press";

  • purchase and establishment of ULO type experimental chambers (4 pcs.) and gas regime maintenance and control equipment.

Perspectives for the Future

The scientific equipment purchased as a result of the project will allow to continue and extend research in the development of innovative – healthy, functionally active products, using up-to-date biotechnological methods. It will also help more easy involvement in the EU Framework projects, as the obtained research results will be more comparable to the results obtained in the developed EU countries.

The up-to-date fruit storage technologies purchased during the carrying out of the project will allow to begin research about new storage possibilities for fruits and berries grown in Latvia, which will result in increased competitiveness of local specialized fruit grower cooperatives, supplying the local market with homegrown products all the season, and create export possibilities for some products.

The project was aimed at the development of healthy,

functionally active products. This means – products obtained from fruits and berries with high biochemical value, grown by using sustainable, environment-friendly technologies. Latvia is one of the few countries in the world where the climate allows production of fruits with high biochemical activity while using minimal applications of chemical sprayings. The development of innovative, characteristic (specific) to Latvia food products certainly will indirectly facilitate also the development of tourism.

One of the projects of the National Programme implemented in 2005 is the Ventspils University College project "Provision of Infrastructure and Modern Scientific-Technical Equipment for the Antennae of Ventspils International Radio Astronomy Centre (VIRAC) for Implementation of Scientific and Commercial Projects"(http://www.virac.lv). Total budget of the project is LVL 405 000, of which ERDF financing – LVL 303 750 and MoES co-financing – LVL 101 250. The project envisages the renovation of premises, establishment of fast internet broadband connection, purchase and installation of equipment in the former military object – Ventspils International Radio Astronomy Centre. In the framework of the project the purchased equipment will provide possibilities to do observations of radio waves with radio telescope RT-32. It will serve as a precondition for the integration of VIRC into *The European Very Long Baseline Interferometry* thus gaining opportunity to take part into extensive international research projects. In the result of a project, the purchased equipment will be available for carrying out different research tasks and also for students and new specialists for writing their bachelor, master and doctorate theses.

In 2006 it is planned to implement the project "The Improvement of the Agricultural and Forestry Research in the University of Agriculture of Latvia". The project envisages purchase of 14 units of new scientific equipment (e.g. ultrasonograph, liquid chromatograph for determination of vitamins and amino acids, infra-red light analyzer for determination quality parameters of the fodder), installation of equipment and personnel training for the work with the equipment.

Conclusions

1. From 2004 the Structural Funds (SF) were used in Latvia.

2. With the goal to modernize Infrastructure in National Research Institutions, the National Programme *"Support for Modernization of the Scientific Infrastructure in the State Research Institutions"* was elaborated.

3. The National Programme is coordinated by the Ministry of Education and Science (MoES).

4. The National Programme includes 22 projects, of which 6 projects are implemented.

5. Purchased equipment will be available for carrying out different research projects in international collaboration and also for students and new specialists to carry out research work.

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DEVELOPMENT TENDENCIES OF LAND MARKET IN LATVIA IN THE FRAMEWORK OF LAND USE POLITICS

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Abstract

Before Latvia initiated the transition to market oriented economies, large collective units, which had the right to use the land, used most of the land but were not necessarily the landowners. This situation provided a special starting point for the return to the market economy in the agricultural sector. The government of Latvia decided to implement restitution of land ownership rights to former owners basing on historical boundaries as a method to privatise and open the land market. There were two processes going on at the same time: the restitution of private ownership rights to land, and the break-up of collective productive units. The restitution processes are the starting point for the development of land markets. Moreover, it represents a necessary condition to open land markets. However, the pace at which this land market opening is occurring depends on the way each government implemented the land reform.
Key words: land, price, market.

Introduction

Land prices are needed to determine the optimal allocation of land resources among different uses, as well as to determine the value of land as collateral for credit or to define land taxes. Therefore, wrong or misperceived land prices could lead to inadequate allocation and use of land resources. Land markets face constraints derived either from the characteristics of the factor (land), such as being a not mobile resource, or from the economic environment, such as taxes or regulation on land uses. All these factors, as well as the relevant cultural and socio-political characteristics, affect the solutions reached in the land markets to solve the land allocation problem. These solutions are expressed by the market prices for land.

Several Latvian economists have analysed findings on the market of state owned and behoving land for the period between 1997 and 2002. This research dwells upon the organizations of the land market, dynamics of sold (privatised) land areas, prices fluctuations and relations between means of payment (Špoģis, Dobele, 2003). There are different researches in social, economic and ecological factors affecting the land market in Latvia, which present different opinions of the factors that affect the land market (Dobele, Špoģis, 2004). Some of them had made analyses in land use and analyse the land market in the district of Madona (Dobele, Grundmane, 2003). There are also researches in the role of planning in land use policy after the land reform in Latvia (Dambīte, Vilciņa, 2004), but there are not enough researches about the land market behaviour to prescribe the basic regulations and to put into effect defined instruments in the land use politics.

Two important issues should be addressed when analyzing market solutions for land allocation through land prices. First, land prices will be capturing all the factors affecting the performance of land markets. Second, land market prices will not necessarily reflect the value of land; land market prices are a solution to the land use problem in the short run, while the value of land should be the instrument to define long-term land allocation (long run land prices will tend to equal the land value). Land prices are the result of the interaction of various factors in the land markets.

The author propounds the following **hypothesis:** researches of the land market preconditions may improve working out of land use politics instruments after land reform.

The **objective** of the research is to evaluate the land market development factors, which influence land use, to better understand how land markets work and which variables, that are not directly related to land use, affect the land market functioning, to promote prescribing the basic regulations of land use politics.

The following tasks have been set to achieve this objective:

- to analyse theoretical aspects and factors which influence land rent, land prices and land market;
- to find out land market and land price changes within the framework of land use politics;
- to evaluate land market development tendencies.

Materials and Methods

Materials, which have been used for this research, are data from Central Statistical Bureau of Latvia, special literature about land and real estate market, and data from the State Land Service of the Republic of Latvia.

The following research methods were used: linear regression and correlation analysis, as well as the method of statistical grouping.

Results

Preconditions of the land market, factors, which influence the forming of land market, and development tendencies of land market in the framework of land use politics may be studied considering various aspects, which include several economic branches. The research can be worked out in different ways. Land market development tendencies, demands and problems changes with the growth of development of the level of welfare and joining the international organizations. The author of the research basis arguments on the necessity to investigate land mar-

ket preconditions and factors which influence land market to estimate the probable influence on land use politics and to find connections among economic indicators. Using all this knowledge corresponding activities, promoting and restrictive measures are taken to improve the development of land use politics. During the research work there were analysed one of the important tendency of land use, to estimate factors of land market and its influence on agriculture land prices in Latvia.

Land as a resource of means of production in comparison with other means of production has various specific differences. The basic of them:

- land is a natural resource and not a person's work product. Land becomes the means of production only in the result of historical development of a society;

- all other means of production increases their indicates in a quantitative and in a qualitative level. Land as area is limited, it could not be maximized, created again, substituted with another means of production;

- land use is connected with a permanent place. Land is using only there, where it is situated. It could not move to other place, in the case of need is it a possible to move other means of production;

- in the process of use all means of production are going to depreciate, to minimize their own expedient characteristics, and at the end completely going out of production. While land in the process of production is getting more fertile;

- one of the important characteristic of the land as agriculture means of production is its fertility. (Špoģis K., Vedļa A., Mihejeva L., 1996)

There are a number of common obstacles faced by the land markets:

- restitution and/or privatisation processes are not finished (unsolved restitution claims, differences between legal and physical restitution, registration problems, etc.),

- political restrictions imposed by the governments to avoid drastic changes in agricultural sector (prohibitions on certain land transactions, incentives to avoid massive decollectivizations, etc.),

- lack of incentives to undertake private, either individual or collective, farming business (credit, technical assistance, marketing, etc.),

- significant power of state agencies in the land market (as owners or lenders) and as providers of the regulatory framework,

- social and economical differentiation between managers of reformed collective units and private farmers,

- relevant governmental organizations still in a transition and/or redefinition stage, and

- cultural, ethnic and social values strongly attached to land ownership. (Trivelli, 1997 b)

All these characteristics together affect the performance of land markets in Latvia. As a consequence, markets forces do not necessarily drive land allocation among different uses and/or users. Land prices, which should be the mean to define the best land allocation, are conditioned to the factors affecting the land market performance. In this sense land prices are not resulting from the market adjustment of supply and demand, but from the factors described previously.

During the process of land tenure restitution there was realized idea to give back land to natural persons as tenure. Figure 1 shows that 59.3% of the total area of the Latvia in 2004 are under the properties and land assigned for uses to natural persons, which compose 3 827.2 thousand ha of land.

Structure of land properties and uses shows the actual results of land reform. It is a very positive result of land reform because the tendency of land properties is still increasing. Good conditions in the tenure system in the country promoting further development in the market conditions, because of the secure environment for entrepreneurship. Till the registration of the real property in the Land book, the real estate acquirer to the third persons have no any rights and can not be used not a single one precedence which is related to the real estate.

The problem of how to define, determine and assign a price, or a value, to land is an important issue in the economic literature. Land could be seen as an asset, but also as production factor that serves production and consumption purposes. Land assets have three important characteristics: scarcity (land exists only in fixed amounts and cannot be created easily), not mobile, and durable (it cannot be destroyed easily). These characteristics make land an attractive asset as productive factor, as collateral for credit and as store of wealth.

Most of the literature on land prices agrees that the price of land can be obtained based on the estimation of the present value of the stream of all future net returns to land, as in the case of any other asset. However, this does not necessarily mean that the market price of land will always equal the present value (PV hereafter) of the future rents because there could be different factors affecting the market price of land, that do not affect the present value measure.

The PV formulation is a good representation of the long-run equilibrium price of land because is based on all the theoretical sources of land value. This long-run equilibrium price is called, in the economic literature, a market fundamental because it is based upon fundamental economic variables. This long-run price should equal the land value. Market prices, however, can deviate from the market fundamentals for several reasons, such as expectations of future changes in land prices, land market imperfections, among others. The PV formulation is not necessarily an appropriate representation of the short-run behavior of land prices. This PV formulation states that the price of land is a direct function of the rents that could be obtained from the use of land for productive activities; that is, the higher the rents, the higher the land price; and that
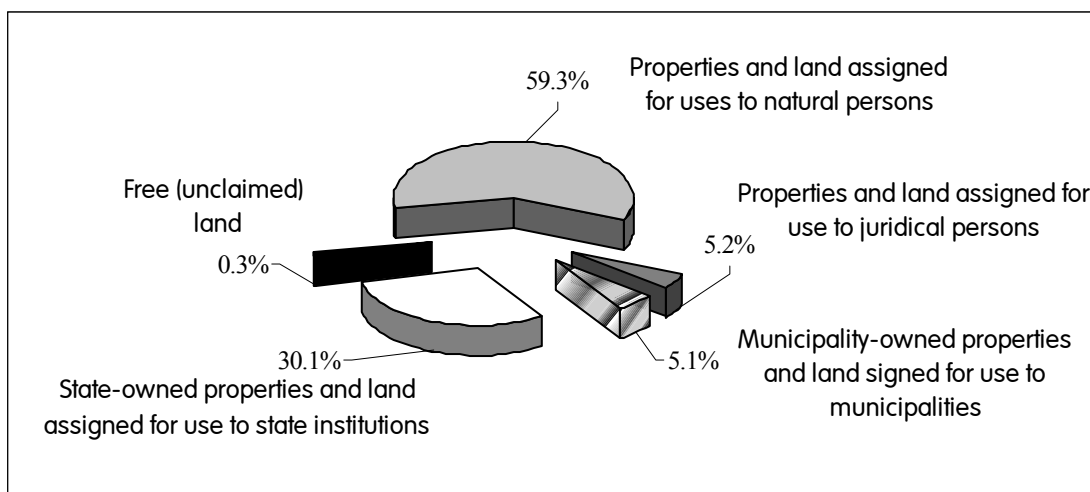
Source: Land balance, 2005.

Fig. 1. Structure of Land Properties and Uses According to Owner's Status and Free Unclaimed Land in Latvia
(% of total area of Latvia on 01.01.2005.).

the price of land is a function of the inverse of the interest rate (that defines the discount rate), meaning that higher interest rates will mean lower land prices. (Trivelli, 1997 a)

Land rents (R) are defined as the net return to land, accounting for the income remaining after paying for all productive factors and inputs (except land) involved in the agricultural production process. In the case of rented land, the amount paid as rent by the tenant represents the total rent for land, which becomes the net return to land after paying all ownership costs (property taxes, maintenance costs). Alternatively land rents (R) can be defined not only as net rents, but as the aggregation of two factors: the net residual income (R1), and the net capital gains (R2) defined as the change in land value caused by changes in opportunity costs or inflation (then R = f [R1; R2]). Land rents and capital gains determine land prices. Land rents are the fundamental source of value, but there are other sources of land value that can result of changes in land rents due to market adjustments and or to changes in the benefits of owning land, mainly due to speculative movements in the asset markets. The two land rent components have different determinants and arise from different processes. Assuming that R can be decomposed we could analyze the main components of net rents. On one hand, R1 is the result of the agricultural production process. In a world with fixed supply of agricultural land, the potential land buyers determine R1 or tenants, which, based on their technology, availability of other productive resources and the market prices of agricultural inputs and outputs, determine the demand for agricultural land. On the other hand, R2 responds to expectations about the changes in the value of land due to changes in prices and opportunity costs in other economic sectors. This rent component is more related to land assets used as stores of wealth than to land used as productive factor. In most of the literature R2 is assumed to be a function of expected changes in net rents or in the value of land,

and in that sense the issue of how expectations are formed and what information is available at a certain time becomes relevant. Capital gains, R2, could be as important as R1 in determining the price of land, especially in inflationary and unstable economic environments. (Trivelli, 1997 a)

A land buyer will be willing to pay the full capital value of land, the total PV, accounting for the total net rents (R), land as a productive factor and as store of wealth, because he/she will obtain full benefits of both uses of land. A tenant will be willing to pay rent only based on R1, without considering R2 because the tenant only receives the benefits derived from using the land as productive factor.

Our goal in the next lines is to discuss the expected effects of different variables and scenarios that affect net rents and the capital gains components of land prices. We will discuss the variables that affect the R1 component of land net rents, as well as the ones affecting the capital gains component (R2). Land net rents are determined in the land market by the adjustments of supply and demand. Supply and demand for agricultural land jointly determine the price at which land will be allocated, that is the land rent. To simplify, let's assume for a moment that there are no costs of owning land (property taxes, depreciation), and then the land rent determined in the market will be the net return to land. If there is a fixed supply of land for agricultural production, rents (R1) are determined by the demand for land for agricultural activities. The demand for land is determined based on the value of the marginal product of land (VMP), which is the value of the production that can be attributed to land (implicit land rent). The VMP is the result of the production conditions (technology, input prices, capital level, and other production factors use) that can be seen as the production function of certain output, and the output market prices. Then, land rent (R1) equals the marginal productivity of land times the output prices. Marginal productivity of land can be derived directly from the production

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function (that is the technical relation between inputs and output for a given technology). The VMP is a measure of the shadow price of land (implicit land price). (Trivelli, 1997 a)

Land rents will change if demand for land changes. The main reasons for changes in land demand, considering land only as productive factor only for agricultural purposes, arise from changes in the determinants of the VMP, such as changes in relative prices (output/inputs), access to capital, technological improvements and in production conditions. Of these changes only the ones related to technology can be endogenous, the others are exogenous. If land supply changes (with constant demand for land) rents will change as well.

Production infrastructure has also a positive effect on land rents, and therefore on land prices. Similarly, better production conditions, such as irrigation systems or water availability are reflected in higher land prices.

Land demand is based on the VMP, which is a function of the real prices of the output. The relevant output prices for each land buyer or tenant are the net prices received for the output in the market, which is the market price less all the costs of taking the products to the market. These relevant prices are a function of the marketing system (more market efficiency then less marketing costs), the distance and transportation systems, the market information system (that reduces uncertainty and also the probability of having an inefficient transaction), among others.

In regional or local markets the distance between the markets gives the main difference among producers and the plot of land, then among land plots with the same characteristics, the more valuable land is the one located in the better position with respect to the market. (In rural areas distance is not always the better measure for proximity - transportation systems and communication infrastructure have decisive effects.) The localization of land becomes an important characteristic because land is not a mobile asset. There was found that the less favorably located (with respect to the market) were more affected by land price changes that the ones located near the market.

Fixed land zonification laws have an impact on land prices. If land can only be used for agricultural production then the rate of return of alternative uses of land becomes not important in the land price determination. With fixed agricultural zoning regulations, the shadow price of land is based only in the agricultural use of land (the VMP). This situation allows inefficient land allocation, because land will be used for agricultural production also if there is more attractive return opportunities derived from using land in other activities (urbanization, mining activities, and tourism).

The degree of land fragmentation could be affecting land prices. Once land is divided in small units the cost for a buyer of obtaining an efficient size plot are higher than if the plot is not divided and the buyer could choose the size of land he/she wants to buy. In the case of agricultural land the degree in which fragmentation will affect land prices

depends on the size of an efficient agricultural exploitation, meaning that if land plots are above the efficient (scale-efficient) size, land could have higher price respect to similar subdivided land.

Given that land is not mobile, and land supply tends to be fixed at local level, the local demographic conditions have a direct effect on land prices through land demand. Population growth and demographic variables could have an important effect on land prices at least through two different channels, first through the demand of agricultural products (food and fiber), and second, through demanding space (e.g. urbanization pressure).

According to Figure 2, the calculated linear regression coefficients are b = 0.1011; a = 4.2179. And the linear regression equation is Y = 0.1011x + 4.2179, the R – squared value equals to $R^2 = 0.5031$. The correlation coefficient is r = 0.709. So, that indicates an existence of comparatively tight positive relationship between agriculture land prices and the density of population. According to Figure 2, the increasing of density of population may be expected in the future that average price of agriculture land increases for 0.1 LVL per hectare.

Inflation has an important effect on land prices and one of the more controversial topics in the economic literature on land prices. In the first place, when there is inflation and full indexation (all prices grow at the same rate) then real output prices remain constant and so do real land rents. Obviously, inflation is never homogeneous and there is not perfect indexation, so one first effect of inflation on land prices arises upon the relative effect of inflation on agricultural real output and input prices. During inflationary periods there is also a tendency to observe growing nominal prices of assets as the money supply increases.

The second, effect, and probably the most important one, arises from the use of land as store of wealth. Real assets with fixed supply tend to hold its real value during inflationary periods and in that sense there is an inflation-hedging motive for land purchases. One argument supporting the inflation-hedging motive to buy land comes from the assumption of the availability of credit to purchase land. Under inflation, the real credit payments tend to decline over time, while the value of land remains constant or increases. In absence of credit programs to buy land, land purchases still an attractive investment opportunity as an inflationary-risk-free saving instrument. However, this type of investments (buying land) involves high searching and management costs that act like a disincentive to land purchases.

The attractiveness of land in inflationary environments is strongly related to the effect of inflation on real interest rates. If real interest rates are negative, then interest-bearing assets are no attractive, so investors search for other assets like housing and farmland.

The use of land as an inflation hedge affects directly the demand for land without affecting necessarily the use of it for agricultural production. This is a case of speculative

y = 0,1011x + 4,2179
R² = 0,5031

Density of population per km2

Average price of agriculture land LVL ha⁻¹

◆ Empirical data ——— Linear (Empirical data)
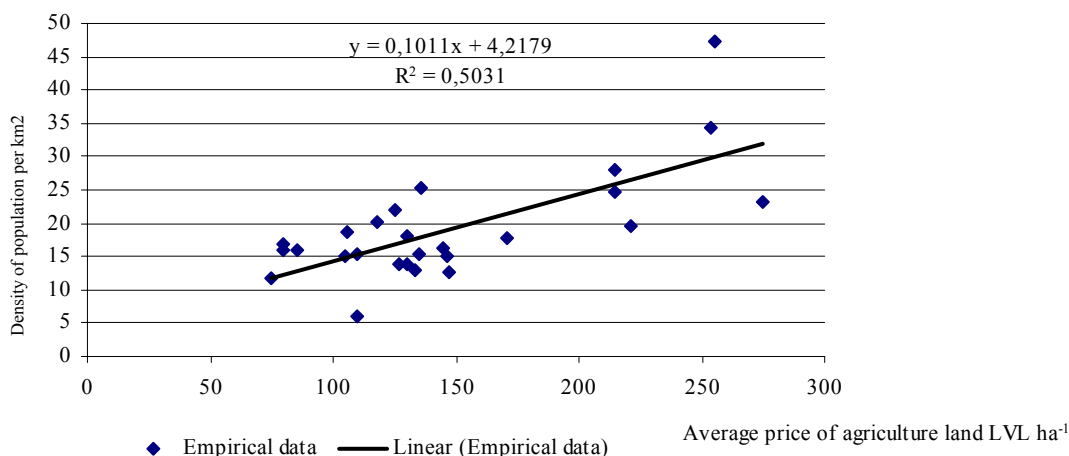
Source: Calculations according to data from the State Land Service, 2000 and Results of the 2001 agricultural census in Latvia, 2003.

Fig. 2. The empirical and theoretical regression of average price of agricultural land and density of population.

movements of land prices based on the expectations that potential investors have about the trend of real land prices under inflation. Investors expect real prices of land to grow or at least to stay constant during inflationary periods, as in the case of other durable assets. Two important issues need to be recalled here; first, investors which see land as an inflation safe investment usually are not land users, so they tend to keep leasing the land, which means that inflation hedging motives will affect the value – through capital gains – but not necessarily the rental value of land for agricultural production. (However, rental values will be affected by inflation through the changes in real output and input prices.) Second, to be able to reap of the benefits of the investments in land there must be a land market, in order to allow investors to buy land, but also to be able to sell it and obtain the benefits (in cash) of their investment. (Trivelli, 1997 a)

There are three variables which impact of price changes, these variables are: the liquidity constraints, the transactions cost in the land markets and the socio-economical and political environment where the land market is operating.

Liquidity constraints are important because of the direct effect in the opportunity cost of money. In the case of long – term investments, like most agricultural business, liquidity constraints are usually the binding constraint. If there is no financial system, land can only be purchased if one has enough cash to buy land, which will make demand for land small and scarce, but land under leasing arrangements will have a large demand. If there is a financial system the demand for land could increase proportionally to the access to financial tools (it is usual to find that financial systems operate under credit rationing). If everyone can access a loan to buy land, buy using the purchased land as collateral, land prices will tend to rise.

Furthermore, liquidity constraints can be binding not only the land transactions but also the use of land (production) through production credit constraints. In that case,

where land is used as collateral, the higher values of land will be translated into better credit conditions or availability. Then, land prices should be higher (have a premium) if that land serves as collateral for credit, than if it does not.

The transaction costs in the land market are the aggregation of a number of costs: legal paperwork, searching cost, valuation of the asset, management costs, bargaining, etc. The higher the transaction costs in the land market, the lower the incentives to do land transactions. This disincentive to do land transactions has two important effects, it does not allow land allocation to its best economic use and it reduces the demand for land as an asset because it becomes costly to obtain the benefits derived from owning the asset. This last situation is highly relevant for the use of land as collateral for credit. Banks are not interested in land as collateral if they cannot easily sell the land and obtain money in a short term at a low cost. (Trivelli, 1997 a)

Finally, but not least important, the socio economical and political environment where land transactions are taking place is crucial. If there are no attractive and safe investment opportunities, for example, land prices will tend to increase because of the higher returns and security offered by this asset. If the legal system is highly complex or unstable, if there is no security on land tenancy, if there is an unstable political environment no long term investments will be done, and that will affect land prices. If there is land ownership risk, prices will be affected negatively. Every economic, social and political context will offer distinctive features affecting land prices; all of them need to be taken into account when analyzing land market performance. (Trivelli, 1997 a) A summary of the main expected effects of different variables on land prices is presented in the following table.

Conclusions

1. Land prices, which are primarily a function of net returns to land, are affected by a number of variables

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Summary of the main expected effects of different variables on land prices

Expected Effects on Land Prices		
Changes in: (other things constant)	Expected Effect on Land Prices	Main reason
Increases in output prices	+	Increases the VMP of land
Increases in input prices	? (-)	Depends on the effect on output prices
Increases in the output/input price ratio	+	Increases the VMP of land
Technological change	+	Increases production per unit of land (VMP increases)
Soil conservation programs	? (+)	Depends on the capitalization of the soil conservation, that could be a function of the initial degree of soil problems
Increase of subsidies for agricultural production	+	Assuming subsidies have real impact on production costs, they increase the VMP
Increase in transaction costs in the output or input market	-	Decreases the real net rent received by the tenant/landowner
Increase in landowners fix costs (depreciation, maintenance costs)	-	Reduces the net rent that could be obtained from land. Also induces renting instead of buying.
Increase in searching, bargaining and transfer costs in the land market	-	Reduces the net rents that could be obtained from land. Also induces renting instead of buying.
Property taxes	? (-)	Represents an increase in owners costs but the effect depends on the relation between the taxes and inflation, and on the type of taxes.
Income taxes	? (-)	Reduces the net land rents, but it depends on the relation with inflation.
Inflation	+	Double effect. Speculative, increases attractiveness of land as asset (store of wealth) and, depending on the effect on real output prices, could affect demand (VMP)
Increases in real interest rate	-	Changes the opportunity cost of investments, makes more attractive other sectors.
Increase in expected future capital gains	+	The effect could be seen in two cases. With perfect information the expected gains tend to be real gains then price bubbles could be observed. With less information, more speculative movements and price overreaction.
Reducingfixed zonifications (agricultural land/urban)	? (+)	Breaking up fixed zonifications tends to open the market. The final effect will depend on what alternative uses for land come to be relevant.
Credit programs to buy land	+	More demand for a fixed or quasi fixed asset supply
Population growth	+	More demand for agricultural output (more demand) and more demand for space.
Government programs	? (+)	Depends on the program, but usually the possibility of capitalizing government benefits increases the capital gains (subsidies, etc.)

Source: Trivelli, 1997a.

defined by the socio-economic, legal and political environment where these prices are formed. These variables affect the price of land through different means and their importance as price shifters varies according to the way in which land is being considered (only as productive factor, or as an asset, or both).

2. When agricultural land prices are measured (or estimated) based only on the value of land as productive factor, the analysis will be biased and the estimates will not reflect the solutions reached by the land market. To obtain a reliable analysis of land prices, and of land markets in general, one needs to consider the whole demand for land.

3. Both land markets for buying and selling and rental markets provide information on the alternative uses for land resources and, up to some extent, of the importance of different variables related to the socio economic and political environment where these markets operate. In this context, the need to understand the contribution of each value source to land prices seems clear, in order to predict, support and help the land market work in such a way that land resources are allocated in the most efficient and sustainable way.

4. A better understanding of how prices are formed and what variables affect them will help to identify policy options to improve land market's efficiency. In this respect, the benefits derived from improvements in policy advice and in resource use are enough to encourage sustained research on the topic.

5. During the last ten years land property is the most stable real estate sector in the land market in Latvia. The land market characterizes by increasing demand and corresponding increase of land prices. These tendencies will keep constant and the prices will increase in neighbourhood of Riga and in the surroundings of the biggest cities. In the regions of Latvia the prices of land will increase slowly, but it would be expect the increases of prices in all segments.

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RETAIL CREDITING IN LATVIA

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Abstract

The necessity of the research is determined by the fact that in Latvia there is a strong growth in bank credit to the private sector like in several transition countries in Central and Eastern Europe. Its implications for macroeconomic development and financial stability can be ambiguous.

The aim of the research is to find possible scenarios for positive credit (to private sector) growth implications for macroeconomic development and financial stability in Latvia.

Attainment of the objective comprises analysis of available statistical data about Latvia, identification of factors affecting bank credit growth following up some recent researches and modeling scenarios how the credit growth could facilitate further economic development in Latvia.

This paper presents only recent trends in bank credit to the private sector in Latvia and evaluates some of the factors affecting these trends. It does not provide updated practical models and scenarios because the research has been started only recently.

Key words: macroeconomics, bank, credit growth, crediting.

Introduction

In Latvia, there is a strong growth in bank credit to the private sector (BCPS) like in several transition economies in Central and Eastern Europe. For example, the cumulative growth of BCPS in real terms in Latvia was 304 percent during 1998–2002. While the initially low levels of credit stocks inflate these rates, the BCPS-to-GDP ratio (BCPS ratio) also increased by 17 percentage points [1]. Credit development has not been studied extensively, but IMF and the Bank of Latvia (central bank) are worried that its implications for macroeconomic development and financial stability can be ambiguous.

The aim of this research is to find possible scenarios for positive BCPS growth implications for macroeconomic development and financial stability in Latvia.

Attainment of the objective comprises analysis of available statistical data about Latvia, identification of factors affecting bank credit growth following up some recent re-searches and modeling scenarios how the credit growth could facilitate further economical development.

Structure of this paper: section 2 describes statistical information about economics of Latvia; section 3 focuses on recent trends in bank credit growth; section 4 is dedicated to identification of factors affecting bank credit growth; the main conclusions are in section 5.

Statistical information

Latvia is one of the transition countries – in 1990 a process of transformation from socialist to market economy began. In 2004, Latvia joined the European Union (EU). On December 30, 2004, the Bank of Latvia fixed the peg rate of the lats (LVL) and euros at EUR 1 = LVL 0.702804, which took effect on January 1, 2005 in line with the plan for Latvia's preparation for full-fledged membership in the Economic and Monetary Union (EMU) approved by the government.

In Latvia there is the growth in the economy – gross domestic product (GDP) is increasing rather fast during the

Table 1

Basic indicators of economy in Latvia in 1994–2004
Unit: as per cent over previous year [2]

	GDP	Average net wages and salaries of the employees	Consumer price index	Inflation	Real wages and salaries of the employees	Unemployed persons
1994	102	147	136	126	108	109
1995	100	121	125	123	97	99
1996	103	107	118	113	91	109
1997	108	112	108	107	104	94
1998	105	110	105	103	105	131
1999	103	105	102	103	103	98
2000	107	106	103	102	103	85
2001	108	106	103	103	104	98
2002	106	108	102	101	106	98
2003	108	111	103	104	108	101
2004	109	109	106	107	103	100

Fig. 1. GDP growth in Latvia (1997–2003) [3].

recent years (compared with the previous year, GDP in 2004 increased by 8.5%, according to the Central Statistical Bureau, see Table 1).

One of the reasons is the stable domestic demand. Growth of private consumption is really high (Fig. 1).

The income of individuals has increased in recent years, which can be explained by several factors: growth of salaries, credit development for households, and rather low inflation. Consumer prices changed after the EU enlargement, which is why in 2004 the inflation was rather high (consumer prices in 2004 increased by 7.3% –7.8% for goods and 6.1% for services). The potential for growth of private consumption still remains. Unemployment decreases, but few short-term fluctuations are possible. Interest rates started to increase in the second half of 2004 (Fig. 2), and with the increase of liabilities the net income of households will decrease, but it could be compensated by salary increase.

Bank credit growth and shifts in banks' balance sheets

In Latvia, similarly to other European countries, financial system is centered on banks. As the equity market is small (stock market capitalization in the year 2003 was

9.6% of GDP), bank credit is one of the most important sources of financing to private firms. In recent years, the stock of BCPS in Baltic countries has started to rise from fairly low levels in line of private sector activity and institutions.

Comparing the situation in Latvia with the other Baltic states, in Estonia the growth of BCPS started earlier, but in Lithuania – later than in Latvia (Table 2). The way the increase in BCPS was financed is similar (Tables 3–4) – the increase reflected in part increased bank intermediation and also net borrowing from abroad.

The greatest impact on the growth of total loans has the increase in loans to private enterprises, but the steepest slope has loans to private persons (Fig. 3). Besides, the slope became steeper in the second half of 2002. For private enterprises, one of the incentives to take loan is to make some improvements / investments (competitiveness or qualifying with the EU restrictions etc.) with funding from EU.

The other way is to look at the most popular loans (Fig. 4). Commercial credit is for the enterprises or businessmen (for example, industrial credit is only for enterprises) and in total loans there are both the loans for individuals and for enterprises. The overdraft can also be for
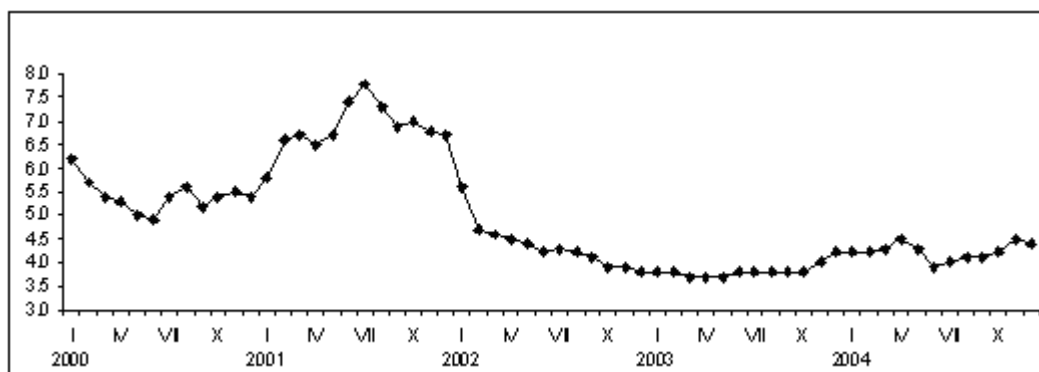
Fig. 2. Interest rate – RIGIBOR (3-month loans) (2000–2004) [Drawn by the author using data of the Bank of Latvia, see source 3].

Table 2

Measures of growth of bank credit to the private sector (BCPS) [1]

	Turning point*	Average annual real growth rate**	Change in BCPS ratio	Average annual change in BCPS ratio
Estonia	1994	25.9	35.3	4.4
Latvia	1997	31.4	17.9	3.0
Lithuania	2002	23.7	2.6	2.6

*Year when the BCPS-to-GDP ratio starts rising.
**Credit growth is deflated by the GDP deflator.

Table 3

Financing the growth of the BCPS ratio: changes in the ratio between balance sheet items and GDP (in % points of GDP) [1]

	Reference period	Bank loans to private sector	Bank loans to public sector	Bank deposits	Net foreign liabilities	Other net liabilities
Estonia	1992–2002	35.2	−0.2	19.0	9.9	6.2
Latvia	1998–2002	16.7	0.2	11.1	10.3	−4.4
Lithuania	2002	2.6	0.6	2.3	1.2	−0.2

Table 4

Financing the growth of the BCPS ratio: annual average changes in the ratio between balance sheet items and GDP (in % points of GDP) [1]

	Reference period	Bank loans to private sector	Bank loans to public sector	Bank deposits	Net foreign liabilities	Other net liabilities
Estonia	1992– 2002	3.2	−0.0	1.7	0.9	0.6
Latvia	1998– 2002	3.3	0.0	2.2	2.1	−1.0
Lithuania	2002	2.6	0.6	2.3	1.2	−0.2
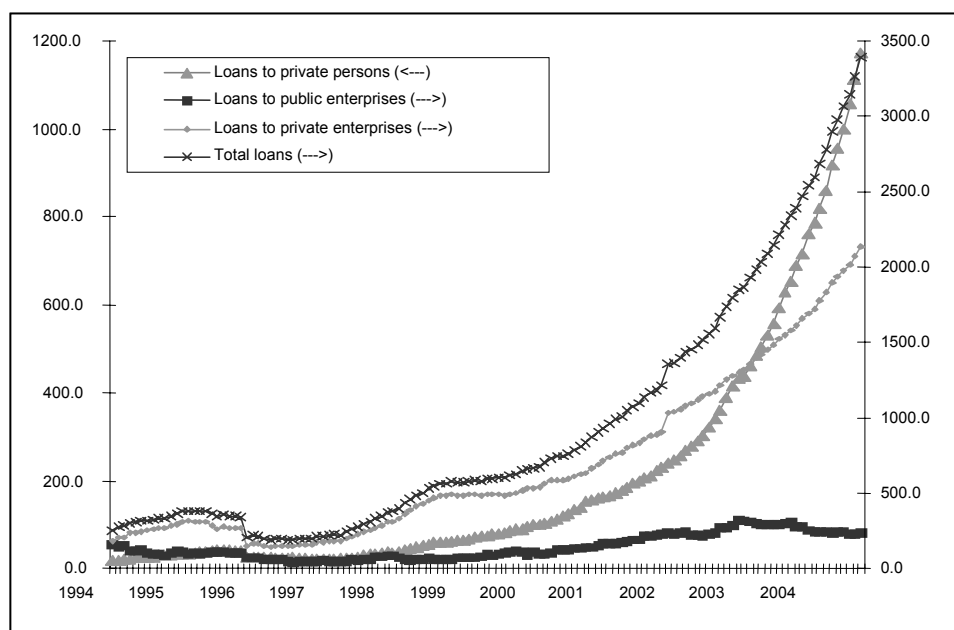
Fig. 3. Loans to domestic enterprises and private persons (at end of period 1994 – 3Q 2004; in millions of LVL)
[Drawn by the author using data of the Bank of Latvia, see source 6].
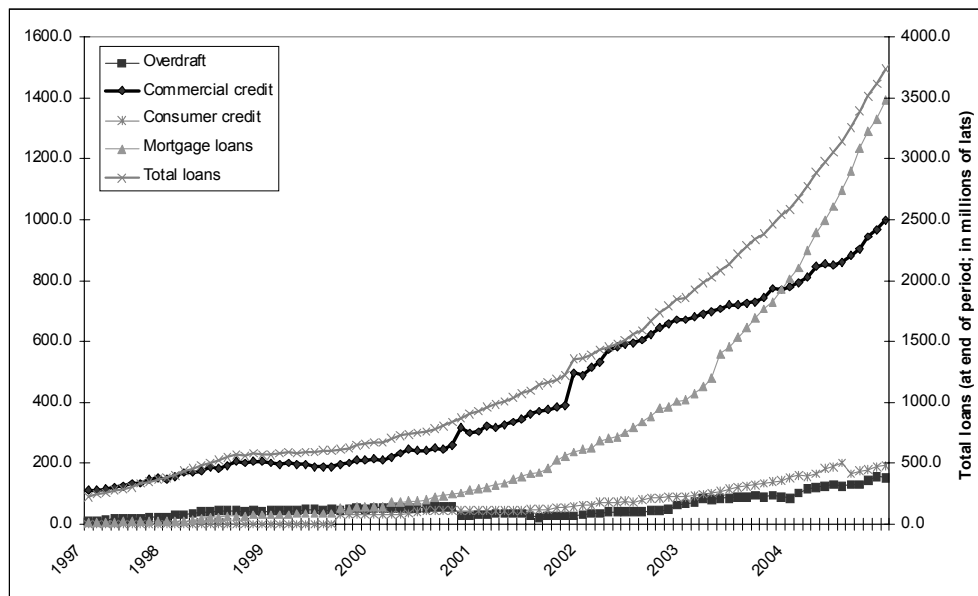
Fig. 4. Lending to domestic enterprises and private persons (at the end of period 1997–2004; in millions of LVL)
[Drawn by the author using data of the Bank of Latvia, see source 3].

enterprises, although the credit line is a more popular product. The consumer credit and mortgage loans in Fig. 4 are the loans for private persons.

People want to take mortgage loans because they are ready to pay for a better place to live. From the customers' point of view – if monthly payment for the mortgage loan is the same as the rent payment, it is better to have a real estate in 20–30 years. For now it is hard to forecast if there will be new apartment house projects enough to satisfy the demand in the next few years. That is why the secondary apartment market also runs up. The growth in real estate market is closely related to the credit growth and it could cause problems for economy. For example, if there is a crisis in the real estate market – slowdown in economy decreases prices in secondary market or the quality of these apartments sharply goes down and many people are eager to get rid of such apartments – then there could appear problems with loan payments or with the value of collateral which could be a starting point for chain reaction and even in the worse case for banking crisis.

The curve for mortgage loans in Fig. 4 can be divided in three parts – the slow growth till the midyear of 2000, medium growth for next 3 years, and fast growth from the middle of the year 2003. Some of the reasons for such a growth: the economy has been stabilized, people have better jobs and wages / salaries, so they can dream for the better future, and the competition in the banking business helps to get better conditions for credit.

In order to facilitate balanced long-term economic development and reduce domestic demand, the Bank of Latvia increased the refinancing rate to 3.5% in March 2004 (before that it was decreasing from 27% in 1993 to 3% in 2002). This increase, however, did not have a significant effect on the increase of the amount of loans granted, since

the number of borrowers opting for loans in a foreign currency instead of LVL and, consequently, the number of banks taking the currency risk grew. The Bank of Latvia also increased the reserve requirement for banks and foreign bank branches from 3% to 4% (in effect as of July 2004), with a view to reduce macroeconomic risks in the country and to ensure the sustainability of the current rapid economic growth. The minimum reserve requirement for credit institutions is a part of deposits received from enterprises and residents or non-banks that have to be kept with the Bank of Latvia. The increase of the reserve requirement will make banks and foreign bank branches keep larger amounts of funds with the Bank of Latvia thereby reducing the resources available for lending. The planned reduction of the reserve requirement for banks to 2% set by the EU will take place gradually in line with the minimisation of the risks mentioned above. The refinancing rate again was raised in November 2004 to 4.0%. In order to unify the bank competition conditions and slow down the quickly growing borrowing of the Latvian banks from foreign banks, starting from January 2005, the minimum reserve base shall include bank liabilities to foreign banks and foreign central banks with an agreed maturity or redeemable at notice of up to 2 years [4].

Factors affecting these trends

Microeconomic factors

Important factors are related to bank ownership, bank profitability, and credit risk.

In Latvia there are 22 banks, affiliate of Nordea Bank Finland PLC and 31 savings and loan associations. Bank profitability in the middle of the year 2004: ROE was 19.7% and ROA – 1.7%, according to the information from the Bank of Latvia. The three major banks of Latvia (Hansabanka, SEB Unibanka, Parex banka) already are comparable with the

medium size EU banks by assets. The rest 19 are competitors of small banks of the EU.

Credit risk can be understood in several ways. For example, Latvia has been rated by the Standard and Poor's with A- and by Moody's – with A2. The other way to look at this risk is to evaluate the specific legislation. The supervisor from the year 2000 is the Financial and Capital Market Commission (FCMC). The strategic goals of it:

- promotion of the stability in the financial and capital market;
- promotion of the development of the financial and capital market;
- protection of the interests of investors, depositors and the insured.

The main strategic goal of FCMC is to ensure overall stability in the financial and capital market. That means that, within powers granted by law, the FCMC will turn against any participant of the financial and capital market whose action or inaction may cause instability in the financial and capital market as a whole or its separate sectors. FCMC issues regulations and orders governing the activity of the market participants, licenses participants of the financial and capital market as well as certain products, controls compliance with its regulations and orders, collects, analyses and publishes information about the financial and capital market (quarterly report to the Bank of Latvia and the Ministry of Finance, annual report to the parliament, monthly statistics), prepares recommendations for the improvement of regulations (for example, New Basel Capital Accord) and their harmonisation with the norms of EU legislation, carries out the assessment of risk on the level of an individual market participant, individual market sector as well as of the system as

a whole, ensures the accumulation and management of guarantee funds for the protection of the investors, depositors and the insured, co-operates with foreign financial and capital market supervisory organisations, international financial institutions (IMF, EBRD etc.), the Bank of Latvia, the Ministry of Finance of the Republic of Latvia and provides methodological assistance to the Office for the Prevention of Laundering of Proceeds Derived from Criminal Activity [5].

As mentioned in IMF working paper, the BCPS ratio in other European countries is higher than in Baltics and other transition countries, and there are even differences among countries with similar per capita income (Fig. 5). Latvia and Lithuania have much more space to converge faster in terms of increase in BCPS ratio than Estonia.

Macroeconomic factors

Two main factors are likely to lead to rapid growth of BCPS – crowding-in and capital inflows. In most transition countries, the rise of BCPS has been accompanied by a falling bank credit to the government ratio. In Latvia it was not the subject till the year 2004 when loans to public enterprises started to decrease (Table 4 and Fig.3).

Banks can expand their available resources not only through domestic deposits, but also through capital inflows as borrowings from abroad (some of the banks in Latvia are owned by banks of existing euro-area members which lightens this process) [1].

Detecting lending booms

The growth of the BCPS ratio in transition countries can be compared with that of the countries, which already had banking crises (Fig. 6).

The growth rate in crisis countries, except for Chile

Fig. 5. BCPS-to-GDP ratio and purchasing power parity (PPP) per capita income, 2001 [1].
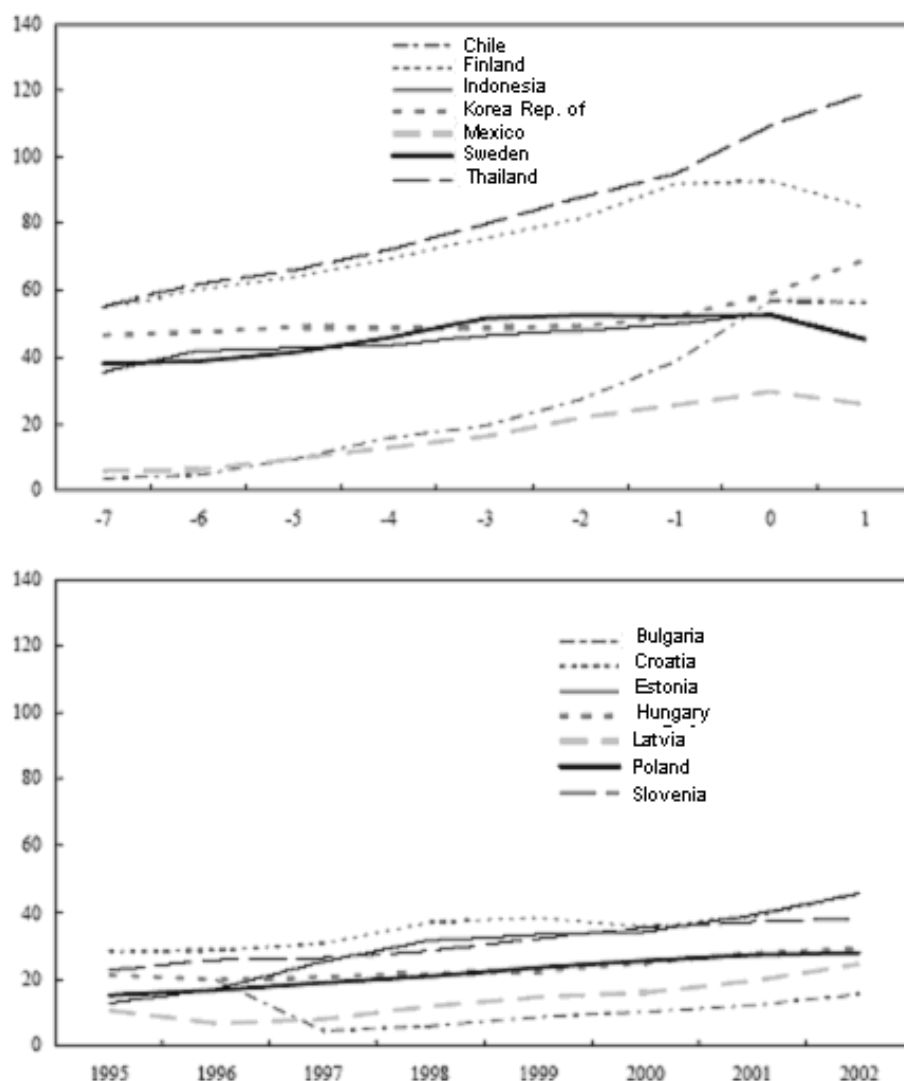
1/ Year 0 is the crisis year

Fig. 6. BCPS ratios in bank crisis countries and some of transition countries [1].

and Mexico, before the crisis was higher than it is in Bulgaria, Croatia, Estonia, Hungary, Latvia, Poland, and Slovenia. In the IMF working paper, the authors had constructed the backward looking stochastic trend for the BCPS series in order to examine the presence of lending booms. Their conclusions from the results were that Bulgaria in 2002 was the closest to be detected as a lending boom country. The next result was for Latvia. But these results can be doubted because these tests were conditional on several caveats, mostly relating to the difficulty of distinguishing what is "abnormal" growth of credit, since all these countries have been in transition [1].

Conclusions

Credit development has not been studied extensively, but it is the subject for the transition countries like Latvia. Credit growth is closely related to macroeconomic development.

There are different situations in Baltic states – in Estonia the credit growth took place earlier than in Latvia and Lithuania.

The fastest growth is for loans to private persons in Latvia, but in overall – total loans development depends on BCPS growth.

The Bank of Latvia operates by raising the refinancing rate and the reserve requirement for banks and foreign branches.

Latvia and Lithuania has space for further credit development more than Estonia.

The further research about credit development and the factors affecting it is necessary in order to prove the results of some previous econometric models and finding the new ones, besides it could help to draw consequences for explicit detecting of lending booms.

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BUSINESS CYCLES OF BALTIC COUNTRIES AND THEIR MAIN TRADING PARTNERS

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Abstract

The aim of the paper is to analyse relationship between international trade and the correlation of the business cycles between Baltic countries and their main trading partners. Two univariate methods are used to extract cyclical components in the time series: exponential smoothing procedure the Hodrick – Prescott filter and unobserved components method. A simple regression model proves the hypothesis that trade intensity has led to business cycle synchronization.

The main conclusion is that there exists a strong correlation between the business cycles of the Baltic countries. However, the economic cycle of Baltic countries is different from that of their main trading partners in EU. According to Optimum Currency Area theory, these results cast doubts on the usefulness of adopting the euro in the Baltic countries in the near future. On the other hand, recently the deepening of economic integration has led to make intense trade between the Baltic countries and the EU, which may eventually imply more synchronised cycles in the future.

Key words: business cycles, international trade, Optimum Currency Area.

Introduction

Recently much attention has been paid to the question of what extent the business cycles of the EU new members correlate with the business cycle of the old Member States. The main reason for this interest is the enlargement of the European Union on the 1st of May 2004. A few years after joining the EU all new Member States, including Baltic States, will have to take into use the single currency, the Euro. Therefore, these countries will belong to the group of states implementing a single monetary policy. This fact entails a significant change for these countries, as until then they can use their own monetary policies to reduce cyclical fluctuations of the economy. The effectiveness and suitability of a single monetary policy to new Member States depends partly on the interconnection of the business cycles of these countries and old EU members. If the business cycles are synchronized, the single monetary policy will also be suitable for the country. In the opposite case, it may amplify cyclical fluctuations.

Optimal Currency Area (OCA) theory provides a set of criteria, which would guaranty successful participation in monetary union. Following the seminal paper of Mundell (1961), according to the traditional statement of OCA, the dominant criteria are to what extent trade with potential partner countries and extent to which the experience of shocks is common or asymmetric. A widely used tool for measuring the symmetry or asymmetry of shocks is a measure of the synchronicity of business cycle experience. The empirical evidence discussed in the literature shows that openness, trade integration and similarity of economic structures have strong effect on international co-movements. In this paper the focus is on trade integration. So, the main purpose of the article is to analyse correlations between business cycles of Baltic countries and their main trading partners.

There are several papers related to this synchronization topic. Fidrmuc and Korhonen (2001) find that the correlation of cyclical fluctuations between the EU accession countries (now new member states) is less than the correlation of business cycles within EU. They also emphasize that new member states might satisfy OCA criteria after joining the EU and at a higher level after they enter monetary union. This is referred in the literature as the endogenity of the OCA properties. The main reason for that is the coordination of economic policies. An other possible reason for higher correlation of business cycles is the increasing international trade among member countries. Rose (2002) showed that on average 19 studies have found that currency union members trade about two times more than the countries that have their own currencies.

A number of studies (Frankel and Rose, 1998, Fidrmuc, 2001 etc.) analyse how international trade affects business cycle correlation. The main findings reveal that trade has positive effect on the synchronicity of the fluctuations of the economy. However, there is not much certainty of how it happens. Maurel (2002) finds that more intense trade transmits the shocks to the economy more efficiently. Another way is related to the composition of the bilateral transactions. The level of intra-branch transfers has effect on the level of similarity of composition of industry; and it would stimulate the development of comparable industrial structures and, consequently, more correlated business cycles. Similar structure of economy guarantees a symmetrical reaction to shocks and facilitates the implementation of joint policies to alleviate the impact of economic fluctuations.

Artis, Marcellino, Proietti (2003) analyse the evolution of a business cycle in the accession countries focusing on the cross-correlations and the degree of cyclical concordance. They conclude that Baltic countries constitute an exception from other new members of EU: they share similar tendencies, in the past they have been less correlated (especially Latvia and Estonia) with Euro area, but more correlated with Russia. Artis et al (2003) also maintain that the

main reason for the asymmetric nature of business cycles is the strong impact of single shocks that accompany the transition process. This is especially evident for Baltic States.

The rest of the paper is organized as follows. Firstly the data used are described and the applied de-trending methodologies are explained. After that calculated values of cross-correlations are presented and analysed remembering stress to international trade. A simple regression model confirms the hypothesis that trade has positive effect on business cycle synchronization. The last section summarizes the main findings.

Materials and methods

The traditional way to assess the similarity of business cycles is to study the correlation in the cyclical component of the economic growth of different states. Comparing only the dynamics of growth indicators it was not possible to get an adequate picture of the cyclical development of an economy. There is no single methodology for separating the cyclical component from trend (economic growth) component.

Also measurements of business cycles differ in various studies. For example, Lucas (1987) viewed the business cycle facts as the statistical properties of the co-movements of deviations from trend of various economic aggregates with those of real output [3]. Frankel and Rose (1998) used real GDP and industrial production index, total employment and unemployment rate as proxies for the economic cycles, but there is problem in application of this framework in Latvia and other former transition economies: the data are limited, available time series are short. So, this paper employs only industrial production index for measuring correlations between cyclical components for Latvia, Lithuania, Estonia and their main trading partners. These time series are available for longer time horizon and with higher frequency – monthly data.

Data

Industrial production indices were taken from from Eurostat, but for Russia – national SO. Most economic variables including output, are characterized as non-stationary as they grow over time, hence they contain a trend component; in additional they often display cycles. High frequency cycles corresponding to the seasonal component can be removed prior the analysis, so that one is left with the component of interest – low frequency cycles, interpreted as business cycles.

After visual examination, time series have been seasonally adjusted using a traditional X12 Census method. The seasonally adjusted series have been transformed into natural logarithms.

ln(observed variable) = Trend + Cycle + Seasonal component + White Noise

As the cycles will not be invariant to how one describes the trend component in the data, the results should be tested against alternative trend specifications. Two univariate methods will be used to extract cyclical components in the time series:

(i) exponential smoothing procedure Hodrick–Prescott filter with two different values of the smoothing parameter λ;

(ii) unobserved components method. This method uses the structural time series approach, which is set up in terms of different components that have direct interpretations, but cannot be observed directly.

As the choice of appropriate data transformation depends on the nature of underlying dynamic properties of the time series, data has to be first tested for unit root. So, augmented Dickey-Fuller (Harvey, 1989) unit root test is first applied to the data. For all countries industrial production indices were first order differenced series – they were not stationary in the level, but stationary after taking first differences. Hence, they contain a unit root and could not be represented with a smooth (linear) trend.

Description of used detrending methods

The Hodrick – Prescott (1997) filter

The H-P filter has become a popular choice among business cycle analysts. This filter extracts a stochastic trend that moves smoothly over time and is uncorrelated with the cycle. The filter is obtained by solving the minimization problem:

$$\min_{\{g_t\}_{t=1}^{T}} \left[\sum_{t=1}^{T} \left(y_t - g_t\right)^2 + \lambda \sum_{t=2}^{T} \left(\left(g_{t+1} - g_t\right) - \left(g_t - g_{t-1}\right)\right)^2 \right] \qquad 1)$$

$$\hat{c}_t = y_t - g_t, \qquad (2)$$

where λ is an arbitrary constant that penalizes the variability in the growth rate of the trend [12].

When $\lambda = 0$, the trend component is the data itself, hence no smoothing takes place. In this case, the cyclical component vanishes. Conversely, as λ grows large, the smooth component is closer to a linear trend. According to suggestion of Kydland and Prescott (1990), for monthly data an optimal value of smoothing parameter is $\lambda = 14400$ (frequency in square multiplied by 100). Use of this value allows us to compare results with relevant findings in the literature. Also we choose a variant of HP filter with $\lambda = 144$, which can account for relative more volatility in the trend.

The advantage of the HP method is that it is easy to apply, and the broad use of it in many international studies makes it interesting for comparisons. However, the method has also come under severe criticism. Among others Harvey and Jaeger (1993), Cogley and Nason (1995) showed that when the HP filter is applied to an integrated series, it can generate spurious cycles. The filter also depends on the choice of λ which makes the resulting cyclical component and its statistical properties highly sensitive to this choice.

Unobserved components method

In this method a structural time series model is specified in terms of components that have a direct interpretation. These components are not directly observable, but are assumed to have ARIMA representations (Harvey, 1989). Structural time series model consists of a trend, cycle,
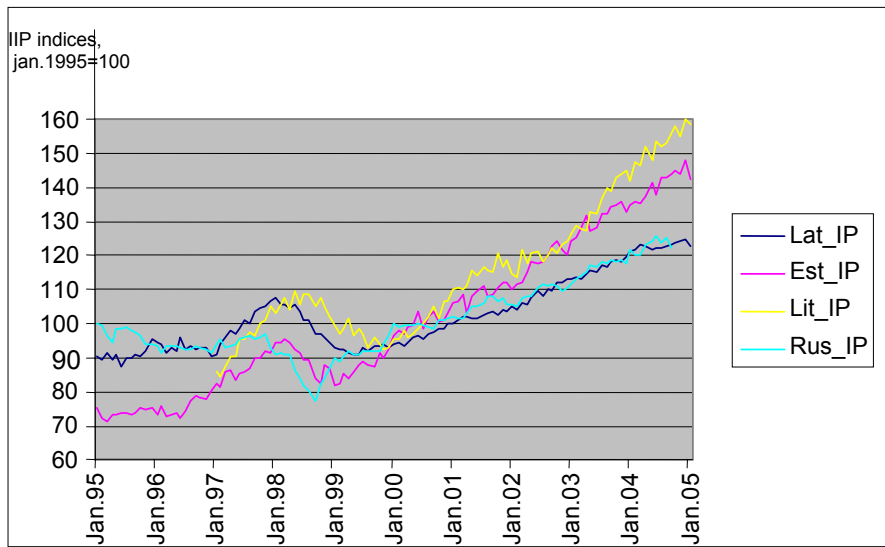
Fig. 1. Industrial production indices for Latvia, Estonia, Lithuania and Russia (in constant prices)
(Author's calculations using data from. [19], [20]).

seasonal and irregular component. All four components are stochastic, and disturbances driving them are mutually uncorrelated. In this framework the stochastic trend evolves as:

$$g_t = g_{t-1} + \beta_{t-1} + \eta_t, \tag{3}$$

$$\beta_t = \beta_{t-1} + \zeta_t, \tag{4}$$

where β is the slope of the trend,

η and ζ are normal, independent, white noise disturbances, with variances σ_η^2 and σ_ζ^2.

The cyclical component is defined as:

$$c_t = \rho \cos \lambda_c c_{t-1} + \rho \sin \lambda_c c_{t-1}^* + \upsilon_t \tag{5}$$

$$c_t^* = -\rho \sin \lambda_c c_{t-1} + \rho \cos \lambda_c c_{t-1}^* + \upsilon_{t-1}^*, \tag{6}$$

where ρ is the damping factor such that $0 \leq \rho \leq 1$,

λ_c is the frequency of the cycle in radians, and

υ_t and υ_t^* are independent white noise disturbances, with variances σ_υ^2.

Finally, the irregular component is assumed to be white noise, and seasonal component will be estimated as a trigonometric function [9].

Estimation of the whole model is carried out by maximum likelihood with Kalman filter in the Eviews package. The unobserved components model has the advantage that it can be applied directly to non-stationary time series without having to difference the data explicitly. If we compare both used methods, Hodrick – Prescott filter can be a special case of unobserved components method.

Results

A visual inspection of the raw industrial production series for Latvia, Lithuania, Estonia and Russia shows a
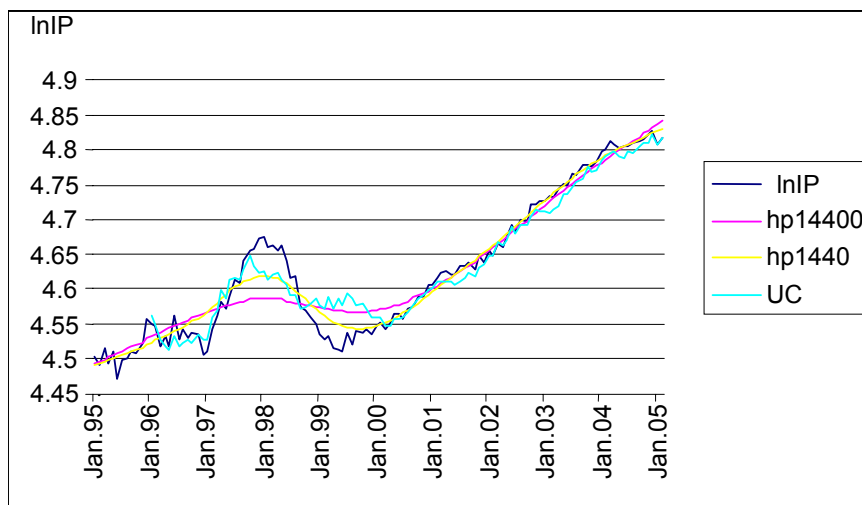
Fig. 2. IP series (Latvia) and estimated trend-components.

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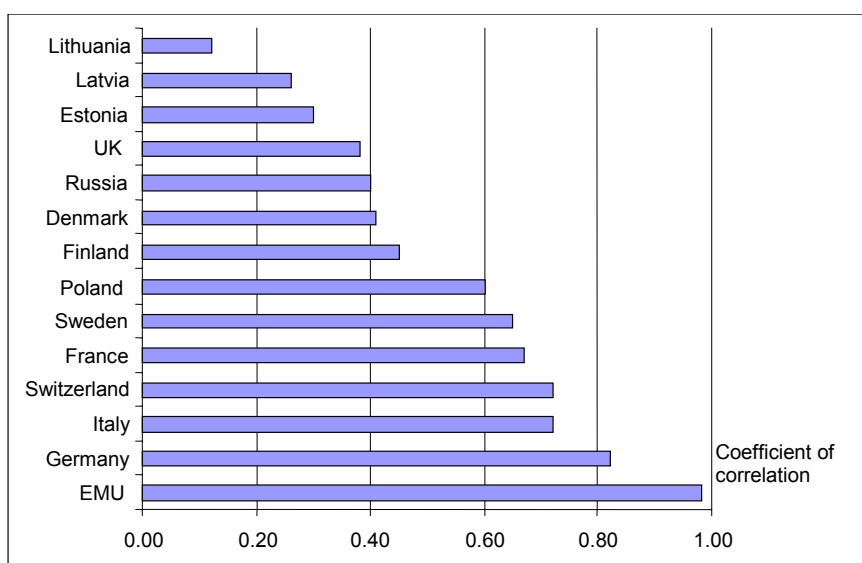
Fig. 3. Correlations of the business cycles of Baltic countries and their main trading partners
with that of the EU (1997–2004).

similarity. In the period from 1995 till 2000 there is high degree of correspondence with the development in the Baltic countries and that of Russia.

This close connection with Russia is based on the fact that in this period Russia was an important trading partner for all three Baltic countries. The impact of Russian crisis in 1998 was also significant. However, the reaction of Latvia's current trading partners in the European Union to the Russian crisis was only modest. So, even before calculating the cycles in this time span, a high correlation can be expected between the cyclical components of industrial production indices of the Baltic countries with Russia than with the western trading partners.

All discussed above calculations were made using two de-trending methods: the Hodrick-Prescott filter with two different λ values and the unobserved components method (see Fig. 2).

Figure 3 illustrates the correlations of the business cycles of Latvia, Estonia, Lithuania and their main trading partners, the correlation of the business cycle of Latvia and other Baltic countries with that of the EU is relatively small.

Term "business cycle of EU" should be commented. Artis et al. (2004) proved that correlation between "old EU Members" is relatively high. There is only one exception – UK, which has a less synchronised business cycle with the aggregate EU cycle than other countries in the union. This fact is usually explained by emphasising that foreign trade with United States and Canada plays of larger role in UK than in the EU on average (see Bjornland (2000)). Surprising is the fact that Russia has higher correlation with EU than Baltic countries. Cyclical component calculated from HP filter does not show such result.

Figure 4 reflects the interconnectedness of the business cycles of Latvia and its main trading partners.
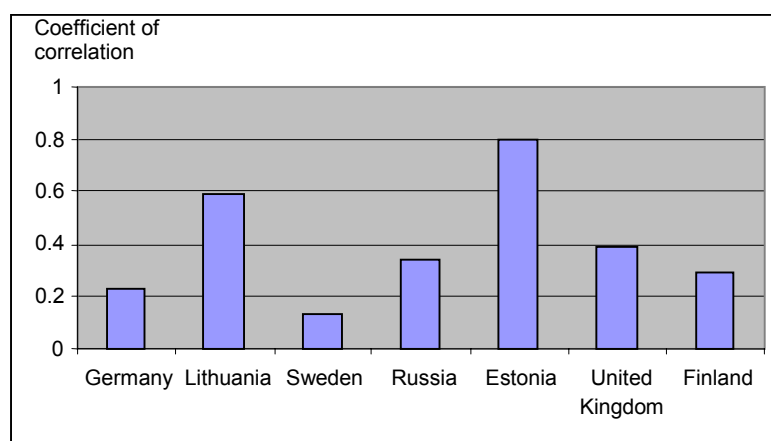
Fig. 4. Correlation of Latvia's business cycle with that of its main trading partners (1995–2004).
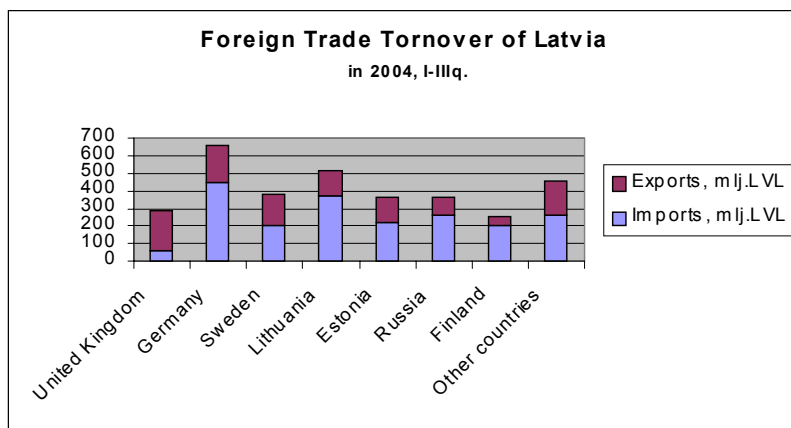
Fig. 5. Main trading partners of Latvia. [19]
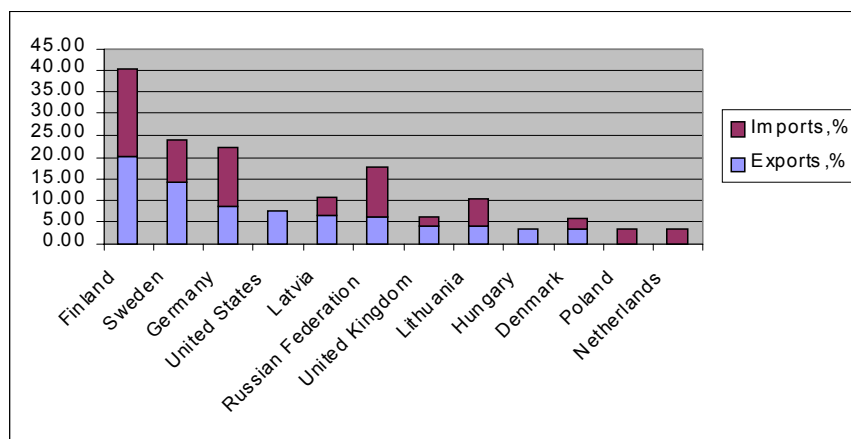
Fig. 6. Estonia's main trading partners in 2004. [19]

In figure 4 countries are ranked taking into account the role in total international trade of Latvia. The main Latvia's trading partner is Germany, but correlation is relatively small. So, data of Latvia, there is no high relationship between correlation of cyclical components of IP and trade.

In the case of Estonia, high correlation between Estonia and Finland is not surprising as Finland is the main trading partner of Estonia, and Russia was an important trading partner also for Finland. The negative correlation

between Estonia and Sweden should be noted. Sweden is the second country ranking by share of sum of export and import to total trade of Estonia. This can also be traced back to the Russian crisis, during which the Swedish economy was growing, unlike that of Estonia. There is also an example that not only intensive trade relations are important for synchronicity of business cycles – Estonia's export to Great Britain has been quite moderate to date but the correlations are relatively high.
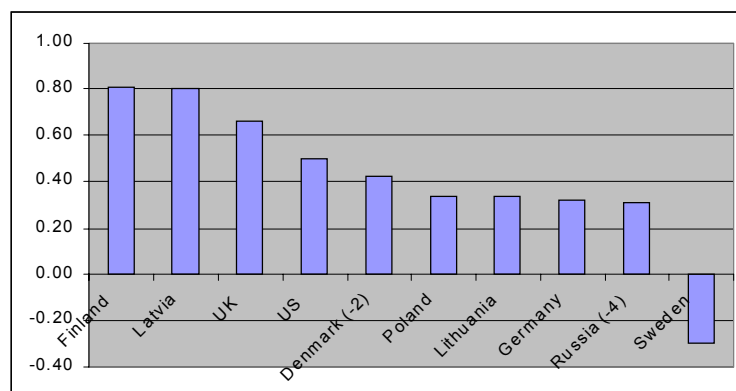
Fig. 7. Correlation of Estonian business cycle with that of its main trading partners (values on 0y axis).
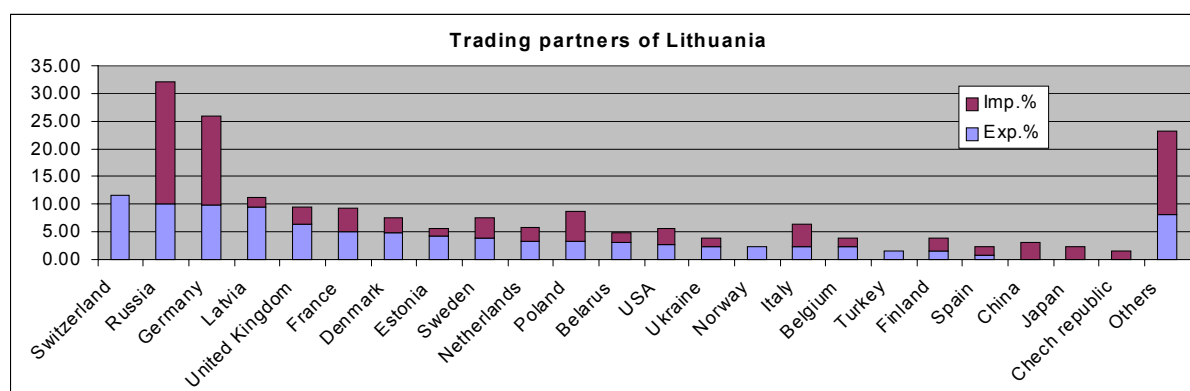
Fig. 8. Trading partners of Lithuania in quarter 1, 2004. [22].

Effect of trade intensity on business cycles correlations

De-trending method	R^2	β_1	p-value
HP 14400	0.201	0.066	2.40052E-05
UC	0.1328	0.102	0.000764

The most important partners of Lithuania in 2004 were Switzerland (16.8%), Germany (10.1%), Latvia (8.9%) and Russia (8%t). The most significant partners in imports were Russia (24.4 %), Germany (15%), Poland (5.1%) and France (4.3%). Full list of trading partners of Lithuania is shown in Figure 8.

In Figure 8 we can see that Russia still remains as very important trading partner of Lithuania. But correlation coefficient between cyclical components of industrial production is about 0.5. Only if we take lags in IP of Russia (-3 months) correlation is a bit higher: 0.57.

Empirical analysis did not show close relation between business cycles synchronization and trade.

Regression analysis

There is no clear correspondence between correlations and trade observed. Since cross-correlations and trade indicators did not show unambiguous relationship, a quite simple model is estimated:

$$Correlation(cycleIP_i; cycleIP_j) = \beta_0 + \beta_1 \cdot \text{Trade intensity}_{ij} + u \text{ , (7)}$$

where $Correlation(cycleIP_i; cycleIP_j)$ is correlation coefficient between cyclical components of industrial production indices for country i and country j.

"Trade intensity$_{ij}$" is one of ways how to measure trade intensity from country i to country j. Approach used in this model is taken from Frankel and Rose (1998):

$$\text{Trade intensity}_{ij} = \frac{\text{Import}_{ij} + \text{Export}_{ij}}{(\text{Import} + \text{Export})_i + (\text{Import} + \text{Export})_j} \cdot \quad 8)$$

The error term u_i represents the influence of all other effects impacting business cycle correlations [9]. The positive and significant value of regression coefficient in model (7) confirms the hypothesis that higher trade intensity is associated with higher correlation between business cycles. Negative value of β_1 would show that increase in trade causes divergence of the economic cycles. This situation can be observed when structures of economies are different, when there is a high level of specialization.

Regression was run for 82 pairs of countries. Both coefficients are significant and positive, but values of R square are relatively small. Although in Frankel and Rose (1998) this kind regression suffered from problem of heteroscedasticity, in our case Goldfend – Quandt test we did not reject H_0 about homoscedasticity. One of explanation could be specific completion of countries with high level of similarities.

Regression results are summarized in following table.

Both de-trending methods show almost the same results. As it was expected, β_1 is positive. It is not surprising because usually industrial production mostly consists of tradable goods and increase in IP value can positively influence amount of export. Low value of R^2 shows that trade is not the main reason for business cycle synchronization, and this research should be continued.

Conclusions

- A strong correlation between the business cycles of the Baltic countries is clearly evident. It can be supposed that one of the reasons of high correlation coefficients is international trade. Before Russian crisis, all three Baltic countries had Russia as one of three main trading partners, Russian crisis hit all three economies causing reducing in production levels and in amount of exported goods, but after that all three countries reoriented their markets to EU. So, development of the economies of Baltic States was quite synchronized.

- In recent years, the correlation between the business

cycle of Russia and Baltic countries has decreased. In the same period, the role of Russia in international trade of Latvia, Lithuania and Estonia has decreased.

- The economic development cycle of Baltic countries is different from that of their main trading partners in EU. A higher level of synchronisation can be expected in future taking into account that Baltic countries have been EU members for less than one year. Therefore, it may be assumed that the deepening of economic integration and joining to the EMU in future will bring business cycle of Baltic countries closer to that of the European Union.

- Research should be improved using multivariate methods for measuring business cycles, because use of industrial production indices restricts analysis to sphere of industry, not whole economy. Recently in most of EU countries the share of industrial production in GDP has been reducing, and is close to 25%.

- A simple regression model proves the hypothesis that trade intensity has a positive effect on business cycle correlations.

- To get clearer evidence about relationship between international trade and business cycles, sources of shocks should be examined, i.e., if the business fluctuations are caused by supply or demand shocks.

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ICT – RESOURCE OF DEVELOPMENT

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Abstract

The changes taking place in economics, its internationalisation, development of information and progress of science and technique determine the necessity to raise the country's economic competitiveness, as the result of it the level of life will rise. It is relevant for Latvia to be aware of its advantages and potential competitiveness in EU market in order to carry out appropriate macroeconomic policy and favour the introduction of appropriate macroeconomic as well as social policy. The main advantage for providing more rapid development is the fact that Latvia is a small country, able to adopt flexibly, the demand of economic environment where it is easier to achieve a compromise with society. As well as the fact that it is characteristic for the population of Latvia to have a constant tendency towards better life. The way in which Latvia will be able to use its comparative advantages in context of EU market will determine the progress of the national economy including agriculture. At the moment, several problems, which are to be solved, have already appeared in agriculture. The more rapid introduction of technologies of information communication (ICT) in agriculture could be one of the ways to solve the problem. It would provide the development for both economic and social spheres motivating exchange of information, expanding of the market, increasing of production quality, improving work organisation in enterprises, and providing more possibilities for education.

Purpose: To carry out the questioning of students of the Latvia University of Agriculture in the course of study in order to find out the level of ICT application among students, as well as to obtain information about ICT application in the process of education.

Key words: technologies of information communication, process of education, students' questioning.

Introduction

The entering into European Union determines that EU market is at the same time both possibility and trial for Latvia's national economy. Therefore the relevance of agriculture remarkably changes in the total development of national economy. Some decades ago agriculture and its enterprises were dominant elements of rural farming, which provided work, production in rural territories and also created social infrastructure. At the present moment, agriculture has become an important sphere, however now it is only one of many other spheres that coexist. The volume of production has dramatically decreased due to changes of market and political situation, unemployment causes serious social problems in the countryside. In the context of agriculture in Latvia, it is important to consider not only production of agricultural products but also conservation of rural environment.

At the present moment when Latvia, as EU member, carries out its agricultural policy, it is relevant to take into consideration the supply of agricultural products, their quality, prices and amount, which are offered by other member countries, as well as opportunities for production of agricultural products in Latvia, their quality, costs and prices, ecological problems, and social factors (employment of rural population, geographical distribution of population).

Furthermore, legal aspects are of high importance (country has to observe international normative). In the authors' opinion, agriculture is affected by the following problems, which are to be sorted out by the state:

1) adopting of farms to EU demands, standards and introduction of quotas;

2) increase of costs in farms;

3) lack of government's support for agriculture;

4) lack of information.

As one of the ways to tackle the problem in the authors' opinion could be more rapid introduction of technologies of information communications in agriculture. The sector of telecommunications makes up a remarkable share of infrastructure and motivates more rapid development of national economy. The density of this branch has increased rapidly in the last years due to stabilization of market relations in society and increase of demand for telecommunication services of different kinds. Generally available telecommunication services in the country expand both qualitatively and quantitatively. Despite this fact many inhabitants of Latvia, especially those who live in rural areas, still have not had the possibility to find out and use the possibilities that modern technologies provide. The number of users' lines, which have been connected to digital system in 2003, was 80%, which proves the development of telecommunication network in Latvia. The development of mobile telecommunications is very dynamic (the coverage of mobile connections is rapidly approaching to 100% coverage of the whole country), however there is tendency to decrease the number of fixed lines. The comparison of Baltic States indicated Latvia's digital distributions as the most irregular ones. Teledensity in the capital and the biggest cities is higher than in all country altogether, however it is very low in the rest part of the country. This causes a big gap between urban and rural areas. The conclusion is that the development of telecommunication network in Latvia is irregular and big investment is necessary in order to reduce this difference (Kopeika, 2004). The support of the state is dominant for the establishment of appropriate infrastructure, such as education of population in ICT sphere.

Methods

Analysis of situation in the country is basing on different statistical data. The influence of ICT in agriculture has been worked out basing on theoretical conclusions and personal experience. Econometric, comparative statistics (variance analysis) and logical regression "Binary logistic" are also applied in the research. Two software programs *"SPSS"* and *"Excel"* were used.

With the analysis of data acquired in questioning, the authors assess how the relative number of computers at home, besides Internet access, is influenced by students' place of residence. In regression analysis, Binary logistic method is applied in order to predict if an event will take place or not, basing on different interpretation variables. The model is created in a similar way as in linear regression but it differs from it as it applied in case of dichotomous variables. Binary logistic factors are applied in order to assess probability that an event will take place, with every independent variable.

In total, 118 Latvia University of Agriculture first-year students from the Faculties of Agriculture, Engineering, Rural engineering, Food technology and the Forest faculty were questioned. The quantity of students is sufficient to get a taste about the level of ICT application among students.

Characterization of the situation

According to the latest research of the World Economic Forum (WEF), Latvia takes the 56th position in the world in field of usage of connections of information technologies. Latvia has faced the incline for 21 position in comparison with last year's range. The report about information technologies includes 104 world countries and it has already been worked out for years in turn. WEF has used an index consisting of three components for development of ICT rate. The first component of index characterizes ICT environments - infrastructure, legal regulations, and market development. The second component characterizes the ability of population to use technologies, including level of education and knowledge. The third component characterizes usage of technologies, including such indicators as the number of Internet and mobile connection users. Among these indicators Latvia has taken the highest – 55th – position in the field of ICT environment. According to usage of technologies, Latvia takes the 58th position among all countries included in the range, and the 61st position according to readiness of technologies application.

The new European Union countries develop rapidly in the field of e-administration it was recognized in the fifth annual report of European Commission about development of electronic administration. At the same time, the rest of the new EU countries are positioned in the lower part of the list in the field of e-administration, and the lowest development indicates Latvia, where complete interactivity is provided only for about 5% of organizations.

As it was mentioned before, lack of information is a serious problem in agriculture. More rapid introduction of ICT usage, especially expansion of Internet network, could reduce this problem, as the Internet is defined as mechanism for transportation of information. The prevalence of Internet in Latvia in comparison with the situation in other European countries of course is relatively low. The authors are hopeful that Latvian Internet services' providers will not lose their position in this competition and will catch up with their northern neighbor Estonia, as well as with many other western countries (Virtmanis, 2000).

As a serious problem of Latvia could be mentioned availability of information which is recently more provided by the Government. More often it is just formal, inconsiderable, and contextually poor. The updating of it takes place very slowly. The nominated demands, necessary for satisfactory or useful information – information must be available, comprehensible, valid, and apropos. Critical assessment of useful information shows that only small part of all available information is useful. In order to provide comprehensible information, it should be delivered in language, which is understandable for the target group and it should be explained with understandable terms. In order to provide apropos information, it is necessary to use such information providers that are simple and quick to update as well as easy to change. For valid information could be assumed any official information that is broadcast or created and codified by a competent state or independent organization. Latvian state and self-government institutions should be aware of the conceptual, political and technical range of problems related to information availability, in order to provide successful flow of information between the country and its citizens.

In Latvia, the Internet is used by approximately 34% of the population but the biggest part of these users live in Riga or in its nearness (61%) or in the biggest cities (44%). In the countryside, the Internet is used only by less than 11% of the population. Approximately 100 thousand of permanent connections are used for Internet access and 72% of them are located in Riga. A serious obstacle for Internet usage is lack of availability of infrastructure. The second serious obstacle is readiness and skills of rural population to use modern technologies. According to the authors' opinion, the development of these tasks is the state's competence.

The project "e-Latvia 2005–2008" was announced in the Session of State Secretaries on February 17 this year. The target of this project is dynamic development and competitiveness of Latvia State and its society in status of economy that is based on knowledge Latvia will achieve through six directions of development: e-Administration, e-Education, e-Business and welfare, e-Health, use of comma. There is specified in this project that in declarations of Latvia's government necessity to support the formation of information society has always been emphasized. The text of the projects allows to draw consequences that those have been only declarations, as the project includes activities of programs and conceptions which have not been implemented before.

The project of the program does not hold out hope that this program could be implemented, as several imperfections have already been observed: there are not defined mutual priorities among the activities and terms of their implementation in such a way that activities and preconditions for achieving the aims are carried out first in order to give prospect for real success. The aid that is necessary for accomplishing of e-Education activities is insufficient. The project defines that in order to develop economy that is based on knowledge in Latvia, it is necessary to have a bigger number of students in technical and natural sciences. However, the promotion of these sciences is the only activity mentioned here. The project does not provide any participation of Latvia in international cooperation programs connected with e-society topics. Further on, there are not mentioned any government activities in the project of this program that could motivate active participation of self-government and private sector for achievement of e-society targets. It is absolutely indeterminate how and in what terms Internet broad-zone access will be provided for the rural areas.

Results of research

ICT implementation could motivate the exchange of information among enterprises, including agricultural enterprises, between enterprises and consumers and the state. For all that ICT could provide more efficient activity for enterprise itself (Figure 1).

It is necessary to provide rural population with permanent and extensive possibilities of education in order to

manage in the present economic conditions without previously mentioned knowledge in the field of ICT. One of the ways is E-education possibility, which could allow country dwellers to acquire necessary knowledge in pace and place that are advantageous for them.

ICT development, including development in the countryside, could motivate the development of e-commerce, which is a comparatively new branch. E-commerce is a modern business methodology that is related to necessity of organizations, traders and consumers to reduce costs at the same time improving the quality of the products, servicing, and speed of supply. E-commerce relates to usage of computer network as well in order to search and update information that is necessary for taking decisions (Hartman, 2001). E-commerce is developing in Latvia, however it considerably drops behind many other countries. Many potential customers and marketers have wait-and-see attitude against e-commerce, as there is lack of comprehensive information and advice. The most rapid of the development of e-commerce is in such branches where the end product is digital (for example, entertainment or advertising). However, it might include the sales of agricultural products as well. E-commerce processes include: the presentation of electronic goods and services; accepting Online orders and billing, issuing of automated cognition about status of customer's account; processing Online payments and taxation. Furthermore, e-commerce as itself does not ensure financial success for the enterprises, however it opens wider possibilities and advantages: provides entre-
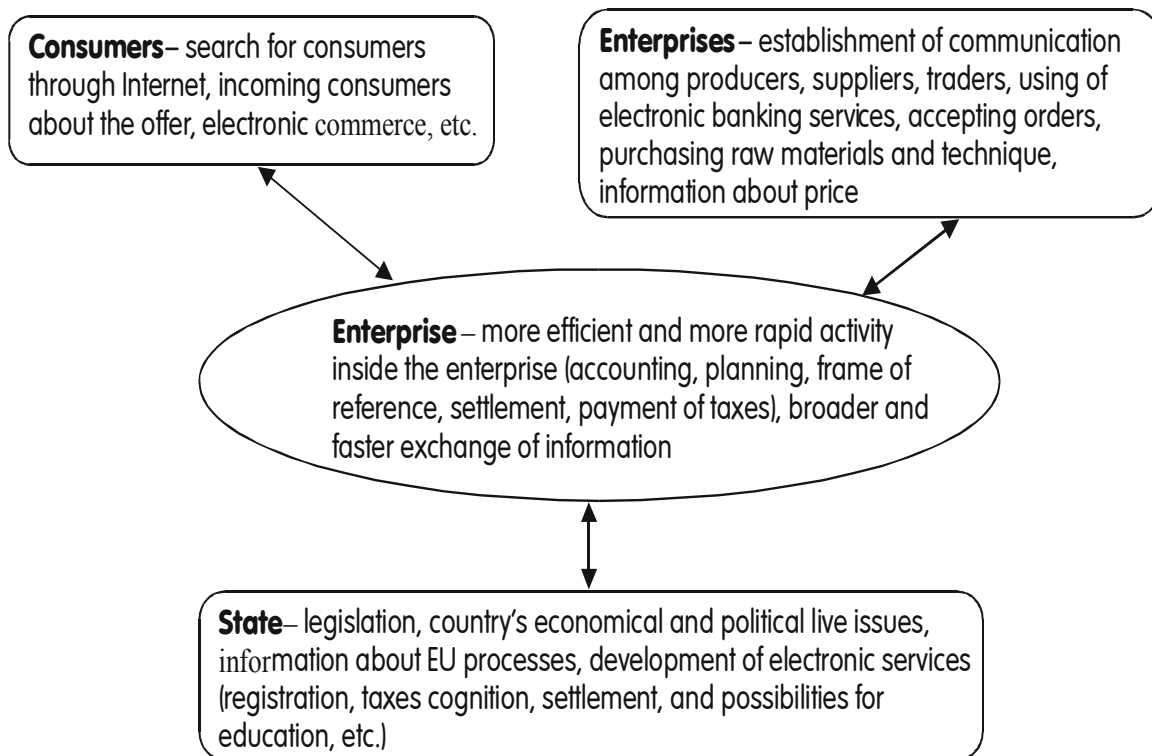
Fig. 1. Information exchange (Made by authors).

preneurs with faster communication, allows to offer their products 24 hours a day, which favors amount of business and reduces costs, saves time, but consumers may receive their goods faster and for lower price.

Internet banking is not a novelty any more either and its services for several years are provided in a digital form as well. The advantage of Internet banking is a possibility 24 hours a day of inquiring about the remainder of the account, pay the bills as well as any payments, receive report about your account, receive information about currency exchange rates, carry out currency exchange operations, find out the status of payment order, use any previously fulfilled payment order as a sample for filling in a new document, access Internet bank from any point of the globe wherever a computer with Internet connection is available, specially create the samples of payment orders. However, many agricultural enterprises do not have the opportunity to use these services due to the lack of possibility to use modern technologies with Internet connection.

The second direction, where ICT finds expression as resource of development, is education process, the aim of which is creation of person's self-confidence and employment potential (European Commission, 1998). The research proves that at the moment there is insufficient training of specialists in Latvia, and an engineer is often considered more as an academician profession but not a practician with skills of an entrepreneur. That is why questioning of students of the Latvia University of Agriculture was carried out in order to find out ICT application, how to acquire information about ICT application in their process of education.

After performing the questioning, it was found out that 51% of the respondents do not know where the Internet is available for them at LLU (Latvia University of Agriculture). Only 36% of the students know that the Internet is available in the reading-room. Altogether 3% of the students declared that the Internet is available at their faculties, 2% at the Faculty of Rural Engineers. The rest part uses the Internet only at the Faculty of Information Technologies (mainly for mathematics laboratory works and studies of information).

It must be noted that students' questioning points to

the most successful application of modern technologies in physics, often used in economics and ecology as well. Of the total, 1% of the respondents claimed the application in all subjects but it is unlikely that these answers are true. While answering these questions students definitely have meant those subjects where they use the Internet themselves for receiving information. Only a few students claimed the application of modern technologies in studies of tourism, English and German languages, ethics, timber studies, building graphics, and studies of food chemistry. On the question how the Internet could be applied in the chosen profession, 12% of the respondents replied that there are various ways of application. However, three students think that the Internet is not applied in their profession at all, but 36% do not know how it could be applied. 32% of the rest of students will use Internet for search of information, 16% – for electronic communication, 3% of students will find out about the latest technologies, 5% will use modern technologies for creating databases and reports, but 2% for advertising purposes, 1% for data transmission, 0.5% for writing, and 0.5% for creating a web site. The data acquired in the research shows that the majority of students do not have comprehension about application of modern technologies in their chosen speciality.

With the purpose to assess how the place of residence affects application of the computer in general and also Internet at home, an assessed variable – Internet application at home – was chosen. Different models were created and, after testing their significance, 7 independent variables were selected.

Consequently, regions: Riga – R; Zemgale – Z; Latgale– L; Vidzeme – V; Kurzeme – K.

Figure 2 reflects the division of respondents according to regions where they live.

It is expected that the region's effect on Internet application is positive mainly in its centres, as well as in Riga, as it is possible that Internet connection is available not only at home.

The place of residence is located in: city – P; village – C; individual farm – S.
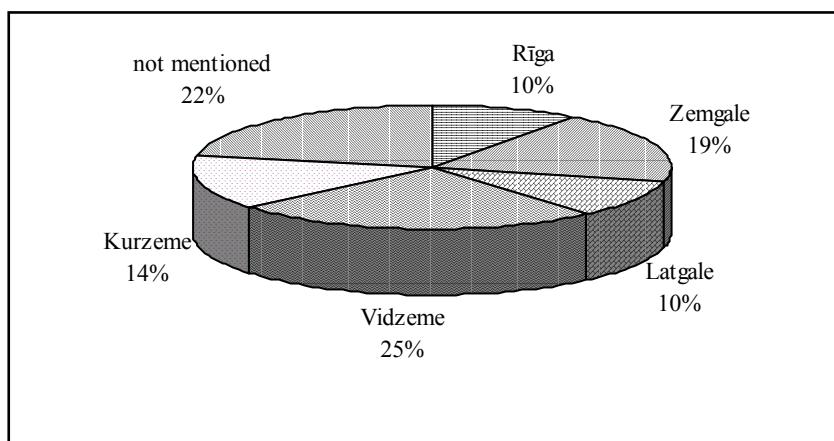
Fig. 2. Distribution of respondents' place of residence by regions in percent.
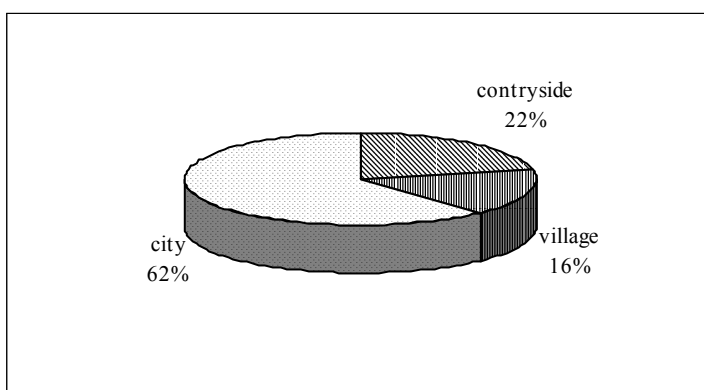
Fig. 3. Lifestyle of respondents' place of residence.

It is expected that both cities and villages especially cities will have a positive effect on Internet application. Whereas, individual farms in the countryside will have a negative effect as in the country there are still problems with the creation and provision of a complete communication network in remote regional centres or bigger cities in general.

Regression analysis

Let's check out the effect of the place of residence, i.e. region's, where the respondent lives, as well as if he lives in rural area or in a city, on computer and Internet application.

Applying regression analysis, the authors set the goal to find out whether initially proposed predictions correspond with real data, as well as how big is influence of interpreted variables.

Applying Binary logistic analysis, where the dependent variable is Internet application and interpreted variables are place of residence of surveyed LLU students, i.e., region and lifestyle of the residential area, the following regression model was obtained:

$$I = 1.033 + 1.313R + 0.725Z + 0.499L + 0.832V + 0.464K + 1.153P - 0.980C - 1.344S.$$

From the model's table of variables it was observed that all interpreted variables are significant.

Let's assess the preciseness of the model's prediction.

Table indicates that in 21 cases out of 33 (that is 21+12) or in 64%, the model had correctly predicted that the student does not apply the Internet, and in 83 cases out of 85 (that is 83 – 2) or in 97.6%, the model had predicted that the person uses the Internet. Consequently, the model is very precise in predicting that the person uses the Internet but not so precise in predicting the possibility of not using the Internet.

The total preciseness of the model is 81.4%, which is a very good indicator.

Interpretation of Regression Model

Factors of the regression model indicate that places of residence (except cities) have negative effect on Internet application, but the region – positive.

The factors of regional effect in regression model are significant. The factors are positive which indicates a positive effect of the region on Internet application. It can be observed from the values of factors that, if a student lives in Riga or Vidzeme, the probability that he/she uses the Internet is higher than in case he/she lives in Latgale or Kurzeme. After assessing the effect of the place of residence, it is evident that the effect is big enough, however the effect of a village and individual farm is negative. Consequently, there is a probability that Internet is used by more students who live in regional centres or cities, less by students who live in villages, but the least by residents of individual farms.

The Table of Classification of Internet users

Observed		Predicted		
		Using of	Internet	Percentage Correct (%)
		no	yes	
Using of Internet	no	21	12	64.2
	yes	2	83	97.6
Overall Percentage (%)				81.4

The cut value is 0.350.

The negative factors are indicating of the negative effect on Internet application.

Why is ICT introduction so important now in the educational process? It is determined by many factors. First of all it is the global dimension of this process following out of "The White Book" of European Commission, which determines that internationalisation of trade, global character of technology and further on development of information have provided people with bigger opportunities to acquire information and knowledge. However, at the same time, they have created a remarkable and necessary reorganisation in the demands of employment skills, and employment models. The national dimension follows the national program "Informatics" (1999), as well as the social economic program "e-Latvia", where it is emphasised that orientation of society and national economy to application of general information and knowledge will create more possibilities for Latvia's development. The individual dimension of this process follows out of "The White Book" of European Commission, which declares that mobility, life long education, application of new technological tools, flexible approach for receiving knowledge to be the facts that determine the necessity for searching of new methods that help to affirm professional skills regardless of the fact if they have or have not been acquired parallel to the theoretical qualification (European Commission, 1998).

The research that was performed before on ICT integration in education indicates that this process is developing in three directions in Latvia – ICT as master object (knowledge about ICT), as modern teaching environment (teaching aid that becomes an assistant of the teaching staff), and application of ICT in the management of any educational establishment in order to facilitate the work of administration and save time. The application of ICT requires at the same time both developing skills for working with the tool (computer, using simple formal and communication programs) and skills for working with information (its identification, searching, selection, and assessment)

(Malzubre, 2002). It is important to note that it creates the basis for life-long education.

Conclusions

The introduction of ICT in agriculture could favour both social and economic situation in Latvia rural areas. It could favour the exchange of information, increase the quality of production, and increase the work organisation in enterprises. The farmers would have wider possibilities for searching new markets, find out and make themselves familiar with agricultural novelties in Latvia, EU as well as in the world in general. In order to put it in practice, it is necessary to receive support from the country not only for furthering the possibility to sell agricultural production and giving financial support in a form of subsidies or financing production or development programs, but also as a complex of activities which could provide support for:

1) ICT and data transmission for creation of infrastructure in rural areas;

2) improvement of ICT skills of rural population.

As well it is necessary to define activities of the government, which could motivate self-government and private sector for active participation in achieving purposes of the e-society.

After assessing the effect of the place of residence, it is evident that the effect is big enough, however effect of a village and individual farm is negative. Consequently, there is a probability that the Internet is used by more students who live in regional centres or cities, less by students who live in villages, but the least by residents of individual farms.

The Latvia University of Agriculture prepares specialists mostly for rural needs. Therefore it is significant to prepare such specialists who will be able to analyse the situation in the future, assess possibilities and take the right decisions. One of the ways to achieve this task is a more rapid ICT introduction in the process of education. It was found out in the research that there is much to be done in this sphere. The research is in development state, and solutions how to solve the problem will be offered in the next reports.

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THE ANALYSIS OF INFLUENCING FACTORS OF REGISTERED SMALL AND MEDIUM ENTERPRISES DEVELOPMENT IN LATVIA

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Abstract

The research paper summarizes the results of the influencing factors of small and medium enterprises development: government's policy, access to short and long term financing with reasonable interest rate, investments, tax system, geographical environment, business environment and infrastructure, experience and knowledge. Most of all the small and medium enterprises development is influenced by the investments but also other factors have very significant role.

Key words: small and medium enterprises, factors, development.

Introduction

The small and medium enterprises (SME) have the most important position in the forming of economical situation in the state. They provide people with job, create competition and serve as a source of innovation. The small and medium enterprises are very important for providing of market economy dynamics [2]. The SME are approximately 90% of all enterprises in Europe. Such rate is analogical in the other countries. Also the SME sector has the important role in the national economy of Latvia. Latvia had 45 014 economically active SME in 2003, which is 99% of all economically active enterprises. They produce approximately 65% of gross domestic product (GDP) and employ 70% of all working population. Similarly as in other countries, Latvia has considerable barriers and problems for the development of SME, especially in countryside, that's why they need special support. In the most of all countries with developed market economy can be realized out some different enterprises for the development of SME. The successful development of SME defines a lot of various factors[4]. It was the basic for the choice of the research theme.

The objective of the research – to analyse the development of small and medium enterprises in Latvia and to evaluate the impact of different factors on their development in the regions of Latvia.

Such tasks are nominated for realization of the objective:

1) to identify the influencing factors of small and medium enterprises development;

2) to evaluate the impact of the influencing factors of small and medium enterprises development on their growth.

Materials and methods

The Central Statistical Bureau data, information of the commercial register of the Republic of Latvia, scientific publications that relate to previously formulate the solution of objective and tasks and other informative materials are used for the research.

Such scientific research methods – deduction, induction, analysis and synthesis, and statistic research methods (analysis of regression and correlation) – are used for the solving of tasks.

The composition of publication is formed according to the research tasks.

Results

There are still few small and medium enterprises in Latvia. In 2003, Latvia had 18 small and medium enterprises per 1000 population in comparison with European countries – 40 to 60 small and medium enterprises per 1000 population.

According to the authors' opinion, the development of small and medium enterprises is influenced by various factors, which are showed in Figure 1.

Figure 1 shows that one of the influencing factors of small and medium enterprises development is **government's policy.** One of the tasks to achieve the development of SME is to explore the factors of government and other macro levels such as system of legislation, political culture etc., whose action promotes or disturbs the growth of small and medium enterprises.

The basic regulation of SMS development in Latvia is established by Direction No. 61 issued by the Cabinet of Ministers of the Republic of Latvia **"On the Basic Statements of Development Policy for Latvia Small and Medium Enterprises".** Defined directions and sub-directions of operations in basic regulation have been directed toward the achieving of strategy objectives of Latvia – facilitation of competitiveness and employment – formulated in the Development plan (Single Programming Document), and they comply with the defined priorities in the National Development Plan – facilitation of economics development and competition, as well as development of human resources and employment [8].

The main regulation expect to realize policy based on the best samples in the practice of the most developed countries and on the directions of the small enterprises in European charter taking into consideration the specific problems in Latvia [6;7;11;12].

Five main directions of operations are formulated in the basic regulation [1; 12, 14].

• Improvement of small and medium entrepreneurship environment.

• Promotion of financing access for small and medium entrepreneurship development.
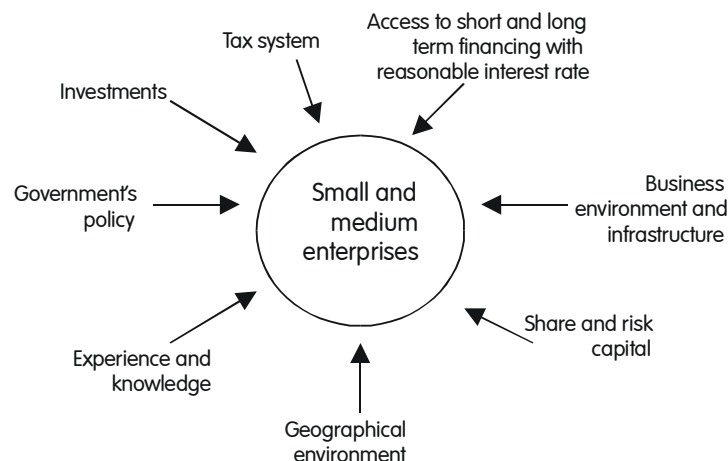
Fig. 1. The influencing factors of small and medium enterprises development.

- Development of the initiative of human resources and new entrepreneurship.
- Facilitation of SME competitiveness in the market.
- Promotion of SME development in territories with a relatively low index of socio-economical development.

In order to ensure the defined purposes in Basic regulation of the SME development of Latvia, **Development Programme for the Small and Medium enterprises in Latvia (2004–2006)** [9] has been elaborated.

The objective of the programme is to promote the formulated purposes in Basic regulation of the SME development policy forming favorable environment for entrepreneurship, derogating management difficulties, motivating entrepreneurs' initiative, derogating general risk, promoting access to financing, improving the efficiency and services of entrepreneurship development, at the same time developing the competitiveness of enterprises in Latvia [5].

For the SME development, different institutions are formed, for example, Rural development fund of Latvia,

Regional development fund etc. with the task to promote the SME development.

The government should promote for the SME development such measures as:
- promote the SME access to market;
- improve the flow of information and to develop instruments of risk management;
- invest in public goods that improve the competitiveness of SME including infrastructure (information, communication, energy, transport, development of education, and technology).

The second influencing factor is the **Access to short and long term financing with reasonable interest rate.** The SME crediting project (1999) for the financing support SME has been elaborated in Latvia. Mortgage bank realizes it with success. The programme forecasts to help the enterprises with potential to develop but in which financing commercial banks are not interested [10].

During 2000–2002, a state guarantee (LVL 10 million) was assigned. The financing was used for outside financ-
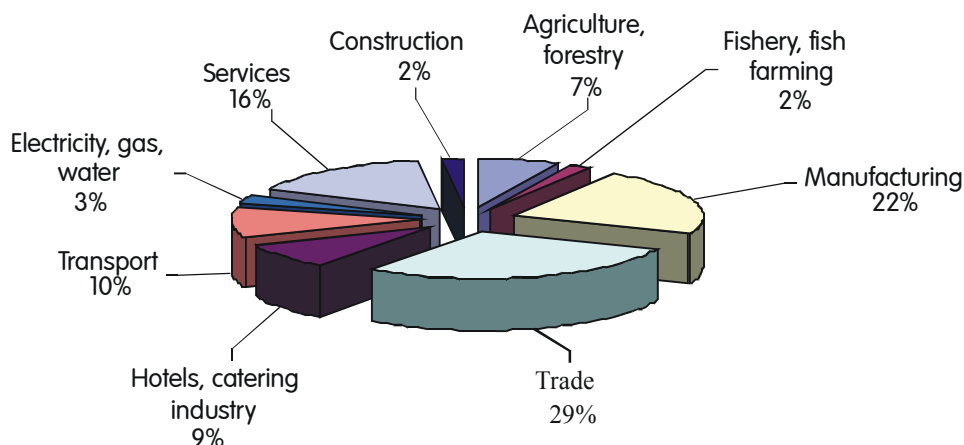
Fig. 2. Division of the small and medium enterprises by directions of operations.
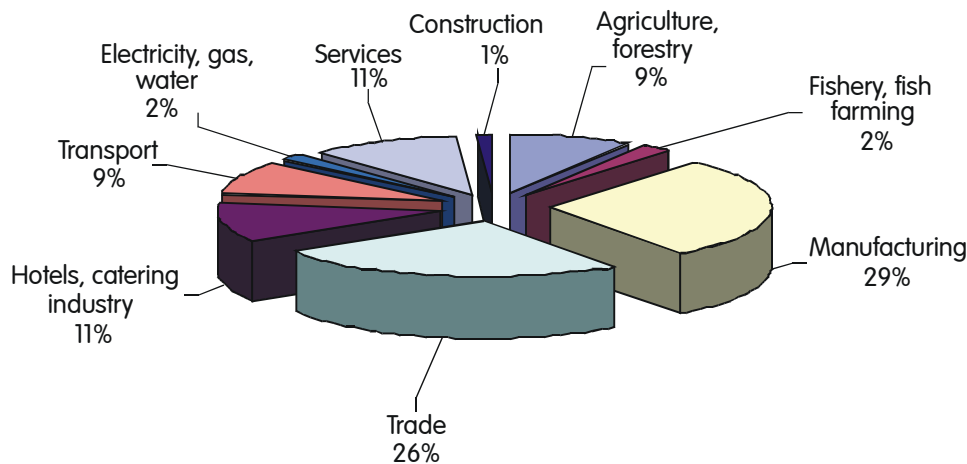
Source: calculations according to the Central Statistical Bureau of Latvia [3].

Fig. 3. The composition of investments by amount of sums in the small and medium enterprises into sectors.

ing from German development banks, European Council development banks, and European Union. In 2002, in the frame of the programme, the Mortgage bank assigned loans – EUR 15.5 million (approximately LVL 9.7 million), but in 2003 this amount of money was EUR 10 million.

From 17.01.2000 till 31.12.2004, 1449 loans where allocated to the SME (the total sum EUR 77.2 million). The average size of loans was EUR 53.3 thousand (LVL 37.4 thousand). The loan granting promoted 4129 new working places in national economy of Latvia.

Figure 2 shows the density of grantees.

Figure 2 depicts that the largest density of grantees is in the trade sector (29%), but the smallest – in the construction and fishery sectors (only 2%).

In order to facilitate the access of financing, especially the guarantee of SME loans, in 2004 the loan guarantee programme there has been started according to this Mortgage bank provides guarantee for every client of other commercial banks in Latvia.

Investments is one of the factors that influences favorable SME development. Figure 3 shows the composition of investments.

Figure 3 shows that the largest density of investments is in the sectors of manufacturing (29% of total amount of investments) and trade (26% of total amount of investments).

To verify is there any linear connection between non-financial investments and the number of small and medium enterprises the correlation analysis has been realized and the correlation coefficient had been calculated among number of the small and medium enterprises in the regions of Latvia (Statistical classification of regions has used for calculations) and total in Latvia (see Table 1).

Table 1 shows that regions of Riga, Vidzeme and Latgale have close positive correlation. It is indicative of possible non-financial investments' impact on the number of SME. The correlation coefficients in regions of Kurzeme and Zemgale are lower and depicts that these regions have an average close correlation between the number of SME

and non-financial investments. Analysing correlation coefficient about the situation in Latvia it is visible that the correlation coefficient is 0.949 and a very close positive correlation exists between the number of SME and non-financial investments.

Table 1

Correlation coefficient among the number of small and medium enterprises and non-financial investments in comparable prices in million lats of 2003 in Latvia and its regions

Region	Correlation Coefficient
Riga	0.986
Kurzeme	0.618
Zemgale	0.445
Latgale	0.846
Vidzeme	0.758
Latvia	0.949

Source: calculations according to the Central Statistical Bureau of Latvia [3].

As the correlation coefficient is high we decided to research this interconnection in details using regression analysis.

To define the existence of such interconnection, there the regression model has been analysed:

$$Y_i = \beta_0 + \beta_i \cdot X_i + r_i \,, \qquad (1),$$

where

Y_i – number of small and medium enterprises,

β_i – parameters of regression model,

X_i – non-financial investments in comparable prices in million LVL of 2003,

r_i – casual mistake.

Figure 4 shows the evaluation of results of the above described regression model.

The regression model (see Figure 4) demonstrates that if non-financial investments increase by LVL 1 million the

$$y = 12.744x + 25621$$
$$R^2 = 0.9$$
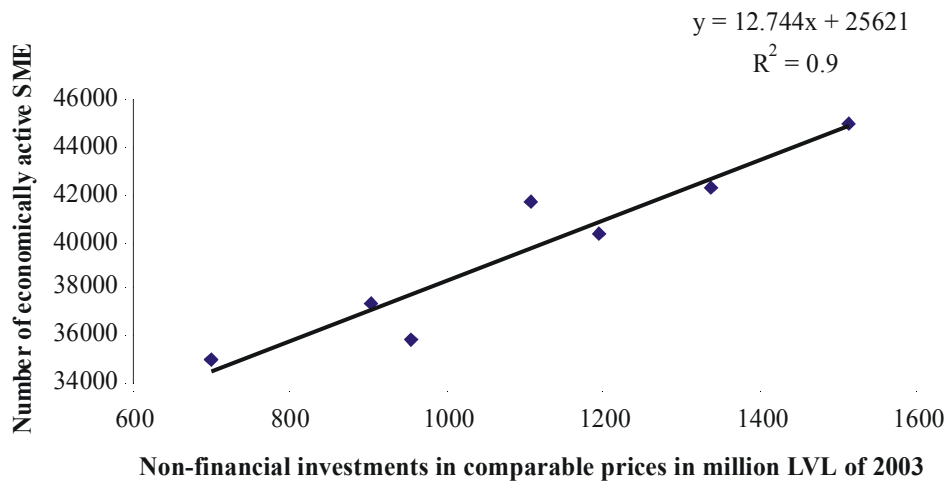
Source: calculations according to the Central Statistical Bureau of Latvia [3].

Fig. 4. Interconnection between the number of small and medium enterprises and non-financial investments in comparable prices of 2003 in Latvia.

number of SME will increase by 13 enterprises on average. The influence of factor is significant with probability 95% (p-value = 0.001115).

The determination coefficient $R^2 = 0.89$ points at preciseness of possible prognosis of the regression model because 89% of actual data dispersion is explained by the chosen model.

Tax policy or **tax system** also has a significant role in the SME development. The reduced rate of taxes allows to invest the largest part of profit in further growth of the enterprise. Sophisticated legislation of taxes and interpretation of legislative acts is also one of the problems, as well as the high requirements according to the management of accountancy. Not always a small enterprise can employ a specialist hereby the accountancy in the enterprise is done by its owner. Misinterpretation of laws causes a big imposition of a fine. To decrease the arising of such situations, the specialists of the State Revenue Service offer technical assistance in issues of accountancy and taxes.

According to the authors' research, the **geographical environment** also influences the SME development. The geographical sector of SME function is rather small there-
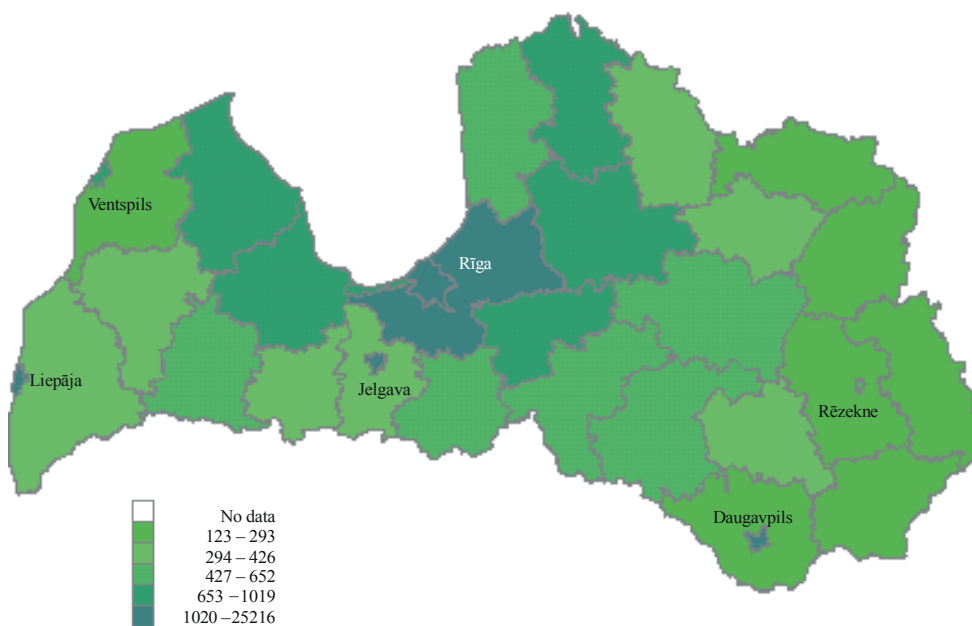
Source: The figure created by the authors [13].

Fig. 5. The number of the small and medium enterprises in cities and districts of Latvia.

fore there is subordination from appropriate geographical environmental factors. Figure 5 shows it in details.

Figure 5 shows that most of all enterprises are in the region of Riga. Almost a half (45%) of all SME is in Riga and district of Riga.

Such factors as **business environment and infrastructure, and experience and knowledge** also influence the SME development. The lack of experience and knowledge among entrepreneurs dislocate the SME development. Business management usually prefers to intuition and personal experience. Leaders of enterprises usually have no time to focus on the growth of the enterprise because of solving daily problems most of the time. As well as such enterprises cannot invest great resources to research market. The lack of knowledge about consumers' needs doesn't allow to react quickly and flexibly on changes in the market and demand.

One of the possible solutions of this problem can be the forming of enterprises clusters and net that promote mutual collaboration between the small and medium enterprises and business infrastructure development in the regions of Latvia as well as forming processes of business incubators and innovation centre – where the business incubators offer a chance to start the activity for the small and medium enterprises with preferences at first, on the other hand the innovation centre try to offer them with services and advisory help for specified sector.

Conclusions

1. The small and medium enterprises have the most important role in the forming of economical situation in the state. They provide people with new working places, create competition and serve as source of innovation.
2. The development of the small and medium enterprises is influenced by such factors.
   2.1. Government's policy helps promote and support the access to market of the SME.
   2.2. Most of all the SME development is influenced by investments. Possible non-financial investments also have significant influence.
   2.3. Access to short and long term financing with a reasonable interest rate.
   2.4. Business environment and infrastructure. Experience and knowledge. Lack of knowledge about consumers' needs doesn't allow reacting quickly and flexibly on changes in the market and demand.
   2.5. Geographical environment. Most of all enterprises are in the region of Riga. For developing of the SME in remote regions of Latvia it is necessary to form the clusters and net of enterprises.

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OPPORTUNITIES FOR DEVELOPMENT OF INNOVATIVE BUSINESS IN LATGALE REGION: FINANCIAL ASPECTS

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Abstract

The paper is aimed at the assessment of opportunities for the financing of innovative activities in Latgale region. The analysis is based generally on the case of Rēzekne. Firstly, the problem is determined – Latgale is the weakest region in Latvia from economical development point of view. Secondly, the overview of the financial resources for innovative activities is given. Finally, the author argues his opinion on necessity to develop innovative business in order to improve the situation in Latgale. One of the most important aspects that hamper Latgale's development is the lack of financial resources. The optimal schemes for the financing of innovative business are offered.

The research lead to the conclusion that finances for sustainable development of innovative business could be attracted through the Latgale's small enterprices (SMEs) cooperation with regional higher education institutions (Rēzekne Higher Education Institution, Daugavpils University), business support centres and Rēzekne Special economical zone structures.

Key words: innovative business, regional development, financial basis, foreign direct investments, the EU Structural Funds.

Introduction

Experience of the EU countries evidently shows that innovative business is the only way to sustainable economic development. Fast development of national economy and growth of social welfare for Latvia, as a small country with open economy, is largely dependent on its ability to produce and offer in the international market competitive goods and services. In order to enhance the overall level of Latvia's economic competitiveness, it is necessary to implement a targeted state innovation policy that should promote accelerated development of new knowledge-based production sectors, as well as increase the share of high value added products within the traditional sectors.

The development experience of the world's developed economy countries evidently shows that these countries have been creating economy open for innovation already for several decades. For some countries, the globalisation of economic processes and fast development of technologies create unique opportunities for fast development, for other countries it creates certain threat for stagnation or even decline. Ability to generate new ideas and apply them commercially is the main driving force ensuring economic growth.

Welfare of Latvia is dependant on welfare of its regions. Latgale is the problem region in Latvia and in the EU. In order to improve the situation, it is vitally important to start developing of innovative activities firstly in such depressive regions as Latgale. The author mentions two major problems that hamper development of innovations: lower level of entrepreneurial activities in Latgale and lack of financial resources within the region.

The objective of the paper is to deliver some solutions of the financial problems in order to ensure successful development of innovative business. Of course, the financial problems can not be analysed apart from the entrepreneurial activities' problem.

Research Methods

Following research methods were exploited within the analysis:

1. data analysis methods, including comparative analysis, calculations of structural and average values;

2. case studies on the carrying out of innovative projects in Latgale region;

3. content analysis of Latvia's legislative acts on regional development.

Results

The Problem: Latgale – Economically Weakest Region in Latvia

According to the Table 1 data, it is more than evident that Latgale is still legging behind all the Latvia's regions in terms of economical development. The Table 1 data presents best and worst results within six major indicators of economical development. Latgale consequently achieves the worst result within all six positions. The best one is achieved by the Rīga region. The indicator of difference between the worst and best results represents one of the major problems in Latvia – great disparities in regional development.

Latgale region is still lagging behind all the rest regions despite the fact that five of its sub-regions (Balvi, Krāslava, Ludza, Preiļi and Rēzekne) were granted the status of an assisted territory and many measures to promote business were implemented there. It means that such policy was not successful and effective.

Analysis the flows of foreign direct investment by regions suggests that also there great disparities are taking place (see Table 2). Altogether 83% of total foreign direct investments are concentrated in the Rīga region. On the total, 93% of foreign direct investments are concentrated in the Rīga, Daugavpils and Ventspils regions. The amount of foreign direct investments per 1 person in Rīga region is 2 times bigger than on average in Latvia, 56 times bigger

Table 1

Territorial Disparity of Latvia's Regions in 2002 (Economic..., 2003)

Indicator	Numerical value		Difference (times)
	Best	Worst	
Gross Domestic Product (GDP) per capita in LVL (2001)	Rīga region 3064.0	Latgale region 1158.0	2.6
Registered unemployment rate, % (average in 2002)	Rīga region 5.2	Latgale region 18.1	3.5
Personal income tax per one resident, LVL	Rīga region 122.1	Latgale region 49.3	2.5
Non-financial investment per one resident, LVL	Rīga region 809.0	Latgale region 261	3.1
Economically active enterprises per 1000 residents	Rīga region 28.4	Latgale region 9.5	3.0
The weighted development index of regions in 2002	Rīga region 2.106	Latgale region -1.069	Difference is not estimated in times

than in Rēzekne region, and 128 times bigger than in Ludza region (Liepiņa et.al.,2002).

Only about 1% of total direct investments are concentrated in Latgale is regional centre – Rēzekne. This fact can be explained by a lower level of entrepreneurial activities. According to the author's opinion, great role in facilitation of business activities belongs to business support centres, Technological centre, and Rēzekne Higher Education Institution.

It is clear that innovative activities require not only finances, but first of all innovative capacity (ability to carry out such activities). In this respect, the author has analysed distribution of IT enterprises by regions.

Table 2 data represents great disparities in the number of IT enterprises not only within Latvia's regions, but also within the Latgale region.

As for Latgale, it is evident that disparities on the one hand between Latgale's two biggest towns (Daugavpils and

Table 2

Distribution of IT Enterprises and Foreign Direct Investments by Latvia's Regions (Information...; Statistic..., 2003; Liepiņa et.al.,2002)

Region	Number of registered IT enterprises (01.01.1991.-12.03.2004.)	Number of IT enterprises per 10 000 inhabitants	Foreign direct invest-ments per 1 inhabitant in 2002, LVL	Region	Number of registered IT enterprises (01.01.1991.-12.03.2004.)	Number of IT enter-prises per 10 000 inhabitants	Foreign direct invest-ments per 1 inhabitant in 2002, LVL
Krāslava	**10**	**2.8**	**8.94**	Alūksne	In facilitation of business 30	11.5	6.27
Preiļi	**18**	**4.4**	**40.35**	Tukums	64	11.6	61.76
Dobele	19	4.8	28.73	Saldus	45	1.8	135.14
Ludza	**21**	**6.2**	**0.64**	**Rēzekne**	**97**	**12.0**	**14.56**
Balvi	**19**	**6.6**	**0.66**	**Daugavpils**	**193**	**12.5**	**401.64**
Bauska	38	7.3	28.13	Liepāja	166	12.5	111.73
Talsi	39	8.0	170.45	Jelgava	133	12.9	37.09
Kuldīga	31	8.4	9.23	Ogre	105	16.7	29.76
Jēkabpils	47	8.5	18.72	Ventspils	98	16.9	524.76
Aizkraukle	36	8.6	14.27	Limbaži	53	17.7	93.37
Gulbene	26	9.3	3.69	Cēsis	122	20.3	31.78
Valka	31	9.4	41.70	Valmiera	123	20.5	161.72
Madona	45	10.0	15.38	Rīga	5242	55.8	822.17
				Total	**6851**	**29.4**	**399.96**

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Rēzekne) and on the other hand between the rest of districts from another one are quite impressive. Two Latgale's districts – Krāslava and Preiļi – have the smallest number of IT enterprises in Latvia.

Analysis of all Latvia's regions shows that only Rīga region (Rīga city, Rīga district and Jūrmala) has achieved the Latvia's average level (29.4 IT enterprises per 10 000 inhabitants). This situation can be easily explained by the dominant position of the Rīga city (76.5% of IT enterprises are set up namely in Rīga, about 41% of Latvia's population are located in Rīga, financial resources are concentrated mainly in Rīga).

Extra efforts should be taken in order to change these great disproportions in regional development. The fact that Daugavpils and Rēzekne represent 9th and 10th best result regarding the on number of IT enterprises per 10 000 inhabitants gives extra evidences that Latgale has a potential for development of innovative business. Furthermore, there is located one of the biggest industrial enterprises – "REBIR" in Rēzekne. Latgale's higher education institutions – Rēzekne Higher Education Institution and Daugavpils University - facilitate in economic development of Latgale and strengthening its intellectual potential. One of the major problems is the lack of financial resources.

Forms of Financing of Innovative Business

Before analysing optimal schemes for the financing of innovative business in Latgale, it is important to the aware of the full spectrum of financial resources.

As sources of financing of innovative activities can be the enterprises, financial and industrial groups, small innovative business, investment and innovative funds, local municipalities, international programmes, private persons, etc. (see Fig. 1). All of them participate in economic processes and promote development of innovative activities. In the developed countries financing of innovative activities is carried out both from state and from private finances (Financing...).

The sources of financing can be divided into two big groups:
- state's funds;

- own, borrowed or attracted funds of business participants (Molchanova).

According to the choice of financing for a certain innovative project, an enterprise should make a choice in organizational form of financing:

1) joint-stock financing:
- participation in the share capital;
- corporative financing.
2) state financing:
- credits from the budget on returnable basis;
- gratuitous assignments;
- target programmes;
- assets of banks and insurance companies owned by the state;
- financing from the government borrowing (international loans and internal bonds or loans);
3) financing of projects;
4) borrowing:
- bank loans;
- foreign loans;
- corporative investments;
- leasing (Gobernik, 2000).

As the **state's funds** are considered the assets from the government budget, assets from national programmes or funds and municipal assets. In this case, financing of innovative activities takes place according to the objectives and priorities of the government policy on innovations. These assets are aimed at the solution of the problems on scientifically technological development and at the support of innovative small and medium enterprises (Gobernik, 2000).

As **assets of business participants** are considered:
- own assets - profit, sinking fund (depreciation charges), enterprise development funds, insurance payments, non-tangible assets, free machineries and turnover assets;
- attracted assets – assets from stocks selling, different charges, target payments, etc.;
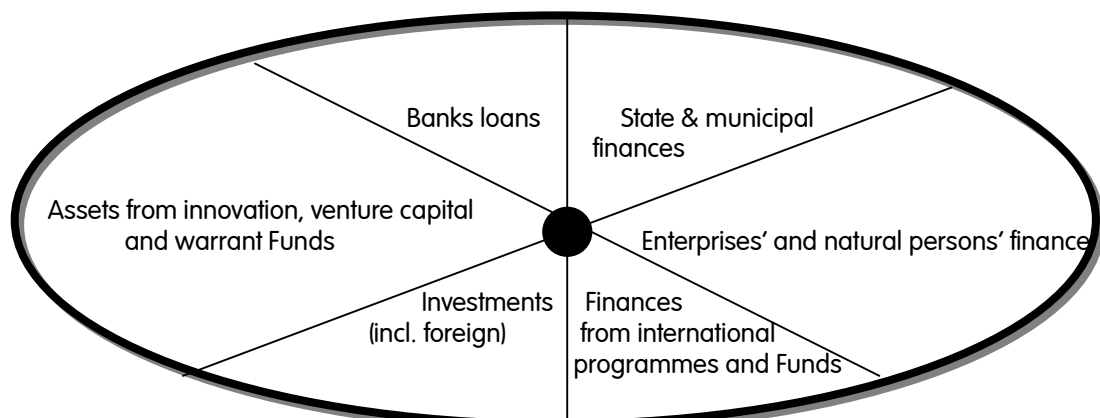
Fig. 1. Financial Sources of Innovative Business (Financing ..; Gobernik, 2000; Molchanova).

• borrowed assets – state budget, banks' loans and commercial loans (Gobernik, 2000).

Financing of Innovative Business Through the Cooperation With Regional Universities and Business Support Structures

Analysing the world practice, the author has come to conclusion that the more developed is a country the bigger responsibility for financing of innovative business belongs to the private sector. The government's main responsibility is to ensure a favourable climate for investments into innovative activities. On average in 15 EU countries, Research and Development (R&D) expenditure compiled 0.68% of GDP from government funds and 1.12% of GDP from private funds in 2002 (in Finland respectively 1.00% and 2.35%; in Sweden 0.87% and 3.07%). At the same time, in the 10 EU new countries this indicator compiled averagely 0.45% of GDP from government funds and 0.35% of GDP from private funds in 2002 (in Latvia respectively 0.22% and 0.08%; in Lithuania – 0.46% and 0.09%; in Estonia – 0.42% and 0.16%) (Statistics,2003).

Thus, it can be concluded that, unfortunately, at the moment the innovative climate in Latvia is far from ideal. Financing of innovative business from the government budget is not sufficient. Support mechanisms for enterprises, which invest their assets into innovations, are weak. On the other hand, enterprises do not have enough awareness of a strong correlation between development of innovations and growth of enterprises' competitiveness. Exploitation of other financial resources is not widely distributed.

Evaluating the opportunities for the financing of innovative activities in Latgale, there are no illusions that local innovative business can rely on a direct financial support from the government. On the other hand, the Lastgale's businessmen can not afford self-financing (self-investments) of innovative business. In the author's opinion, the government should actively exploit the favourable taxation mechanism in order to support innovative activities. Unfortunately, the Latvia's government has abolished 40% of corporate income tax deduction for the IT enterprises, which produce IT products.

Thus, at the moment, the most real opportunities in order to develop innovative business in Latgale and to ensure its stable financial basis is participation in international programmes through cooperation with regional universities (Rēzekne Higher Education Institution and Daugavpils University) and business support structures (Enterprise Advisory Centres, Rēzekne Special Economic Zone, newly established Rēzekne Business Centre).

The author's opinion can be explained generally in two ways. Firstly, Latgale's enterprises are not able to deliver highly qualitative projects in order to attract finances from the international programmes. This, in its turn, can be explained by the enterprises' small capacity and lack of skills and experience in international cooperation. Secondly, the regional universities have already presented themselves as highly experienced partners while participating in international programmes (for example, PHARE and the EU Framework programme).

In the continuation of the paper, the possible schemes of such cooperation will be overviewed.

Regional Universities as Facilitators of Innovative Business in Latgale: the Case of Rēzekne Higher Education Institution

The Rēzekne Higher Education Institution (RHEI) is a regional institution located in the heart of Latgale region – the most depressive from social and economic point of view within the new Europe area. RHEI has a 10 years' long history. Today the institution takes a stable niche on the higher education market in Latvia. During these 10 years, the number of students has grown more than sevenfold and now there are more than 4000 students. The main objective of RHEI is to provide academic and higher professional education, and to develop culture, science and education in Latgale and in the whole of Latvia. The institution actively participates in different projects on regional, national and international level.

One of such projects is REG-ELIN-LAT – Establishing of support network for promotion of innovative SMEs development of Electronic and Information Technology branches in the regions of Latvia.

The project was accepted by the European Commission and financed from the FP5 and Latvia's state budget. The project was carried out in cooperation with national partners ("LEBIC" – as coordinator, RHEI, Daugavpils University, Liepāja, Ventspils and Madona Entrepreneurship Support Centres, Latvian Technological Centre) and international partners (Business and Innovations Centre "Noord" from Netherlands and Emilia Romagna Technologies Development Agency from Italy). This project was carried out in the result of cooperation among local businessmen, regional universities and business support structures.

The project lasted for two years (2001 and 2002) and its aim was the following: to create a professional support network for SMEs of electronics and IT sector in Latvia's regions in order to promote the involvement of Latvian enterprises and research institutions in Community RTD activities, new technology transfer and industrial collaboration with European enterprises. The total amount of project's costs is EUR 636 176. The amount acquired by RHEI is equalled to EUR 32 657.

One of the most significant results of RHEI participation – setting up of "Spin-off Company" at RHEI. The specifics of this spin-off is related to tourism entrepreneurship. It implements the results of researches made by Tourism and Hotel Entrepreneurship Chair of RHEI. This spin-off exploits the experience of such EU countries as Italy and Finland [9,2].

The mission of the spin-off is the following: to deliver new tourism products; to provide thorough information on tourism possibilities in Latgale region in oral, printed and
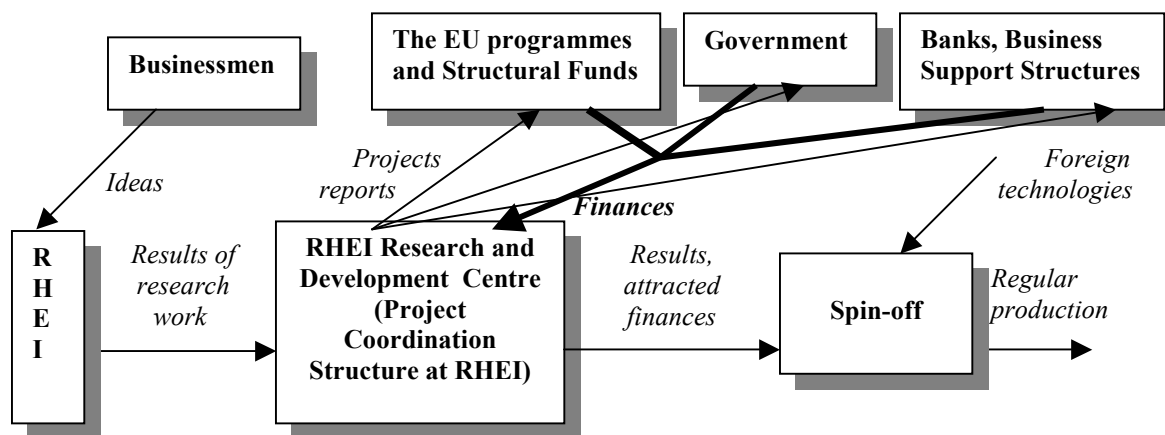
Fig. 2. Principles of the Spin-Off's Activities as the Result of Cooperation Among Businessmen, RHEI and RSEZ [The Author's Model].

digital form; to facilitate development of rural infrastructure in Latgale; and to provide new practical skills for RHEI students and local businessmen.

That innovative activities can be activated in a way of setting up "Spin-off companies". Now Latvia has a number of the 2nd level RTD institutions (Technological Centres and Parks, Business Innovations Centres), which offer consultations, seminars and infrastructure for small enterprises. Latvia has almost no 1st level RTD institutions. Their mission should be related to the shift of scientific inventions and the results of researches in their way towards new and effective technologies or products.

The principles of the spin-off's activities are explained in Fig. 2.

According to the model, RHEI Research and Development Centre serves as the project coordination centre, where the RHEI's academic staff on the basis of the businessmen' ideas and proposals makes the research work, assessing the ideas and elaborating highly qualitative projects. RHEI submits the projects to the EU Framework programme or to the EU Structural Funds. For the approved projects from the Framework programme the programme's authority assigns the finances, and the institution can start to carry out the project within the RHEI's spin-off.

Financing of the approved project from the Structural Funds is more complicated. The Structural Funds do not finance the projects in advance. It means that enterpreneur can get the compensation of the project's expenses only when at least one of its stages will be finished. The businessman must be able to prove the project's expenses with the cheques. Thus the main problem, especially for the SMEs, is related to the ensuring of finances for the initial stages of innovative projects. According to the author's opinion, one of the solutions could be related to the approved projects' initial financing from the government guaranteed loans through the state owned bank – "Hipotēku banka".

This model is only the first stage in facilitation of inno-

vation. Spin-off activity is aimed at the research work and at the initial development of new technologies and new products, but not at the regular production. In continuation of this paper the second stage will be analysed.

Rēzekne Special Economic Zone as Facilitator of Regular Innovative Business

The second stage is related to facilitation of regular production as continuation of successful projects realised within the spin-off. According to the author's opinion, successful realisation of this stage demands activation of RSEZ and setting out of the Industrial park as the RSEZ structure.

According to fig. 3, the SMEs could develop regular production within RSEZ in two ways.

The first one is related to the implementation of SME's business a structural unit of a "cluster". Under the "cluster", readers should understand such form of business, where SMEs take the role of so-called satellites for the big enterprise. These SME offer wide range of services (incl. logistics) or produce spare details for the production process within the big enterprise.

As for RSEZ, there is one big industrial enterprise (SC "REBIR") in the economic zone. Of course, the major prerequirement for the existence of such cluster is related to compatibility of the SME's profile with the nature of business activities of "REBIR".

Activities of the innovative SMEs in RSEZ give financial benefits because of the following tax relief:

1. 80% corporate income tax deduction of the calculated tax amount;

2. 80% land and real estate tax deduction of the calculated tax amount;

3. on the special decision of the Rēzekne town Council, 20% land and real estate tax deduction of the calculated tax amount could be given;

4. all the products and services exported from RSEZ and imported to RSEZ are not liable to the customs duties, excise tax and VAT (Law …).
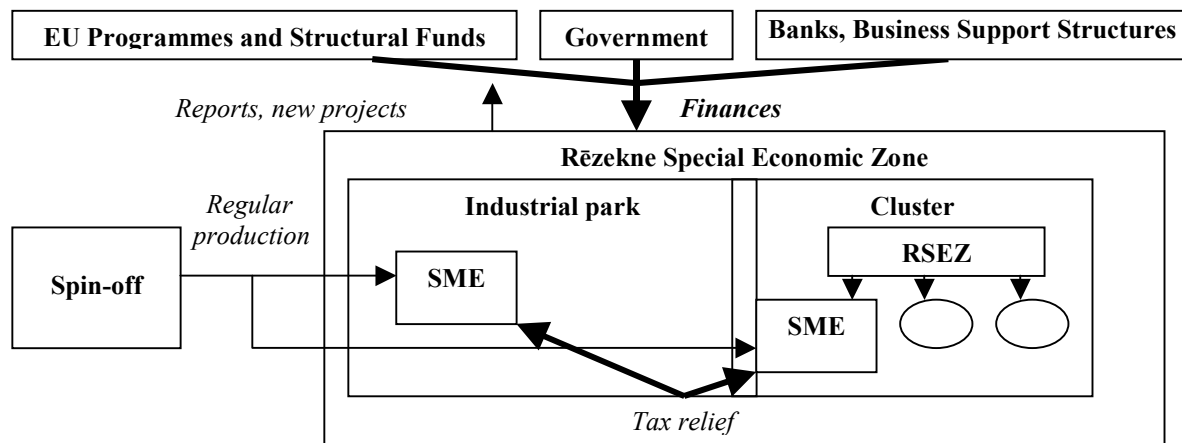
Fig. 3. Development of Innovative SMEs in Rēzekne Special Economic Zone [The Author's Model].

However, despite the tax relief initiatives, the level of entrepreneurial activities is still very low. It can be supposed that RSEZ should reach the next level in its development – setting up of an industrial park. This is the second possibility to develop regular production in RSEZ.

The industrial park is the territory with modern infrastructure and business services in order to facilitate development of different forms of business.

According to the practice, the "bottle-neck" in RSEZ development is inability of the local SMEs to start-up their activities due to the lack of finances. They have no industrial areas and modern technologies in order to implement production process.

At the same time, there are large free industrial buildings that remain from the bankrupted big industrial enterprises in Rēzekne. Setting up of the industrial park is aimed at creation of modern infrastructure in order to carry out the business.

The research suggests that RSEZ should activate the earlier elaborated draft of the concept on setting up of RSEZ Industrial Logistic Park (RSEZ ILP). According to the draft of the concept, RSEZ ILP project has two phases.

Within the first phase the following activities were planned:

1. research work and working up of the business plan;
2. purchasing of land and real estate;
3. creation of infrastructure;
4. landscaping of surroundings;
5. marketing (Draft,2003).

The total costs of the first phase make 135 000 LVL. The sources of the finances could be the following: finances from the Ministry of Economics for development of Latgale Technological Centre (LVL 10000), RSEZ Business Support Fund (LVL 25000) and the government finances (LVL 100000) (Draft,2003).

The second phase is aimed at further development of modern infrastructure and at setting up of business incubator. This phase could be financed using finances of the EU Structural Funds and programmes.

Thus the SMEs' innovative activities in RSEZ ILP could be financially advantageous due to the following aspects: tax relief, opportunity to exploit industrial areas for the lower rent costs or free of charge, opportunity to use offices in the business incubator for free, opportunity to use consultations of business support structures in order to deliver qualitative business projects and to attract finances from the EU Framework programme and Structural Funds.

As it was already mentioned, the main "bottle-neck" for the SME's participation in the EU Structural Fund is inability to attract finances in advance. The author sees several solutions to the problem: initial stages of the SME's project (approved by the EU Structural Funds' Authority) could be financed by attracting municipal finances, bank loans on advantageous conditions delivered as a result of cooperation between commercial banks and the government, and the government programmes' finances.

Also the SMEs should actively exploit the opportunity to find business partners (incl. foreign) through the Latvia's branch of Innovations Relay Centre.

Another source of finances could be RSEZ Entrepreneurship Support Foundation. The total amount of the financial support from the Foundation for the enterprises was equalled to LVL 44470 in 2002 and to LVL 45000 in 2003.

Finalising the results of the research, a conclusion can be drawn that successful development of innovative business in Latgale could be ensured only as result of cooperation among businessmen, municipalities, government, business support structures, and regional universities. The sustainable financial basis for innovative activities could be ensured only by combining different sources of finances.

Conclusions

1. The objective of the paper is show some solutions to financial problems in order to ensure successful development of innovative business. Extra efforts should be taken in order to change the great disproportions in regional development. One of the major problems is the lack of financial resources.

2. At the moment, the most real opportunities in order to develop innovative business in Latgale and to ensure its stable financial basis is participation in international programmes through cooperation with regional universities and business support structures.

3. The research suggests that innovative activities on the universities' basis could be activated in a way of setting up spin-off companies. Their mission should be related to the shift of scientific inventions and a results of researches in their way towards new and effective technologies or products.

4. Rēzekne Special Economic Zone could facilitate regular production carried out by SMEs. Thus, the SMEs innovative activities in RSEZ could be financially advantageous due to the following aspects: tax relief, opportunity to exploit industrial areas for lower rent costs or free of charge, opportunity to use offices in the business incubator for free, opportunity to use consultations of business support structures in order to deliver qualitative business projects and to attract finances from the EU Framework programme and Structural Funds.

5. Finalising the results of the research, a conclusion is drawn that successful development of innovative business in Latgale could be ensured only as a result of cooperation among businessmen, municipalities, government, business support structures, and regional universities. The sustainable financial basis for the innovative activities could be ensured only by combining different sources of finances: business sector finances, municipal and government finances, foreign investments, the EU Structural Funds' and Programmes' finances. Special initiatives should be taken in order to cut the gap in regional development. It could be supposed that special attention and special privileged approach should be paid to the projects from Latgale, which are submitted for financial support from the Structural Funds or local (Latvia's) programmes. It means that in an equal situation the preference should be given to the projects from Latgale. Probably, it is worth to discuss the idea of introducing regional principle in distribution of the Structural Funds' finances.

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INPUT-OUTPUT ANALYSIS OF RURAL PRIVATE HOUSEHOLDS

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Abstract

In the article there are used statistical data about Latvia rural private households of the years 2001 and 2003. The distribution of natural households in Latvia countryside is investigated. The possibilities of the use of input-output models in the research of natural rural household economy are investigated. Making use of private household 'Galakrogs' input-output tables for the years 1999, 2000, and 2001 published by A. Eglite, corresponding input-output models are compiled and their informative analysis is performed.

Key words: rural household, input-output transactions table, duality, input coefficients.

Introduction

The article is devoted to the natural private households in Latvia countryside. Statistical information that should allow to judge about the distribution of natural households in Latvia is analysed. According to the household budget research terminology, the natural income is material benefits that are acquired for personal consumption from an agricultural household, other ways of self-procurement, goods and services got from other households free of charge, as well as from workplace or in a kind of social or humanitarian aid, and so on (CSBL, 2000, p. 9). It is discussed in science about the existence of natural household if the household income and expenditure in kind constitute more than 10% of the total income and expenditure (Eglite, 2003, p. 103). In the article (Eglite, 2003) there are drawn conclusions that it gives rise to speak about wide distribution of natural household in Latvia countryside, but it is little investigated in science. However, the available statistical data do not allow stating how many rural households' income and expenditure in kind constitute more than 10% of total income and expenditure. To prove the distribution of natural households in Latvia countryside, it is necessary to obtain more detailed statistical information.

In the paper, the possibilities of input-output model construction in the economic research of natural rural households are investigated. There are shown methods of informative analysis of input-output models which are easy applied in practice and the results of which are contently interpretive. Making use of the information given in the paper (Eglite, 2003) about private rural household 'Galakrogs', the input-output model of the rural household is calculated, the informative analysis of the model is carried out, and economic interpretations of the results are given.

Methods

The methods of systematization and analysis of statistical information, economic-mathematical modelling methods, and informative analysis methods of models are used. Informative analysis method of models is based on linear equation system pivot transformation and is reduced on comparative statistics or sensitive analysis of economic system.

Results

The results are discussed in the text items 1, 2, 3, and 4.
1. Natural household in rural Latvia.

Let us mention some showings about Latvia agriculture, as the source using agriculture census results of 2001 (CSBL, 2003) and the research about rural household structure in Latvia in 2003 (CSBL, 2004).

On June 1, 2001, 99.8% of total number of households in Latvia was private sector households and 0.2% of households were owned by the state, local authorities, and social organizations (CSBL, 2003, p. 42).

On June 1, 2003, 99.9% of total number of households in Latvia was private sector households and 0.1% of households were owned by the state, local authorities, social and religious organizations (CSBL, 2004, p. 9).

As an economically active rural household could be regarded the household which is producing agricultural products irrespective of the amount produced and the way of its utilization (CSBL, 2003, p.3 84).

To the private sector there are included farmers' and other households that belong to private persons 2 (CSBL, 2003, p. 386).

Agricultural census data of 2001 show that out of 140708 surveyed economically active households of the private sector, the largest part (59.8%) did not produce agricultural products for sale and 11.8% of households sold less than 10% of the produced agricultural products (CSBL, 2003, p. 79).

In the private sector, inhabitants' households were 140138 (out of which 37618 were farmers' households, 96525 were small holdings, and 5995 were private subsidiary farms) which constituted 99.51% of all surveyed economically active households. Altogether 59.9% of inhabitants' households did not produce agricultural products for sale and 11.8% of households sold less than 10% of produced agricultural products (CSBL, 2003, p. 79).

The general data of the rural household structure survey in 2003 show that out of inspected 131316 economically active private sector households, 58.4% of households did not produce agricultural products for sale and 11.1% of households produced for sale less than 10% of totally produced agricultural products (CSBL, 2004, p. 19). In the private sector, the number of inhabitants' households

was 130764 (out of which 33323 were farmers' households, 92397 were small holdings, and 5044 were private subsidiary farms), which constitutes 99.51% of all surveyed economically active households. In all, 58.5% of inhabitants' households did not produce agricultural products for sale, and 11.2% of households sold less than 10% of produced agricultural products (CSBL, 2003, p. 79).

From the data published by Latvia Central Board of Statistics it follows that household income in kind in 1999 formed 20% of household total income in rural Latvia, but in towns – 7.5% (CSBL, 2000, p. 30).

In 2003, the income in kind in rural households formed 16% of their income, but in towns only 3.7% (CSBL, 2004, p. 83). Income in kind has tendency to decrease. In rural households there are a comparatively high proportion of expenses for food, which is largely connected with the consumption of self-produced agricultural products. The proportion of expenses in kind for food expenses in rural households in 2003 constituted 33%, at the same time for inhabitants of towns it was only 9.4% (CSBL, 2004, p.89).

2. Private rural household "Galakrogs".

Let us investigate given in the paper (Eglīte, 2003, p. 104) private household 'Galakrogs' that is managing a farm in the south of Kurzeme, its inter-branch balance tables of elements in kind for the years 1999, 2000, 2001. 'Galakrogs' is a household of five persons: a farmer and his wife are over 40, and their 3 children are youngsters that are still studying. The household's basic source of income is agriculturally available land of 30 hectares owned by the family. On average, every year there are 6 dairy cows, young stock (10 in number), 7 pigs, some hens, and geese. They are selling milk and meat. From agricultural products for sale they are growing potatoes in the area of 5 hectares. For self consumption nature products acquired by picking berries, gathering mushrooms, fishing and hunting are used. The rest of monetary income makes up only social transfers. In the doctorate paper (Eglīte, 2003) 'household inter-branch balance table' is discussed and with the help of it, the model of balance for the analysis of private household elements in kind is constructed. The term 'elements in kind' marks material wealth which is self-produced and consumed, not involving monetary form. The research could

have been more informative if the inter-branch elements in kind balance table had been compiled in natural or physical measures and additionally the prices of elements in kind for the adequate time period had been given. Unfortunately, the balance table of elements in kind is given monetary expression, not stating the changes of the price vector.

During the survey period in the 'Galakrogs' household, the following four branches were active: crop cultivation (garden), cattle breeding (cattle), foodstuff processing for subsequent consumption (product processing), and resources received from the forest, fishing or hunting (nature products) (Eglīte, 2003, p.111).

The first aim of present paper is, based on international methodology of input-output table compilation and interpretation, what is discussed in the fundamental book (Система национальных счетов 1993,1998) 'Galakrogs' inter-branch balance table of products in kind structure will be changed, to specify the notion of added value, purchased products will be looked upon as analogues of import. The results of our input-output transactions table compilation by international metodology are presented as Tables 1, 2, 3.

How could household 'Galakrogs' be estimated according to agricultural census data of 2001?

By the share of agricultural products output for sale. In 2001, 'Galakrogs' sold 72% of processed agricultural products. According to agricultural census of 2001, rural households that sold 51–75% of processed products were only 5.3% out of all households (CSBL, 2003, p. 79).

By the sources of farm income. In 2001, the main income of private sector inhabitants' households from agriculture was in 39625 rural households or 28.3% of all private households (CSBL, 2003, p. 371).

By the total area of agricultural land. From 30 to 49.9 hectares land area each in 2001 was cultivated by 5455 rural households or 3.9% of the total number of households (CSBL, 2003, p. 92).

By the number of persons employed in agriculture. In 2001 there were 133007 households in Latvia where only the household owners and their family members were people were employed, were 56633 or 42.6% of the total number (CSBL, 2003, p.355).

The second aim of present article is to work out meth-

Table 1

Inter-branch Balance of the "Galakrogs" Househould, Year 1999

	Garden	Cattle	Product processing	Nature products	Own consumption	Sold	Given away	Final product	Total
Garden	20	100	69	0	180	450	30	660	849
Cattle	60	483	0	0	380	1694	100	2174	2717
Product processing	0	0	0	0	270	0	40	310	310
Nature products	0	1	41	0	23	0	0	23	65
Value added	634	1935	171	-55					
Bought	135	198	29	120					
Total	849	2717	310	65	853	2144	170	3167	3941

Table 2

Inter-branch Balance of the "Galakrogs" Househould, Year 2000

	Garden	Cattle	Product processing	Nature products	Own consumption	Sold	Given away	Final product	Total
Garden	18	120	35	0	180	480	20	680	853
Cattle	25	520	0	0	350	1352	0	1702	2247
Product processing	0	0	0	0	390	0	0	390	390
Nature products	0	0	20	0	18	0	0	18	38
Value added	730	1438	321	-22					
Bought	80	169	14	60					
Total	853	2247	390	38	938	1832	20	2790	3528

Table 3

Inter-branch Balance of the "Galakrogs" Househould, Year 2001

	Garden	Cattle	Product processing	Nature products	Own consumption	Sold	Given away	Final product	Total
Garden	50	300	85	0	200	575	35	810	1245
Cattle	75	650	0	0	420	2356	0	2776	3501
Product processing	0	0	0	0	445	0	0	445	445
Nature products	0	0	30	0	15	0	0	15	45
Value added	990	2311	303	-35					
Bought	130	240	27	80					
Total	1245	3501	445	45	1080	2931	35	4046	5236

odology of informative analysis of a natural rural household input-output model, and by analysing the information about 'Galakrogs' household, get the conception about Latvia rural natural household productivity and profitability.

3. Theoretical basis of input-output analysis.

Input-output table is the aggregate of statistical information which in widespread way shows the coherence of manufacturing, consumption, accumulation and redistribution of goods and services within the national economy branches. Making use of input-output tables, input-output models are constructed.

As stated by Richard Stone (Stone, 1959), there exist almost unlimited possibilities of the use of input-output models. With the help of input-output models, manufacturing, capital investments, energetic, structure of demand, export proportions, necessary import, employment, prices and costs, and structure of added value are analysed and forecasted. The analysis of economy sensitivity is of special importance.

The national economy structure is called the aggregate of sustainable, stable connections between the managing subjects, which ensures the entirety, i.e. ensures perseverance of the peculiarities of the researched object in the case of different inner and outer changes.

Development of input-output model is based on several assumptions.

The first assumption is about national economy structure. Within the household it is possible to define n pure branches and statistical observations allow making up balance for the processed products in each branch and its utilization during the account period:

$$x_{i1} + x_{i2} + \ldots + x_{in} + y_i = x_i \; ; i \in \{ 1, 2, \ldots , n \},$$
where

x_i = the amount of processed product in branch-i,

x_{ij} = the utilization of pure branch-i product in the branch-j,

y_i = the final product amount of branch-i.

There are used marks: complete processing vector $X = (x_1 x_2 \ldots x_n)^T$; final product $Y = (y_1 y_2 \ldots y_n)^T$.

The second assumption is postulate of linearity. The use of resources is proportional to the amount of produced goods, therefore the direct usage ratio a_{ij} is economically valid, which shows how much products of branch-i are used by branch-j to produce one unit of the product.

The direct usage ratio or technological ratio n×n matrix $A=(a_{ij})$ is used. Often matrix A is spoken about as technology.

The assumptions give the possibility with the help of data from input-output table to construct input-output model: $X – AX=Y$.

The usage of outer resources is put down as follows: import $m = MX$, labour application $l = LX$.

According to the definition (Яунземс, 1993, p. 240), technology is called productive if there is such a vector of complete output which gives positive final product in each branch.

Knowing the product prices, there is compiled input-output dual balance which is interpreted as balance of prices and added value: $p_i - (p_1 a_{1i} + p_2 a_{2i} + \ldots + p_n a_{ni}) = v_i$; $i \in \{1, 2, \ldots, n\}$.

Inventing the price vector $P = (p_1 \ p_2 \ \ldots \ p_n)^T$, input-output dual model in the form of matrix is written down as $P - A^T P = V$.

According to the definition (Яунземс, 1993, p. 242), technology is called profitable if there is such price vector which ensures positive added value in each branch.

Input-output proves in theory that technology is productive then and only then if it is profitable.

The notion of added value is one of most important basic notions of economy. Added value is value which is created during the process of manufacturing (Peterson, 1991, p.157). It cannot be expressed in physical measurement units. Added value is balancing indicator in the input-output table. Gross added value is the value of manufactured product minus intermediate consumption value. Net added value is the value of manufactured product minus intermediate consumption value minus utilization of fixed capital.

Gross added value is the measurement of the amount of manufactured products which does include double calculation. From the products' value is reduced the value of these goods and services that are used as manufacturing resources. Manufacturing process can be characterised by the vector Q of the amount of used and manufactured products and services, the components of which, adequate to utilization, are negative, but the components, adequate to manufactured products, are positive. Then gross added value is expressed as scalar multiplication of vector Q and price vector P: gross added value = $P \cdot Q$.

The interest is arisen by the research that is connected with measurements of gross added value in some other time period prices or some other country's prices. That or other manufacturing process which is profitable in one pricing system may not be profitable in other pricing system.

The basic principal issues in the research of economy systems are balance or statics and comparative statics. Input-output model equivalent changes are used in the research of comparative statics of economy system.

If technology is productive and profitable then using matrix I–A inverse matrix $(A-I)^{-1}$, input-output model and the dual model are possible to change into equivalent forms:

$$[Y = (I - A)X, \ m = MX, \ I = LX] \Leftrightarrow [X = (I - A)^{-1}Y,$$

$$m = M(I - A)^{-1}Y, \ I = L(I - A)^{-1}Y].$$

$$[V = (I - A^T)P] \Leftrightarrow [P = (I - A^T)^{-1}V].$$

Algebra proves that $((I - A)^{-1})^T = (I - A^T)^{-1}$.

Matrix I–A inverse matrix $(I - A)^{-1}$ is easy to interpret informatively. It is called the complete utilization ratio matrix and is widely used in comparative statics of economy systems.

4. 'Galakrogs' input-output models, direct and complete utilization ratio matrixes and their interpretation.

Making use of data from Tables 1, 2, and 3, input-output models are constructed; direct and complete utilization ratio matrixes are calculated and interpreted.

In the model there are featuring four producing branches: crop cultivation, cattle breeding, foodstuff processing for subsequent consumption (product processing), and resources received from the forest, fishing or hunting (nature products).

Marked variables (all quantities measured in lats):

x_1 – quantity of produced output in crop cultivation,

x_2 – quantity of produced output in cattle breeding,

x_3 – quantity of produced output in foodstuff processing,

x_4 – quantity of produced output in nature products,

y_1 – quantity of produced final output in crop cultivation,

y_2 – quantity of produced final output in cattle breeding,

y_3 – quantity of produced final output in foodstuff processing,

y_4 – quantity of produced final output in nature products,

v_1 – added value for crop cultivation output unit,

v_2 – added value for cattle breeding output unit,

v_3 – added value for foodstuff processing output unit,

v_4 – added value for nature products output unit,

m_1 – money spent on purchases for crop cultivation output unit,

m_2 – money spent on purchases for cattle breeding output unit,

m_3 – money spent on purchases for foodstuff processing output unit,

m_4 – money spent on purchases for nature products output unit,

m – total amount of money spent on purchases in four producing branches.

There are used vector designations:

$X = (x_1, x_2, x_3, x_4)$ – complete output, $Y = (y_1, y_2, y_3, y_4)$ – final product,

$V = (v_1, v_2, v_3, v_4)$ – added value, $P = (p_1, p_2, p_3, p_4)$ – product price,

$M = (m_1, m_2, m_3, m_4)$ – vector of direct utilization of purchase,

$A = (a_{ij})$ – direct utilization ratio (4×4) – matrix.

In these designations, the initial direct and dual models are written down in Tables 4, 5, and 6. The form of writing down linear system tables and methods of information analysis is offered in the book (Яунземс, 1993).

Example of interpretation of Table 4.

1. Direct model. With initial direct output X = (849, 2717, 310, 65) the final product is Y = (660, 2174, 310, 23), m = 482. Using the direct system, it is possible to state how the changes of the complete output quantities influence the final product and the extent of purchase.

For example, if the complete output of garden is increased by 1, then $\Delta Y = (0.9764, -0.0707, 0, 0)$, $\Delta m = 0.1590$. The adequate final product is Y + ΔY = (661, 2173.9, 310, 23), m + Δm = 482.2.

If the complete output of garden is increased by 10%, i.e. by 84.9 lats, then $\Delta Y = (82.5, -6, 0, 0)$, $\Delta m = 13.5$. The

Table 4

Year 1999. Direct model X–AX= Y, m=MX and dual model P – Aᵀ P – M = V of household "Galakrogs"

	x_1	x_2	x_3	x_4	
y_1	0.9764	-0.0368	-0.2226	0	p_1
y_2	-0.0707	0.8222	0	0	p_2
y_3	0	0	1	0	p_3
y_4	0	-0.0004	-0.1323	1	p_4
m	0.1590	0.0729	0.0935	1.8462	-1
	v_1	v_2	v_3	v_4	

adequate final product is Y + ΔY = (742.9, 2168, 310, 23), total expenses for purchases are m+Δm = 495.5. So the final product of the garden increases by 12.6%, the final product of cattle breeding decreases by 0.3%, the final product of foodstuff processing and nature product does not change. The money for purchases totally increases by 2.8%.

2. Dual model. With initial price vector P = (1, 1, 1, 1), the added value is V = (0.7468, 0.7122, 0.5516, –0.8462). Using the dual system, it is possible to state how the changes in price vector influences added value. For example, if the price of the output from the garden increases by 10%, then ΔV = (0.0976, –0.0037, –0.0223, 0) and the new added value is V + ΔV = (0.8444, 0.7085, 0.5294, –0.8462).

Example of interpretation of Table 5.

1. Direct model. With initial complete output X = (1245, 3501, 445, 45), the final product is Y = (810, 2776, 44, 15), m = 477. The direct model shows how the changes of complete output influence the quantities of the final products and purchases.

For example, if the complete output of the garden products is increased by 10%, the adequate final product is Y + ΔY = (929.5, 2768.5, 445, 15), the total sum of money for purchases is m + Δm = 490.

So the final product from the garden increases by 14.75%, final product from cattle breeding decreases by 0.27%, the final product of foodstuff processing and nature products does not change. The extent of total purchases increases by 2.73%.

2. Dual model. With the initial price vector P = (1, 1, 1, 1), added value is V = (0.86, 0.64, 0.82, -0.58). Dual system shows how the changes of price vector influence the added value.

For example, if the price of the product from the garden increases by 10 %, the new added value is V + ΔV = (0.95, 0.63, 0.81, –0.58).

Example of interpretation of Table 7.

1. Direct model. With the initial final product Y= (660, 2174, 310, 23), the complete output is X = (849, 2717, 310,

Table 5

Year 2000. Household 'Galakrogs' direct model X - AX = Y, m = MX and dual model is P - Aᵀ P - M = V

	x_1	x_2	x_3	x_4	
y_1	0.9789	-0.0534	-0.0897	0	p_1
y_2	-0.0293	0.7686	0	0	p_2
y_3	0	0	1	0	p_3
y_4	0	0	-0.05128	1	p_4
m	0.0938	0.0752	0.0359	1.5789	-1
	v_1	v_2	v_3	v_4	

Table 6

Year 2001. Household 'Galakrogs' direct model X - AX = Y, m = MX and dual model is P - Aᵀ P - M = V

	x_1	x_2	x_3	x_4	
y_1	0.9598	-0.0857	-0.1910	0	p_1
y_2	-0.0602	0.8143	0	0	p_2
y_3	0	0	1	0	p_3
y_4	0	0	-0.0674	1	p_4
m	0.1044	0.0686	0.0607	1.7778	-1
	v_1	v_2	v_3	v_4	

Table 7

Year 1999. Household 'Galakrogs' direct model X = (I − A)⁻¹ Y, m = M (I − A)⁻¹ Y and dual model is P = [(I − A)⁻¹]ᵀ V + [(I − A)⁻¹]ᵀ Mᵀ

	y_1	y_2	y_3	y_4	
x_1	1.0275	0.0460	0.2287	0	v_1
x_2	0.0883	1.2202	0.0197	0	v_2
x_3	0	0	1	0	v_3
x_4	0.000033	0.0004	0.1323	1	v_4
m	0.1699	0.0971	0.3755	1.8462	1
	p_1	p_2	p_3	p_4	

65), m = 482. Using the direct system, it is possible to state how the changes of the final product influence the complete output and the expenses of purchased product.

For example, if we wish the final product from the garden to increase by 10%, i.e. by 66 lats, the complete output should increase by ΔX = (67.8, 5.8, 0, 0), purchase total quantity should increase by Δm = 11.2. So the adequate complete output is X + ΔX = (916.8, 2722.8, 310, 65), purchase total quantity is m + Δm = 493.2.

2. Dual model. With the initial added value vector V = (0.7468, 0.7122, 0.5516, −0.8462), prices are P = (1, 1, 1, 1). Using the dual model, it is possible to state how the changes of added value vector influence prices.

For example, the added value of the product from the garden to increase by 10%, the changes in prices should be as follows: ΔP = (0.08, 0, 0.02, 0). The new prices then are P + DP = (1.08, 1, 1.02, 1).

Example of interpretation of Table 9.

1. Direct model. With the initial final product Y= (810,

2776, 44, 15), complete output is X = (1245, 3501, 445, 45), m = 477. The direct model shows how the changes of the final product influence the complete output and expenses of purchased products.

For example, if the product from the garden is increased by 10%, the adequate complete output is X + ΔX = (1330, 3507.3, 445, 45), expenses of purchased products are m + Δm = 486.3. So the complete output of garden products should be increased by 6.82%, output of cattle breeding by 0.18%, the complete output of foodstuff processing and nature products remains unchanged. Total expenses for purchases should be increased by 1.95%.

If, for example, the final product of cattle breeding is increased by 10%, the adequate complete output should be X + ΔX = (1275.6, 3844.2, 445, 45), expenses for the purchased products are m + Δm = 503.7. So the complete output of the garden products should be increased by 2.46%, products of cattle breeding by 9.80%, the complete output for foodstuff processing and nature products remains unchanged.

Table 8

Year 2000. Household 'Galakrogs' direct model X = (I − A)⁻¹ Y, m = M (I − A)⁻¹ Y and dual model P = [(I − A)⁻¹]ᵀ V + [(I − A)⁻¹]ᵀ Mᵀ

	y_1	y_2	y_3	y_4	
x_1	1.0237	0.0711	0.0919	0	v_1
x_2	0.0390	1.3038	0.0035	0	v_2
x_3	0	0	1	0	v3
x_4	0	0	0.0513	1	v_4
m	0.0989	0.1047	0.1257	1.5789	1
	p_1	p_2	p_3	p_4	

Table 9

Year 2001. Household 'Galakrogs' direct model X = (I − A)⁻¹ Y, m = M (I − A)⁻¹ Y and dual model P = [(I − A)⁻¹]ᵀ V + [(I − A)⁻¹]ᵀ Mᵀ

	y_1	y_2	y_3	y_4	
x_1	1.0488	0.1104	0.2003	0	v_1
x_2	0.0776	1.2362	0.0148	0	v_2
x_3	0	0	1	0	v3
x_4	0	0	0.0674	1	v_4
m	0.1148	0.0963	0.2025	1.7778	1
	p_1	p_2	p_3	p_4	

2. Dual model. With the initial added value vector V = (0.7952, 0.6601, 0.6809, –0.7778), prices are P = (1, 1, 1, 1). Using the dual model it is possible to state how the changes of the added value vector influence the value of prices. For example, the added value of the garden products to increase by 10 %, the new price should be P + ΔP = (1.0834, 1.0088, 1.0159, 1).

Conclusions and suggestions

Input-output model could be successfully used in the research of the private natural rural households. In the given article, the methodology of input-output informative analysis is investigated and in the kind of examples direct and dual input-output models of the private rural household 'Galakrogs' are analysed. The most valuable part of input-output models are the ratios of direct and complete output in natural measurements that are more sustainable economic indicators than prices of products and purchases.

Input-output transactions tables unfortunately are given in money expression. The corresponding price vectors are not given, therefore the models do not allow to conclude on changes of the extent of manufacturing in household 'Galakrogs'. For a more important economy research of private rural households, the balance sheets should be done in natural measurements fixing also the prices of products and purchases.

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COST EFFICIENT BIODIVERSITY PRODUCTION IN THE PASTORAL LANDSCAPE – ESTIMATION OF COST FUNCTIONS

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Abstract

Some public goods can only be produced jointly with private goods. This paper focuses on the biological diversity that could be produced on semi-natural pastures through the assistance of grazing animals. The question that is being investigated is what shapes the total and marginal cost functions for biological diversity production on semi-natural pastures have if private goods are already being produced using livestock at farms near the pastures. The empirical analysis shows that a quadratic function describes the costs well and that the production is characterized by increasing marginal costs.

Key words: biodiversity, cost function, semi-natural pastures, public goods, multifunctionality.

Introduction

In recent years, the traditional view of agriculture as a producer of only the traditional goods food and fibers has been challenged by a view where it is recognized that it also supplies non-market goods and services. The goods may for example take the form of an attractive countryside with a high level of biological diversity. Since these goods typically take the form of public goods and frequently are highly valued by the population (Drake, 1987, 1992; Hasund, 1998; Hägerhäll, 1999; Hökby and Söderqvist, 2001), policy measures may be necessary if an optimal supply of the goods, from a welfare economics perspective, is desired.

Even though high support levels for agricultural products, which is common among the OECD countries, theoretically could be justified through the production of landscape amenities, the current support systems could hardly claim that they fulfill that function: usually only a small fraction of the total support is directed towards what reasonably could be considered landscape public goods. The lions share tends to be income support or related to the production of private goods (OECD, 1998). Furthermore, Brunstad et al (1999, 1995) finds that it is highly unlikely that the current levels of support in the more generous countries could be defended on public goods arguments. Despite the fact the current levels of support may be hard to justify from a welfare economics perspective, there is a fairly widespread consensus that agriculture produces non-market goods and that countries are entitled to correct market failures, so called non-trade concerns, through decupled support systems (WTO, 1994; OECD, 2000b).

If it is deemed desirable to establish policies that promote the biological diversity on pastures efficiently, it is important to know the costs of biodiversity production. The purpose of this paper is to estimate the costs of production for biological diversity on Swedish semi-natural pastures. The paper improves the knowledge of biodiversity production costs on semi-natural pastures insofar as it provides a link between the costs of managing pastures and the biological diversity that is the result of that management. Although important, other public goods of the pastures, such as recreation, that could be deemed important are not included in this paper. The only pasture service that is considered is the biological diversity produced.

This paper consists of four parts. Section two presents background information regarding the characteristics of Swedish semi-natural pastures and the design of the policy measures currently in place. Section three is the main section of this paper. It begins with a description of the various factors that influence costs and then presents a model describing the biodiversity production cost minimization problem. Subsequently the data is described and the empirical analysis performed. Finally, conclusions are drawn and the paper is summarized.

In the last few years, researchers have increasingly started to focus on problems where public goods are produced jointly with agricultural public goods. The concept has come to be known as multifunctionality and this paper is involved in the same problem since it implicitly assumes that production of private goods takes place jointly with the production of biodiversity. OECD (2001) and Romstad et al. (2000) both discuss multifunctionality broadly, although the former has a more thorough treatment of joint production as such whereas the latter focuses on criteria for policy measures and evaluation of policy strategies. Romstad et al. also discusses the complications involved if farmers are not pure profit maximizers and analyzes direct indicator and index payments for public goods. Boisvert (2001) analyzes policy design for multifunctionality at the farm level using a model where two agricultural outputs are produced jointly with one positive and one negative externality. One important conclusion is that technically joint public and private goods are also economically joint, regardless of the source of jointness. Other studies that have expanded the knowledge regarding policy measures for agricultural public goods are for example Vatn et al (2002), Vatn (2002), Peterson et al. (2002), Lankoski (2003), Lankoski and

Ollikainen (2003a), Paarlberg et al. (2002), Peterson et al. (1999), Hediger and Lehman (2003), Wätzold and Drechler (2002), and Guyomard & Levert (2001).

Biodiversity, semi-natural pastures and existing policies

The focus of this study is on semi-natural pastures. These are essentially old grasslands that ideally have not been exposed to any kind of yield improving measures such as fertilizers, pesticides or sowing. The only agricultural interferences that normally have taken place are fencing, grazing, mowing and clearing of bushes and trees. Many semi-natural pastures have a very long history of management, although the intensity in grazing and management tend to have varied over time. The result of this process is a type of land that often is characterized by nitrogen scarcity. Because of this characteristic, and the stress and disturbances caused by continuous grazing of the land, the semi-natural pastures are frequently rich in biological diversity (Grime, 1977, 1979). Densities of forty vascular plant species per square meter may appear (Ekstam et al., 1988) and the semi-natural pasture is the home of many of the endangered red-listed species in Sweden (Matzon, 1996).

To promote the biological diversity on the semi-natural grazing lands, it is necessary to use the land in a way that suits the species that inhibit it. Most obviously, management and grazing has to continue on the land. If grazing were to cease, the semi-natural pastures would eventually be transformed into forests with a different form of biological diversity. Furthermore, grazing and management can be performed in various ways depending on how well the quality of land is to be upheld. Important may for example be to keep the grass sward low through grazing in order to preserve the living space for demanding species that otherwise loose out to trivial grass types (Swedish Board of Agriculture, 1994). It should be noted though that if maintenance ceases, biodiversity might increase over a period as the height of the grass sward develops. One main reason is the species that previously have not been able to develop, due to the intense grazing, now have a chance to prosper while the more demanding species still remain for some time. A higher grass sward may be positive for e.g. bumblebees.

Due to changing agricultural practices, a majority of the Swedish semi-natural pastures have vanished. The acreage has been reduced by sixty percent over the fifty years prior to 1994 and substantial parts of the remaining areas have diminished in environmental quality (Carlsen, 2001). As mentioned above, a fundamental condition for maintaining pastures with a high biological diversity is a sufficient supply of grazing animals on the lands. Several factors determine to what extent the farmers utilize the pastures for grazing animals. Those factors include, among others, meat prices, the yield of pasture feeds, demand for

necessary fencing, the size of the pastures and the distance between them and the farming centre. Since the number of hectares devoted to semi-natural pastures has continuously decreased during a longer period, it is evident that the farmers have turned to other, more economically beneficial, production forms.

Among the Environmental Quality Objectives developed by the Swedish government (Government Bill 1997/98:145), the goal of A Varied Agricultural Landscape is the one that has the strongest relevance for pastures. In order to attain the goals, the Environmental and Rural Development Plan for Sweden (Ministry of Agriculture, Food and Fisheries 2000), which follows the Council Regulation (EC) No. 1257 /1999, has been developed. The aim of the policies are not explicitly related to the production of biodiversity but rather to keeping the pastures from being abandoned and subsequently transformed into forests. One explicit goal is that in the year 2010, at the latest, all pastures and meadows should be managed in such a way that their values are maintained. Still, one of the underlying arguments for the policies is the importance of pastures for biological diversity so one could argue that an implicit goal is to help the production of biological diversity. There is one basic payment of 1000 SEK/ha^{-1} that farmers could apply for if they are holders of pastures. The basic compensation is paid for measures that conserve and enhance the natural and cultural heritage values of grazing lands. The farmers must therefore manage the land annually in accordance with certain stipulated conditions. There are also additional payments of 1400 SEK/ha^{-1} that the farmers could be granted if their pastures are deemed to be of high biological or cultural heritage value. After application, the Country Administrative Board tests the compensation individually. In addition, there exist payments for complementary measures such as haymaking utilizing scythe and special measures for restoration of pastures where the environmental values have been damaged (Ministry of Agriculture, Food and Fisheries 2000).

Estimating production costs for biological diversity

Description of factors influencing costs

It should be emphasized that in the following it is not the total costs of production a farmer faces when producing biodiversity that will be investigated. Rather, the additional cost involved in the production of biodiversity if animals are already kept at the farm is investigated. For example, consider a farmer that has a stock of animals and currently produces in some way that maximizes profit. Initially, the farmer does not utilize grazing on the semi-natural pastures (due to the assumed higher costs involved with that form of production). If the farmer were to switch the production form to grazing on the semi-natural pastures, what would be the additional costs for that form of produc-

tion? This implies that factors such as winter fodder, stables, and most other capital/labour costs and general expenses are not included. Costs that are included are the additional labour and capital costs for transportation of animals, fencing maintenance, etc. To get a more accurate measure of the additional costs, one could deduct the costs that the farmer avoids when practices are changed, mainly costs related to grazing on fields and concentrated fodder. However, since there is a lack of data regarding the farmers' alternative situations, those costs are disregarded.

A useful delimitation between factors that affect the total cost of biodiversity production on semi-natural grazing lands may be between quantity and quality of managed land. Regarding the quantity of land, there are some obvious costs related to the maintenance. The land has to be fenced irrespectively of how many animals there actually are on the land. Bushes and small trees may need to be cleared and fallen branches removed. There also have to be some animals on the land in order to keep the grass from growing too high. These animals need to be moved between the pasture and farm centre as well as looked after on a regular basis. They also have to have access to fresh water even if there is no natural source of water. Access to shelter is further essential for the animals' wellbeing as well as required by Swedish law. Disregarding the costs of fencing, all costs could vary with the intensity of management, leading to differing levels of environmental quality of the land. One may for example improve the quality of the pasture by increasing the number of animals on the land. Another measure could be to increase the length of time per season the animals are stationed on the land. Taking such actions will increase the costs due to additional need for e.g. watering and transportation.

Costs can consequently be of substantially different magnitudes depending on the structure, size and natural barriers of the area. If a pasture is adjacent to a lake, there is a natural source of water and costs for watering will decrease. There will further be less need for fencing and those costs will decrease. The only cost that could be considered completely fixed is the cost for fencing, although it varies depending on the type of animals used on the pasture. The others are either semi-fixed and could be affected by certain investments or they are completely variable and directly related to the intensity of management.

Since there are some fixed costs in the production and all variable factors are assumed to have a fixed unit price associated with them there will over some range be increasing returns to scale in the production of biological diversity. That is the case both for the quantitative and qualitative aspects. Regarding the quantity of production, increasing the size of a maintained pasture increases the perimeter less relative to the increase in area and there will be less fence per area unit. However, once the maximum upper limit of a pasture is being approached, fencing will usually start to take less optimal shapes from a cost structural point of view. Making the fences fit the edges of the pasture perfectly is likely to increase costs as more fence per area unit will be necessary. As for the minimum requirement of animals on the pasture, it is reasonable to assume that the incremental cost of transporting and caring for an additional animal will be relatively low. Eventually though, increasing the number of animals further will lead to an increasing cost structure. For the quality aspects, increasing supply of animals over a certain limit may necessitate construction of a new shelter or making it necessary to travel the distance between the farm centre and the pasture more frequently. A high density of animals on a pasture may further lead to less fodder per animal and hamper growth, thus increasing costs. As for the management of the area, it is reasonable to assume the basic management will have low costs relative to the results. However, if management becomes more intense as a more perfect, from a biological point of view, situation is strived for disproportionately more time will be required for a given level of results. Consequently, costs increase.

Different areas will have different costs depending on their respective characteristics. Even though there are increasing returns to scale over some range in the management of each pasture, there will be increasing marginal costs when the number of managed pastures increases. As less optimal areas are being used for meat and biodiversity production, the marginal costs increase. That is, when additional hectares are utilized, the costs increase. This is valid both for the quantitative and qualitative aspects of production. Initially, only pastures that have cost efficient shapes would be used but when production is increased, pastures with more cumbersome shapes will have to be utilized. Regarding the qualitative aspects, managers could initially focus on pastures that give a high return relative to the effort performed while subsequently less optimal areas will have to be used.

The model

In the following, it is assumed that each pasture, A_P^i i=1,2,...,n, a farmer manages could be used either as grazing land, resulting in the production of biological diversity, or could be abandoned and slowly transformed into forests with a drastic shift in public good production. It is also assumed that the abandoned land has no values and no costs associated with it. This is a reasonable assumption since new forest plantations normally are not profitable in Sweden due to the long time it takes between plantation and harvest.

Another assumption used in the analysis is that the farmer's goal is to maximize the return from his land holdings. This implies that for any level of production he will optimize his production structure to minimize the costs of production per unit of income. The farmers are in a short run situation as their choices are constrained by the shape

and size of the landholdings. Since not all inputs are freely variable, the farmers optimize all other factors given the pastures.

Consider the case where a farmer has access to a pasture where the size is denoted A_P^i. If the farmer chooses to produce nothing on the pasture, no costs are invoked. That is, there are no opportunity costs of letting the land lay idle. This assumption essentially implies that the land has no alternative, profitable uses. Alternatively, the farmer could opt for production of biological diversity on the pasture. If that option is chosen, the farmer has costs related to the number of grazing animals utilized, i.e. livestock, denoted L^i, and costs related to the size of the pasture. The per unit cost of animals is denoted w_L and the per unit cost of pasture management is denoted w_P.

The production of biodiversity, B^i, is a function of pasture size and grazing pressure, G, on the pasture, $B^i = B^i\left(A_P^i, G\right)$. Grazing pressure is the ratio of livestock to area, $G = L^i / A_P^i$. When the number of grazing animals increases on any given pasture, grazing pressure increases and along with it the biological diversity. The biological diversity increases only up to a certain limit though where after it decreases due to too high grazing intensity. The conditions $B_A^i > 0$ and $B_{AA}^i \leq 0$ ensure this relation.

The task for the farmer that produces biological diversity on pastures is to minimize costs subject to the constraints of available land, available livestock, maximum grazing pressure and the given biological diversity production function. A general annual total cost function for the production of biodiversity could be written as a function of the variables as $C^i\left(A_P^i, w_P^j, L^i, w_L^j, B^i, H^i\right)$ where H is a fixed cost component. Note that the cost function for the production of biodiversity is specific for each pasture as the conditions differ between locations. An objective function for the farmers' production of biodiversity can thus be written as:

$$Min_{A^i, L^i} \sum_i C^i = w_P^i \cdot A_P^i + w_L^i \cdot L^i + H^i$$

$$s.t.\ B^i = f\left(A_P^i, L^i\right),\ A_P^i \leq \overline{A_P^i},\ L^i \leq \overline{L^i},\ \frac{L^i}{A_P^i} \leq \overline{G^i} \quad (1)$$

Forming the Lagrangian and minimizing the objective function subject to the constraints give us the first order conditions (disregarding the complementary slackness conditions):

$$w_P + \lambda_1 \frac{\partial f\left(A_P^i, L^i\right)}{\partial A_P^i} - \lambda_2 + \lambda_4 \frac{L}{A_P^{i\,2}} = 0 \quad (2)$$

$$w_L + \lambda_1 \frac{\partial f\left(A_L^i, L^i\right)}{\partial A_L^i} - \lambda_3 - \lambda_4 \frac{1}{A_P} = 0 \quad (3)$$

Solving for the multipliers gives the solutions:

$$\lambda_1 = \left(w_L - w_P + \lambda_2 - \lambda_3 - \lambda_4 \frac{L^i + A_P^i}{A_P^{i\,2}}\right) \cdot \frac{1}{\frac{\partial f\left(A_P^i, L^i\right)}{\partial A_P^i} - \frac{\partial f\left(A_P^i, L^i\right)}{\partial L}} \quad (4)$$

$$\lambda_2 = w_P - w_L + \lambda_3 + \lambda_4 \frac{L^i + A_P^i}{A_P^{i\,2}} + \lambda_1 \left(\frac{\partial f\left(A_P^i, L^i\right)}{\partial A_P^i} - \frac{\partial f\left(A_P^i, L^i\right)}{\partial L}\right) \quad (5)$$

$$\lambda_3 = w_L - w_P + \lambda_2 - \lambda_4 \frac{L^i + A_P^i}{A_P^{i\,2}} + \lambda_1 \left(\frac{\partial f\left(A_P^i, L^i\right)}{\partial L} - \frac{\partial f\left(A_P^i, L^i\right)}{\partial A_P^i}\right) \quad (6)$$

$$\lambda_4 = \frac{A_P^{i\,2}}{L^i + A_P^i} \cdot \left(w_L - w_P + \lambda_2 - \lambda_3 + \lambda_1 \left(\frac{\partial f\left(A_P^i, L^i\right)}{\partial L} - \frac{\partial f\left(A_P^i, L^i\right)}{\partial A_P^i}\right)\right) \quad (7)$$

Interpreting how the values of the multipliers behave is somewhat complicated as they interact with each other. It would be possible to set up the conceivable scenarios and analyze the multipliers thoroughly but because of space constraints it will be disregarded here. The interpretation of the multipliers that are relevant is fairly straightforward though. λ_2 is the constraint related to area and it is the shadow price of pastures. If none of the other constraints binds it is equal to the difference between the optimal costs of a given level of biodiversity production and the suboptimal costs for that level of production when the pasture size is restricted. Likewise, λ_3 is the constraint related to livestock and it is the shadow livestock. If none of the other constraints binds it is equal to the difference between the optimal costs of a given level of biodiversity production and the suboptimal costs for that level of production when the amount of livestock is restricted.

The cost functions for two standard production functions, one Cobb-Douglas and one Linear, have been derived.

Cobb-Douglas production function:

$$C = B\frac{1}{c}\left(w_1\left(\frac{d}{c-d}\frac{w_2 - \lambda_2}{w_1 - \lambda_3}\right)^{\frac{c-d}{c}} + w_2\left(\frac{d}{c-d}\frac{w_2 - \lambda_2}{w_1 - \lambda_3}\right)^{-\frac{d}{c}}\right) \quad (8)$$

Linear production function:

$$C = w_1\left(\frac{B+d}{Zd+c}\right)^2 + \left(w_2 - w_1\right)\left(\frac{B+d}{Zd+c}\right) \quad (9)$$

where $Z = \frac{w_1 - w_2 + \lambda_2 - \lambda_3 - \lambda_1 c}{\lambda_4 - \lambda_1 d}$

Data retrieval and description of study areas

The costs of producing biodiversity are the additional costs that are the result of keeping animals on pastures rather than utilizing the alternative most profitable meth-

ods. In order to estimate an annual cost function for the production of biological diversity on semi-natural pastures, data is needed for the costs of production and the resulting biological diversity on the pastures. Data on the biological diversity on a set of pastures is available, as described below. That is, data is available for the variable *B*. Due to data limitations it has however not been possible to gather the specific costs for each pasture. Rather, the costs have been calculated using the data that is available. These calculations rely on an essential assumption: it is assumed that a specific level of grazing pressure is upheld on all well maintained pastures. Therefore, the amount of livestock, *L*, is directly related to the size of the pastures, A_p, for which data exists and it is not necessary to investigate the actual number of animals on the pastures. Likewise, data for the unit prices of livestock and management, w_p and w_L, are not used independently as it is difficult to separate the management costs from the livestock costs. However, implicitly the unit prices are parts of the cost calculations. The costs are calculated using per hour prices of labor and machinery as well as approximated costs for consumable supplies. These costs are assumed directly related to the size and perimeter of the areas. Another part of the unit prices is the cost of working capital. These costs are also directly related to area and perimeter as they are a specific fraction of the costs.

The data source has been produced by the EU program AEMBAC of the 5th Framework Contract Ref: QLRT-1999-3166 for the purpose of developing a framework for local agri-environmental programs for biodiversity and landscape conservation. The attributes of fields and objects have been measured using a combination of GIS-data, air-photo interpretation and field surveys. The pastures have then been measured according to area and perimeter and several characteristics of the land, e.g. quality of cultivation and percent of land covered with bushes and trees, have been identified through computer inspection of the photographs and field surveys. The characteristics of the fields have then been used to calculate several different indicators out of which one is an indicator for biodiversity quality.

Data is available for two different regions, Selaön and Vetlanda. Geographically, they are located in the southern part of Sweden; Selaön at the level of Stockholm and Vetlanda south thereof. Following the division of Sweden into eight production areas, Selaö is situated in the plain districts in Svealand whereas Vetlanda is in the forest districts of Götaland. Selaön belongs to the administrative region of Södermanland County whereas Vetlanda belongs to the Jönköping County.

Selaön is an island in the Lake Mälaren and it is the largest island of Swedish lakes. The total land area is 9100 hectares and it is connected to the mainland via a bridge. The agricultural and agri-environmental situation of the island is representative of the plain districts in central Sweden.

The Vetlanda study area consists of the parishes Alseda and Skede that are situated in the municipality of Vetlanda. The total area of the Vetlanda study area is 7710 hectares. In many important aspects the area is typical of the agricultural production area forest districts of Götaland. As such, it represents a region that is rich in semi-natural pastures and traditional landscapes.

Description of variables

Below is a description of the different variables that are used in the statistics and regressions. For more thorough information about the construction of the biological diversity indicator, see Nilsson (2005).

Annual total cost (C^i) - calculated total, additional costs of keeping animals on a pasture with the intention of having a sufficiently high grazing pressure rather than handling the animals with the most profitable alternative production methods. The total costs are not measured at the farm level but calculated. The calculation methods used for the calculation of the additional costs for production of grazing lands have been founded on the contents of the report of Kumm (1995). In addition to the factors mentioned below, other assumptions (e.g. regarding the lands productivity of fodder) are implicitly assumed. Important to notice is that the calculation reflects a specific level of grazing pressure and general pasture maintenance. Since a specific grazing pressure is assumed, the amount if livestock (L^i) used on the pastures does not have to be measured. Rather, it is assumed to correlate with the area (A_P^i), which is measured in square meters.

The perimeter of the pasture influences costs since small pastures need more fence per hectare than large pastures do. It is the actual perimeter of the pasture measured in meters, i.e. it is not corrected for possible adjacency to water or other pastures. Fences are assumed to be in place and it is not necessary to replace them if they are maintained properly. Maintenance is however costly. To maintain the quality of fences, one hour of labor / year for every hundred meter of fence has to be deployed for maintenance. Equipment such as tools and tractor usage for the maintenance is utilized in the same proportion. The cost of consumable supplies is assumed to be 50 SEK per 100 meters of fence. The sum of these costs is about 220 SEK per 100 meters of fence and year.

The cost of interest on working capital is assumed to be 8 per cent, which corresponds to the average inflation adjusted return of the Swedish stock market between 1919 and 1990. The average working capital is the sum of the incremental costs multiplied by a certain percentage, which in the case of grazing is 30%. The percent measure is related to the length of time of the year the capital is utilized. For further information on the assumptions laying the foundation for this part of the calculations, see Kumm (1995).

Labor time is needed to maintain the grazing lands,

bushes need to be cleared etc. Furthermore, the animals need to be moved between the pastures and the farm. The basic time needed for this work is one hour per hectare and year. The time use of equipment needed is equal to the time worked. The price of labor is set to 120 SEK / hour and the cost of machinery and equipment is set to 50 SEK / hour.

The resulting incremental costs calculations are the following and the sum of them gives the total incremental costs of production of grazing lands:

Labor costs: $L = w*(a + p/100 + f)$

Machinery/tools: $M = c*(a + p/100 + f)$

Fence: $F = m*p/100$

Working capital: $W = (L + M + F)*0.3*r$

Total costs: $TC = L + M + F + W$

where:
w = wage rate = 120 SEK / hour
c = rental rate machinery / tools = 50 SEK / hour
a = area size in number of hectares
p = perimeter in m
$r = 0.08$
f = fixed minimum time needed per parcel = 0.5 hours
m = cost of materials = 50 SEK / 100 m fence

Biodiversity (B^i) – a measure of the biological diversity produced in the pastures. It is a quantitative measure of the biological diversity at a pasture as it incorporates the two relevant factors into one measure: the area, A_P^i, is multiplied by an indicator for the biodiversity quality at the pasture. The indicator for biodiversity quality is constructed by adding two sub-indicator values for vascular plant species and bushes diversity. The value of the sub-indicator maintenance, which is equal to three representing the general quality of semi-natural pastures, is also added creating a range of 3 to 5.25. The purpose of the sub-indicator vascular plant species is to indicate the values and functions concerning maintenance of vascular plant populations / genetic resources. It measures how many established populations of indicator species, as listed in Nilsson (2005), are present at the object. The sub-indicator receives values between 0 and 2 depending on the number of populations. The data has been gathered through field surveys. The other sub-indicator of bushes diversity is a general reflection of biological diversity but also of some invertebrate values. The values attributed to it are low: if there are at least six different species on the object, the indicator takes the value 0.25, otherwise it gets the value zero. The bushes being surveyed are presented in Nilsson (2005).

Empirical analysis

The data set consists of 122 observations of pastures that are well maintained, out of which Selaö has 45 and Vetlanda 77. However, not all variables have been surveyed

on all pastures, i.e. variables that are sub-indicators for the biological diversity indicator. If one would remove those pastures that have not been completely surveyed for all variables, the set would fall to 30 out of which 25 belong to Selaö and 5 to Vetlanda. Since the positive effect of gaining a larger sample has not been considered sufficiently positive to outweigh the negative effect of including not completely surveyed observations, the regressions are run on the smaller sample. One remaining problem regarding the data concerns the level of grazing intensity: the assumed intensity in the total cost calculations may not correspond perfectly to the intensity level of well maintained in the data set.

To estimate the cost function for production of biological diversity on semi-natural pastures, four econometric models are specified according to the following:

$$1.\, C(bio) = \alpha + \beta \cdot bio + \varepsilon$$

$$2.\, \log C(bio) = \alpha + \beta \cdot \log(bio) + \varepsilon$$

$$3.\, C(bio) = \alpha + \beta \cdot bio + \beta_2 \cdot bio^2 + \varepsilon$$

$$4.\, C(bio) = \alpha + \beta \cdot bio + \beta_2 \cdot bio^2 + \beta_3 \cdot bio^3 + \varepsilon$$

where, as previously stated, *"C"* is the annual total cost measured in SEK for production of biological diversity and *"bio"* is the quantitative measure for biological diversity. Test statistics indicate heteroscedasticity and therefore the coefficients displayed are estimates that are corrected for heteroscedasticity through White's heteroskedastic-consistent covariance matrix estimation procedure.

Two models, the logarithmic and cubic, present poor results. The logarithmic has a relatively low R-square value while the cubic has poor p-values. Model 1 and Model 3 both have very high R-square values, implying that the dependent variable is well explained by the independent variable biodiversity. The quadratic term has a positive effect on the results insofar as it increases not only the R-square value but also the adjusted R-square value. Consequently, the quadratic model describes the relation between the independent and dependent variables better than the linear model. The only disadvantage with Model 3 is the p-value of 0.061 but considering the strength of the coefficient of determination and the better correspondence to theory, Model 3 is considered to be the model that most reasonably describes the cost function for production of biological diversity on Swedish semi-natural pastures. The chosen total and marginal cost functions thus take the following forms:

$$C = 630.91 + 0.023785 \cdot Bio + 0.92927 \cdot 10^{-7} \cdot Bio^2$$

$$MC = 0.023785 + 0.185854 \cdot 10^{-6} \cdot Bio$$

The marginal costs can be related to the possible revenue from the current support system. If it is assumed that the only purpose of the system is to promote biological di-

versity and that the policy makers value one hectare that produces 30000 units of biodiversity (i.e. a well-maintained pasture lacking all the indicator species) to 2400 SEK, each unit is worth 0.08 SEK. Alternatively, assume the policy makers value 30000 units of biodiversity to only 1000 SEK, then each unit is worth 0.0333 SEK. In the first case, a typical farmer would be willing to supply 302500 units of biodiversity, in the second – 51400 units (assuming that no constraints bind). This implies that farmers, in the case of the high (low) payment, would produce biodiversity on between 5.75 (0.98) and 30.25 (5.14) hectares depending on the level of biological diversity quality produced on the pastures.

Conclusions

In this paper it has been attempted to estimate cost functions for the production of biological diversity on Swedish semi-natural pastures. It has been shown that a quadratic cost function is an accurate description of the biological diversity production costs on Swedish semi-natural pastures. The results are particularly interesting for two reasons. Firstly, although it has been attempted previously to estimate the costs of maintaining livestock on semi-natural pastures, those costs have not been related to the actual biological diversity production. Secondly, now when the costs of production have been estimated, there is a foundation for continued research regarding efficient policy measures for landscape public goods. A reasonable next step would be to relate the results to transaction costs and value estimates. Important to keep in mind though is that the results rest on a crucial assumption: the agents are assumed to have access to grazing animals. If that was not the case and investments in e.g. barns and fences would have to take place, costs would be of substantially different magnitudes.

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THE INVESTIGATION ON THE EVALUATION OF DRAINED LAND

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Abstract

Agricultural development based on the laws of market economy enhances a change in the point of view on land as real property and search for optimal variants of its possible usage. As a large part of all agricultural land has been drained, efficient functioning of water regime regulation means is one of the essential factors determining the possibilities of land use as well as its value. Land areas where land reclamation structures are in good condition and do not need to be repaired or reconstructed will always be of higher demand under the conditions of market economy. Present prices of agricultural land do not show the value of land reclamation systems. Therefore a complex land assessment is needed in respect of the present condition of land reclamation structures, its age and probabilities of failures.

Key words: agricultural land market, mass valuation, land reclamation, land price.

Introduction

After the Baltic States have joined the EU, the new enlarged market space has created new responsibilities and improvements of real property management system. The Lincoln Institute has developed courses on the value-based land and real property taxation for countries transitioning to market economies in Central and Eastern Europe and the Baltic's (Malme, 2004). The Baltic countries of Estonia, Latvia and Lithuania have been in the forefront of implementing value-based taxes on land (Malme and Youngman, 2001). Estonia was the first of these new independent states to recognize the benefits of land taxation and to introduce a value-based land tax in 1993, followed by Latvia in 1998. Lithuania has been a leader in integrating and unifying real property cadastral, registration and valuation systems. An automated central database of real property information was developed in the State Enterprise Centre of Registers.

Legal base for land assessment in Estonia is the Land Valuation Act. Three land assessments have been performed in 1993, 1996 and 2001. Last assessment was mainly based on the information collected in the Sales register. At the beginning of 2002, land price and productivity zones were created and edited directly in the digital format (www.maaamet.ee). The sales comparison method, capitalized earnings method, cost method and combinations thereof are used in valuations.

In Latvia, the land cadastral value assessment procedure consists of primary assessment of the land cadastral value (followed by the registration of a land unit with the State) and updating of the land cadastral value in case of amendments (www.vzd.gov.lv). The land cadastral value is influenced by the data about the area of the land unit and qualitative valuation of land (in points) and correction coefficient due to its infrastructure, engineering and technical objects and networks.

Present appraisal system of land in Lithuania is based on the methodology of Lithuanian Land Appraisal made in 1989 (Juodis and Pakutinskas, 1989). Bonitet points are considered as an integrated index of soil quality, relief, water regime in the soil of agricultural land areas and certain other natural factors. The correction coefficients are applied to appraisal bonitet points of soil considering geographical, local and other conditions of the vicinity. Appraisal of agricultural land plots is carried out by the method based on land usage income value (Lietuvos ..., 1996). The background of this method is the calculation of profit when the land is used as a business object, i.e. when it is rented or used for agricultural activity.

As it is noted in joint annual reviews of real estate markets, the growth of economy has stimulated land market in all Baltic States (Review..., 2003). Compared with 2001, the average price for arable land in Estonia has increased by 36% and was EUR 297 in 2003. The highest average price for one hectare of arable land was in the surroundings of Tallinn – EUR 453. This was not due to a better soil fertility, rather to the proximity of the capital city. The average prices of most fertile soils in Central-Estonian counties were between 315 and 380 EUR ha^{-1}. In West-Estonia with poorer soils the average price was between 180-270 EUR ha^{-1}. The counties of South-Estonia had the same price level, but soil fertility there is better compared with West–Estonia. The price of arable land depends first of all on the quality of soil, the size of the parcel and the level of agricultural development of the region. In traditional agricultural regions (Central-Estonia) the prices have increased more than 20%.

The average market price for agricultural land in Latvia's rural districts stayed within the limits of 170 EUR ha^{-1} (Latgale) up to 430 EUR ha^{-1} (Vidzeme). The highest price for agricultural land (875 EUR ha^{-1}) was registered in the Riga region. It shows that the activity of the land market in Latvia was nearly two times more intensive than in Estonia. In 2003, the average increment in prices for agricultural land in the state as a whole, as compared with the previous year, was 23%, but in the Riga region – 60%. The general

level of socio-economic development within a certain territory makes a significant effect on the market prices of land.

The land market activity indices in Lithuania were related not only to the economic and social development in the country, but also to the land restitution and privatisation. Until the 1st of January 2004, land ownership rights were restored to 87.52% of land area. Legal registration was made to more than 3.2 million ha of land, from which agricultural land areas make up 2.57 million ha. In 2003, 3.96 million ha of land (60.6% of total area of Lithuania) were used for agricultural activity. Although the restoration of land ownership rights has not been finished yet, the land market is already functioning. On the average about 2600 sale and rent transactions of private and state land were concluded. Having compared with the previous year, the average price increased by 22% to 129%. Average prices for land in rural area amounted to 264–424 EUR ha^{-1}. The highest average prices were recorded close to Vilnius city – they increased by 87% and amounted to 8723 EUR ha^{-1}. Land market in Klaipėda district was rather active – there the average price increased by 125% and amounted to 2682 EUR ha^{-1} (Bagdonavičius and Mikūta, 2004).

It must be noted that in the year 2003, it was the proximity of the EU accession that activated the real property market in all the Baltic States, especially in the agricultural sector, contributing to a small but potentially growing price rise. Forecasting the development for the nearest future, analysers still appreciate the economic growth potential of the Baltic market zone. The land market development tendencies will remain unchanged, and the demand for land will continue to rise.

Accumulation and distribution of property market data and mass valuation of the property is a part of real property management system. Land appraisal methodology prepared in 1993 and still valid does not correspond to the developed market principles and the value of land plots contradicts to the market values (Tumelionis and Bagdonavičius, 2004). In certain cases the land value, calculated basing on this methodology, differs from market values even several times. According to Pakutinskas (2000), agricultural land productivity points relatively express the productivity of agricultural land plots and evaluate the agrochemical properties of soils. However, there is a wide range of subjective factors increasing the value of land (e.g. irrigation/drainage systems, infrastructure) or reducing it (e.g. fragmentation of land plots due to the changing of land owners, intrusion of another land plots, changes in land purpose). This implies that in fact the land assessment system requires new appraisal methods. The shortcomings of land appraisal methodology might be eliminated having implemented a new mass valuation system of the real property that has been applied in countries of the European Union for about 20 years.

Land Evaluation and Area Review (LEAR) System for Agriculture, developed by Ontario Ministry of Agriculture and Food (OMAF), notwithstanding the soil capability rating, involves lands reviewing against several factors, which could either enhance agricultural potential (e.g. capital investment in farm infrastructure, irrigation systems, tile drainage, etc.) or diminish its long-term capability for food production (e.g. property fragmentation, intrusion of non-farm uses, etc.) (Ministry…, 2003). The rating of water resource availability factor takes a significant place in the Land Evaluation and Site Assessment (LESA) model, which is generally used for rating the relative value of agricultural land resources in California (Wright et al., 1983). Water regime reliability is based on the effects on agricultural production. The factor had to include an interrelation with cost too. In defining the lands that are associated with agriculture, the following aspects should be included: tillable lands, pasture, drainage ditches, and woodlots (less than 2.5 hectares). Thus the specification of land appraisal models is to be done having estimated the interrelations of different factors affecting the market prices. In Lithuania such study has been performed by the National Land Management Institute since 1996. The data about different factors that affect the value of agricultural land market is being collected based on a common methodology and stored in a data bank (Tumelionis, 1997).

The benefits of tile drainage for crop productivity, farm efficiency, and even for reducing environmental impacts have been studied and are generally known for farmers (Vander Veen, 2001). In Lithuania, the surplus of precipitation causes waterlogged soils therefore land reclamation practices such as subsurface drainage and soil amelioration have been very successful in increasing soil productivity. Consequently, the draining condition of agricultural land must correspond to its market price. The objective of investigations carried out by Water Management Institute of the Lithuanian University of Agriculture is to analyse the changes in the value of agricultural land in respect of the changes in the condition of land reclamation systems, and to give motivation for the new criteria of drained land evaluation.

Materials and methods

The studies are based on the methods of the analysis, statistical investigation and comparison of information of different literature resources and legal acts. The analysis of the market of agricultural land has been done using the data of the State Enterprise Centre of Registers as well as the information specified in advertisements by land owners about land plots for sale. The peculiarities of agricultural land are analysed basing on the data of Statistics Department and Institute of Agrarian Economy.

Land reclamation condition of drained land areas is estimated according to the methodology of the evaluation of drainage systems reliability and economic efficiency of their performance, as well as basing on index system created at the Water Management Institute of the Lithuanian University of Agriculture. The basis of the data is the information collected in Land Reclamation Services of Agricultural Departments of different districts.

Results

Mass Valuation of Land in Lithuania

The Law of the Republic of Lithuania on the Principles of Property and Business Valuation sets forth the following definition of mass valuation approach: "Mass property valuation is the way of property valuation, when value is estimated not for an individual property, but value margins, are estimated, including the value of property being valued, employing the analysis of information collected about the property being valued" (Lietuvos…, 1999).

Since 1997, the Centre of Registers has been collaborating with the Lincoln Institute of Land Policy, which provides support in the area of developing the real property mass valuation system for taxation. The goals were to introduce data analysis and mass valuation technologies into practice and prepare property mass valuation methods, corresponding to Lithuanian conditions. Lithuania initiated the development of computer-based real property data 10 years ago. As for August 2002, more than 1 million land parcels were registered (Sabaliauskas and Aleksiene, 2002). Analysis of the selected data permits monitoring of changes in the land market, statistical analysis, and utilization of computer-assisted mass appraisal techniques.

The pilot project of property mass valuation was implemented in 2002. The main objective of the project was to carry out mass valuation of all real property (land and buildings). The base value of land depended on its productivity point and was adjusted by coefficients based on various factors including closeness to city or settlement, evaluation of the parcel in terms of urban-ecological conditions, availability of engineering facilities, etc. (Aleksiene and Bagdonavicius, 2003). It was determined that the greatest effect on market prices is that of land transaction time and place. Therefore the mass valuation model was created on the basis of the mathematical expression of the dependences of those factors and prices. After elimination of the disputed transactions, a specification of the land valuation model is worked out, i.e. factors and characteristics affecting market prices as well as their relationship shall be determined. The impact of time factor on the transaction prices is being analysed in this phase. Having estimated the influence of the time factor, the adjustment of prices is done. The impact of the location factor results in land value zones, the boundaries thereof are defined, analysing the distribution of sales prices in the area, considering the purpose of land and types of the land use, the development of communications, street (road) network, satisfaction of social needs and other infrastructure elements, prestige of the site. Evaluation of the impact of the location factor ends in land value mapping.

When evaluating the land reclamation condition of agricultural land plots, the percentage of land area containing non-functioning or inefficiently functioning drainage systems in the total drained land area was determined. The coefficient was changing within the range of 0.9 to 1.04 depending on the percentage of waterlogged area: if

a land plot is drained effectively, the market value is increased (i.e. multiplied by 1.04); if moisture surplus is more than 30% of the area, market value is reduced (i.e. multiplied by 0.9). The main shortcoming of this method is that the land reclamation condition of drained land plots is estimated only in respect of the functioning or non-functioning of drainage systems, not considering other factors affecting the value of land (Šaulys and Bastienë, 2003).

The second land valuation has been performed on the basis of market as for 1 July 2003, taking into a more precise and accurate consideration not only the most important factor to the real property value – location factor – but also other factors having influence on the value. During the second land valuation more land market data was available, therefore it was possible to estimate the influence of swamps, non-cultivated and derelict land on the value of land parcels (Bagdonavičius and Ramanauskas, 2004). Due to the introduced additional indices, re-calculated average market prices of land plots in certain areas differ from several units to several tens percents.

Nevertheless, it is to be mentioned that mass valuation system of land is not yet complete. Many important factors of land market, such as the possibility of land plot to be used for recreation as well as the installation of communication systems have not been evaluated sufficiently enough. Land reclamation condition of land plots has also been estimated insufficiently. This has become particularly urgent after the new Land Reclamation Law was approved in 2004 and the property status of certain land reclamation structures changed.

As the value of agricultural land depends on income obtained from the land, the price should be determined by the income index. According to D. B. Wissel (2002), appraisers are using the Uniform Standards of Professional Appraisal Practice. Non-producing land is appraised using the market approach of sales of similar properties. Producing natural resource properties are valued via the income approach on the basis of their annual production, minus allowable expenses. As soon as the new Land Reclamation Law is approved, a certain part of the expenses on repair and maintenance works of land reclamation structures will have to be covered by land owners. As it is specified in the regulations of state financial support for owners of drained land areas for the construction, reconstruction, repair and maintenance works of land reclamation structures, the share of private funds should make up no less than 15% of all expenses for repair and maintenance works. Repair works of drainage collectors with the diameter of more than 12.5 cm will be totally financed from state budget. This is to be reflected in the appraisal results of drained land as well.

This implies that a more flexible appraisal system of land reclamation condition of drained areas is needed. In order to evaluate the draining land according to its land reclamation condition, the interrelations of factors influencing land market price (i.e. drainage lifetime, possible failures, soil condition, technical indices of drainage systems

and their repair costs) are analysed and their mathematical dependences are determined. The investment profitability in the tile drainage installation depends on factors such as the number of hectares to be drained, the length of run, the type of tile, and the installation depth. The relative profitability of different drainage investments varies within a wide range. Estimates of profitability can be prepared following a two-step process: (1) estimate the expected change in annual net cash income from the investment, and (2) calculate the internal rate of return on an after-tax basis (Eidman, 1997).

Analysis of agricultural land prices

The government of Lithuania supports the land appraisal methodology that considers soil fertility as the main parameter for establishing land prices. According to the international estate appraisal principles, a comparative and competitive price policy or a price-fixing on the spot should determine the value of the agricultural land (Naujokienë, 1999). During the land reform process, in the absence of a market, normative land prices based on land fertility are implemented in Lithuania (Fig. 1).
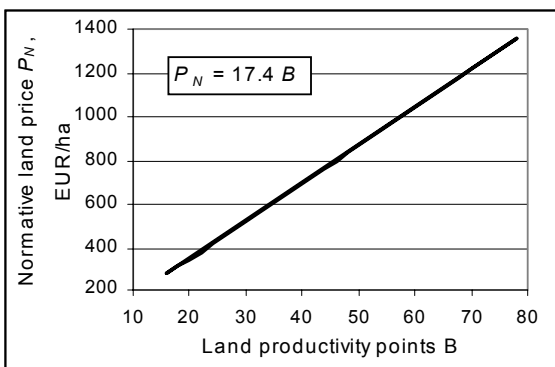
Fig. 1. Normative land price P_N in EUR ha^{-1} as a function of land productivity points B.

Average land prices based on soil fertility range from 664 EUR ha^{-1} in Molëtai district to 953 EUR ha^{-1} in Këdainiai district. The National Taxation Inspection assesses the land basing on these prices. Furthermore, various state compensations (funds for specific crops, subsidies for procured products, cattle, bloodstock and elite seeds, compensations for diesel fuel) for farmers are assessed too.

When investigating the prices of purchase and selling of agricultural land in the period of 1999–2002, it was noticed that often land market prices do not exceed 290 EUR ha^{-1} and are lower than normative price for 1 ha of land (correction coefficients for the distance to town or administrative centre, the limitation of agricultural activities in karst regions are considered too). The value of land sold by the state, the price of wood-covered territories as well as the value of private land plots (due to engineering constructions) are indexed by 1.6 since 1995. This land appraisal is applied in The State Enterprise Centre of Registers when setting the transactions.

Land valuation methods used in the Land Reform for the estimation of sales prices of the state land as well as for the estimation of land rent and land taxes are not in line with the market principles; therefore the estimated land parcel values differ from the market values. In some cases, values estimated on the basis of these methods considerably differ from the market value (Fig. 2.).
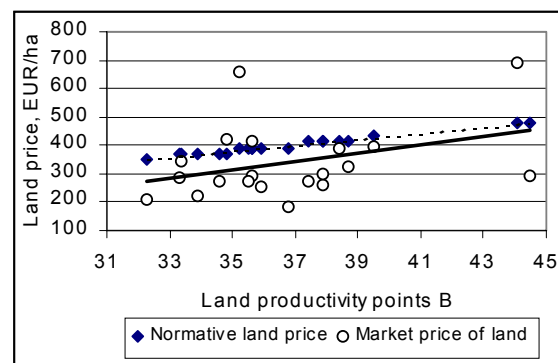
Fig. 2. Comparison of normative and market prices of agricultural land in Kretinga district.

Many different factors influence the market price (P_M) of agricultural land therefore its dependence on land productivity points is lower than the relation between normative land price (P_N) and land productivity points (B). As the equation (1) shows, the correlation is not very strong ($r = 0.35$):

$$P_M = 14.63 \cdot B - 199.6. \qquad (1)$$

On the basis of data collected in Kretinga district in the period of 1999-2001, only in two cadastre vicinities the land market price exceeds 500 EUR ha^{-1}. The highest price of land (692 EUR ha^{-1}) was determined in cadastre vicinity with 44.1 points. Similar price of land (659 EUR ha^{-1}) was observed in cadastre vicinity with 35.2 points, too. However, as it is shown in Figure 2, the market price of even vary productive land (44.5 points) might be comparatively low if the land plot is located in less favourable area, far away from administrative centres and roads. Therefore nearby the towns the average price of land transactions is always higher than in rural vicinities.

The afore-mentioned shortcomings are based on objective reasons. Valuation methods used to calculate the normative price of land plots were elaborated when private ownership and market relations were in the initial stage of formation. Having no transactions to compare, the methods were developed using market modelling.

Land reclamation impact on land value

Many different changes in the quality of soils and land use have occurred since the last land appraisal in 1989. Privatisation has created many small non-economic badly situated holdings. Coupled with low agricultural values, this suggests less favourable cost yields. The quality of the

soil now is relatively less important due to agricultural technology and mechanisation. For instance, wetland can often be drained at an affordable cost. Heavy land can be cultivated more easily with powerful machinery. Acidity is readily corrected by liming. Artificial fertiliser is applied to correct deficiencies on poor land. Nor is it only soil quality that is important in agriculture. Land value of agricultural land is not stable either. Land values can change for a variety of reasons, including but not limited to:

• addition of new improvements;
• remodel or rehabilitation of existing improvements;
• destruction or removal of existing improvements;
• fluctuations in current market trends and conditions;
• positive or adverse outside influences upon the property;
• an order for value increases mandated by State Government.

Compared to other Baltic States, Lithuania has the largest area of drained lands. In Latvia, about 1.6 million hectares or 60% of total area of agricultural land is drained. In Estonia, the area of drained land makes up 0.7 million hectares or 29% of the total agricultural land (FAO, 1998). Whereas in Lithuania at the onset of 2003, about 2.98 million hectares or 88.4% of the waterlogged soils were reclaimed, 2.61 million hectares of which or 77.4% were provided with a subsurface drainage (Lithuanian Ministry of Agriculture, 2003). The percentage of reclaimed soils varies, however, from 50.9% in hilly regions up to 96.8% in plain districts with more fertile soils (Fig. 3). These land reclamation practices supply a solid base for agricultural development and farming operation under any conditions.

The bonitation of the Lithuanian land does not exactly reflect the quality level of land as drainage grades up the land unequally. Drained soils with hypergleyic sand-loamy, loamy or clayey texture (hypergleyic-calcaric gleysols) were upgraded with the highest number of 24 extra points. The

calcaric-hypogleyic luvisols and calcaric-gleyic cambisols with a hypogleyic or hypergleyic sandy texture ameliorates by 10–15 points after draining. Sandy and loamy sandy soils with gleyfication features improve only with 3 points after draining as well as most wet sandy soils where drainage is inefficient or useless.

As it is seen, the value of land much depends on the efficient functioning of the water regime regulation means. Land reclamation conditions of land plots are changing when new drainage systems are arranged or the existing systems are suitably maintained, repaired and renovated. Investments aimed to ensure land productivity and maintain land reclamation condition of land plots positively affect the value of land and increase its price in the market. Having demolished land reclamation structures, the land may loose its initial productivity and farming value.

The drained land value may be corrected by introducing the correction coefficient of normative price that evaluates the functioning reliability of drainage systems considering the probability of failures. In order to determine the

Fig. 4. Changes in the corrected normative price of land with respect to the probability of drainage failures.
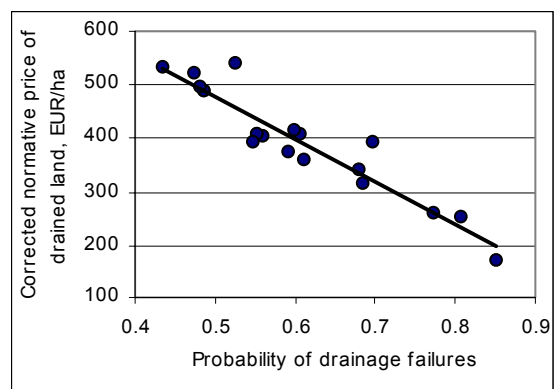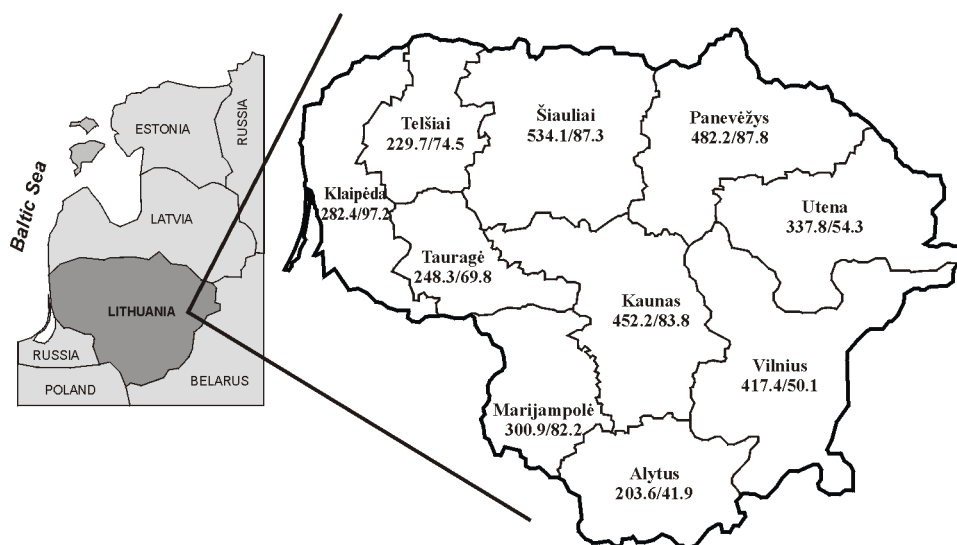

Fig. 3. The position of Lithuania and its subdivision in counties with their total reclaimed area (ha percent⁻¹).

monetary unit of correction coefficient, the analysis of the expenses on drainage repair works was taken into account (Fig. 4).

Corrected normative land price (P_{cor}) evaluating the probability of drainage failures (p_{dr}) may be expressed by the following regression equation (correlation coefficient $r = 0.94$):

$$P_{cor} = 877.2 - 795.7\, p_{dr}. \qquad (2)$$

Having evaluated the condition of drainage functioning and the risk of failures, the price of 1 ha of drained land may increase by 145 EUR ha^{-1} if the drainage is functioning well; it may also decrease by more than 217 EUR ha^{-1} if there is a big risk for drainage failures.

In countries with free market economy, landowners sell their land at prices that yield interest of at least yearly profit gained from cultivation. In Lithuania, considering all productivity expenses (including those of drainage maintenance), farmers will gain profit only when corn productivity exceeds 4000 kg ha^{-1} (Šaulys, 2002). However, yield is not the only factor determining the value of agricultural land. In Lithuania, there is a surplus of agricultural products for various reasons. The agricultural industry was oriented towards the Soviet Union (Russia) market for a long time. The changeover to the West European market is also limited because Lithuania is a newcomer and, moreover, the West European agricultural market is saturated as well. Because of this production surplus, the necessity of maintenance of all drainage systems is highly debatable especially in territories less favourable for the development of farming activities.

Conclusions

Mass land valuation system depends on the amount of information and the possibility to use this information. The more fairly and reasonably these components are developed in respect of the market, the more accurate results are obtained with regard to the market value.

Mass appraisal of agricultural land has some shortcomings and problems. It does not allow the valuation of all individual characteristics of each property. Present land appraisal system in Lithuania reflects neither the condition nor the value of land reclamation structures.

The value of drained land may be corrected by introducing normative price correction coefficient that evaluates the reliability of drainage functioning. Having evaluated the risk of drainage failures, the price of 1 ha of drained land might increase by 145 EUR ha^{-1} if the drainage is functioning well; it may also decrease by more than 217 EUR ha^{-1} if there is a high risk for drainage failures.

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STRUCTURAL DIVERGENCE OF ZEMGALE FARMS

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Abstract

The results of synthesis and analysis regarding the structural diversity of farms, their differences, divergence and development in Jelgava district and Zemgale agricultural region are expanded in the article. Commercial farms and semi-subsistence farms are particularly studied on the basis of farm accountancy data.

The following aspects of divergence have been ascertained: specialization, financial support, income and financial results.

Key words: Zemgale, farms, divergence.

Introduction

According to the statistical data (CSB, 2004, 2003, 2002), the composition and structure of rural farms in Zemgale region, as well as in other regions of Latvia and in Europe, are dispersed. In turn, the press materials (Bušmanis, 2005) lead to the conclusion that even the strategic opinions expressed by local governments of rural farms and public organisations are very dispersed or polarized.

Several researchers in Latvia have already focused on this theme and articles published by them (Špoģis et al., 2002, 2003) also show certain tendencies towards the progress and development of structural processes, however mainly macroeconomic aspects have been laid under the study of these papers, but no sufficient research has been done on microeconomic factors related to the divergence of farms structure.

In addition, a certain and sometimes large impact has been laid by "Lisbon Strategy" (Cālite, 2005) and the European Union new Common Agricultural Policy.

The assessment of the situation has encouraged to undertake more thorough and detailed studies and consequently determined the hypothesis of the paper: many microeconomic and partially also macroeconomic factors characterise and affect structural divergence of farms.

In compliance with the set hypothesis, the target of the research is to study the development of structural divergence processes in rural farms of Zemgale region.

The following tasks of the research are advanced to achieve the set target:

1) to ascertain the land property and the structure of its use in the set of representative farms;

2) to study the divergence of specialisation in the farms subjected to the analysis;

3) to analyse the divergence of financial support for the set of representative farms;

4) to assess the dispersion of the farms revenues and expenditure and cash balance.

Materials and Methods

The research is done on the basis of accountancy data of 45 farms located in the district of Jelgava and covers the period between 2002 and 2004:

1. areas in ha – total land area, utilized agricultural area, lakes, ponds, forests, land under the buildings, and roads;

2. cash flows in LVL – breakdown of income and expenditure by income and expenditure items, total cash inflow and outflow, cash balance at the end of a month and a year.

The sample set is formed due to the combination of two sample types. First of all, the farms were divided into two mutually different groups (stratas) – specialised commercial farms and semi-subsistence farms. In turn, the sample of each group is formed by means of a simple random sample. The sample set of farms producing commercial products sufficiently represents the general set of such farms in Jelgava district, and the research results may be attributed also to the rest of Zemgale region agricultural areas.

The least sample set of semi-subsistence farms comprises 5% of the general set of such farms.

The methods of grouping, analysis and synthesis have been applied for the purpose of the research.

Research results

1. Analysis of land property and the structure of its use in the set of representative farms

For the purpose of the analysis, the set of representative farms is divided into two basic groups 27 farms specialised in production of commercially marketable products and 18 semi-subsistence farms.

Farms with the total land area of 7–835 ha are included into the group of farms specialised in production of commercial products and farms with the total land area of 0.15–78 ha are included into the group of semi-subsistence diversified farms. The method of grouping has been applied for the achievement of the research tasks and the results obtained are summarised in Table 1 and Table 2.

According to Table 1, also relatively large and strong farms are quite different. The land property rights is a very significant indicator. Every fifth farm owns more than 70% of the managed land, every sixth farm owns more than a half of the managed land area, and 37% of farms own less than one third of the managed land. It means that the stability of operation and development of such farms may be imperilled with the change of situation in the land market or fi-

Table 1

Grouping of the set of specialised commercial representative farms in Zemgale by the land area and properties at the beginning of 2005

Groups of farms with the land area, ha	Number of farms per group	Proportion of property land, %	Range of proportion, %
Up to 200	7	53	22 – 93
201 – 300	10	32	0.3 – 77
301 – 500	5	50	3 – 94
501 and more	4	34	9 – 71

Source: Farms data and calculations done by the author.

Table 2

Grouping of the representative set of semi-subsistence farms by the land area at the beginning of 2005

Groups of farms with the land area, ha	Number of farms per group	Proportion of UAA, %	Total forest land per group, ha
Less than 1 ha	2	-	0
1 – 10	6	77	0
11 – 20	6	57	4
21 – 30	3	90	15
31 and more	2	85	12

Source: Farms data and calculations done by the author.

nancial support terms or any other conditions.

The analysis of the land structure by the type of its use leads to the conclusion that it is quite homogenous – absolute majority of the farms have their land areas as utilised agricultural area (UAA) which is the arable land, since only 4 farms have considerable areas (8–49 ha) of meadows and pastures. Only one third of the farms own forests with the area of 5–67 ha.

According to Table 2, semi-subsistence farms by the areas of UAA constitute the largest proportion (85% on average) and the entire UAA is an arable land. Part of the farms owns also forests. In general, this small set by the
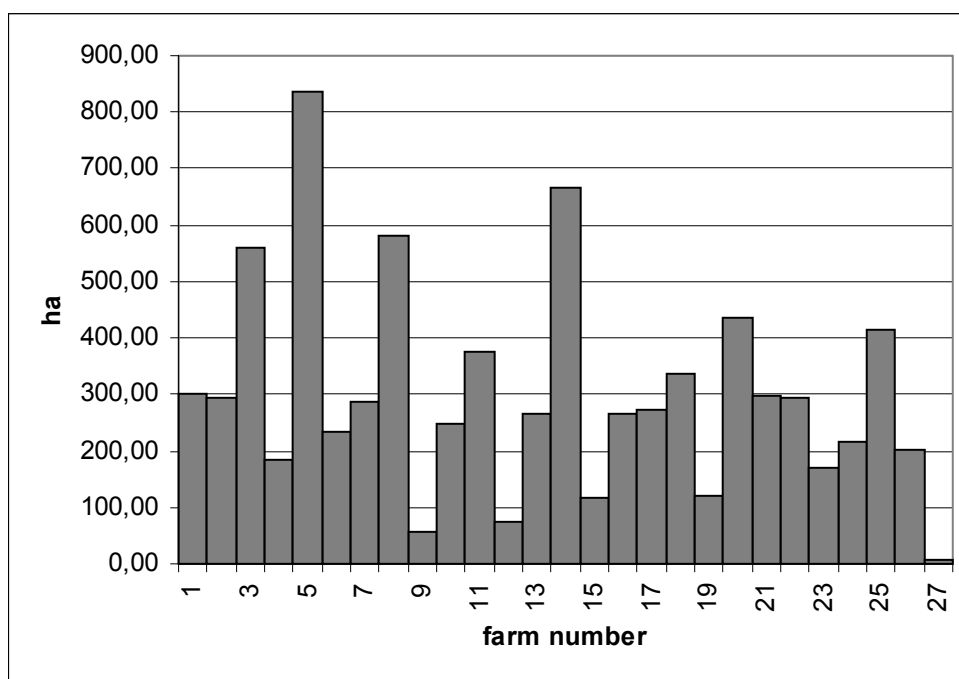
Source: Research done by the author.

Fig. 1. The area of farms specialised in production of commercially marketable products at the beginning of 2005, ha.

Fig. 2 Total land area owned by semi-subsistence farmers at the beginning of 2005, ha.

structure is close to all semi-subsistence farms.

The areas of research farms producing commercially marketable products vary between 2 ha and 850 ha. At the beginning of 2005, in 12 out of 27 farms or in 44% of cases, the land areas range from 200 ha to 300 ha (see Fig. 1), consequently corresponding to the average farm size of Zemgale region.

The total land area in 19 semi-subsistence farms under the research fluctuates between 1 ha and 80 ha. In 14 farms or 74% of the total number of farms it does not exceed 20 ha (see Fig. 2).

2. Divergence of farm specialisation

Specialisation of farms included into the set to be analysed differs, but it is characteristic to the set of commercial farms located in the districts of Jelgava, Dobele and Bauska. Sugar beet is grown by less than half of the farms, but the level of specialisation in the whole sector is extremely diverse – revenues gained from the sold sugar beet of one

Table 3

The average structure of monetary revenues in commercial farms growing grain and rapeseeds between 2000 and 2004

Farms	Proportion of revenues in % of total revenues				
	Wheat	Rape	Barley	Rye and oats	Total grain and rapeseeds
1.	34.1	19.7	17.2	0.0	71.0
2.	62.7	36.3	0.0	0.0	99.0
3.	74.7	25.3	0.0	0.0	100.0
4.	44.2	14.1	15.4	0.0	73.7
5.	16.3	71.2	0.0	0.0	87.5
6.	69.1	30.9	0.0	0.0	100.0
7.	45.9	24.7	7.8	0.0	78.4
8.	100.0	0.0	0.0	0.0	100.0
9.	33.9	49.5	12.0	0.0	95.4
10.	57.6	34.1	0.0	0.0	91.7
11.	61.5	31.3	0,0	0.0	92.8
12.	60.0	0.0	1.1	8.5	69.6
13.	48.6	0.0	10.8	0.0	59.4
14.	67.1	8.5	6.2	0.0	81.8
15.	25.0	48.1	11.0	0.0	84.1
16.	50.3	0.0	0.0	0.0	50.3
17.	39.9	44.4	0.0	7.2	91.5
18.	50.4	32.0	0.0	0.0	82.4
19.	29.1	70.9	0.0	0.0	100.0
20.	58.2	35.3	0.0	3.8	97.3
21.	44.9	27.6	4.3	0.0	76.8

farm exceeds 55%, the proportion of this sector for three farms amounts to 30–40 %, for four farms 20–29%, but for the other farms – just 7–18%.

Two farms have specialised only in vegetable growing, so all the revenues in considerable amount are only related to this group of cultivated plants.

Absolute majority of the farms has specialised in the production of grain and rapeseeds, but the profundity of their specialisation or the sowing area of these cereals and the structure of produce is sharply different, as it is shown in Table 3.

Several conclusions may be drawn according to the information included into Table 3:

- one farm is specialised in the monoculture of wheat;
- in six farms the proportion of revenues gained due to the growing of wheat exceeds 60%, these farms may be counted as farms with highly developed specialisation in wheat growing;
- two farms have rather profound specialisation in rape growing, where the proportion of revenues gained due to the growing of rape amounts to 70.9–71.2%, still in three more farms revenues gained due to the growing of rape exceed 40%;
- majority of farms have developed agro-technologically a very balanced structure of sowing areas, where the proportion of grain and rape sowing areas ensure permanent stability both in terms of agronomy and economy;
- growing of barley is not popular in large-scale farms of Zemgale – only half of the total number of farms grow barley, however in quite small areas;
- only three farms grow some of rye or oats.

The situation in the sample set of semi-subsistence farms is radically diverse – they are many-branched semi-subsistence farms growing variety of vegetables, fruit, berries, potatoes, and beet; producing milk, meat, eggs, honey, and other products. However, the specialisation in the production of agricultural products in these farms is rather explicit:

- in three largest farms the revenues from crop cultivation amount to 45–76% of the total monetary revenues;
- one farm has gained all the revenues only from sales of vegetables, in three more farms the revenues from sales of vegetables amount to 46–54%;
- majority of farms gain revenues from cattle breeding, but only five farms have greater proportion – 38–85%.

3. Divergence of financial support in farms

Farms in regions, as well as other farms, may receive financial support from several sources of financing:
- national subsidies;
- compensation of excise tax paid on fuel;
- EU SAPARD programme;
- EU Structural funds;
- other resources.

The analysis of farm data for the last years shows that the amount and rate of support in commercial farms are extremely different. In 2004, the amount of support has fluctuated between LVL 10.66 and LVL 225.12 for 1 ha of the total managed land area.

The differences equal due to the grouping of farms, though some regularities become outstanding – five largest farms have received 76.87 LVL ha^{-1} in average, but five smallest ones 96.99 LVL ha^{-1}.

Also the proportion of support in total revenues fluctuates in an extremely wide range – from 8.3% up to 37.7%, however this proportion is not significantly affected by the farm size (total area of usable land), as the average amount of support in five largest and five smallest farms is 16.0% and 15.7% respectively.

The amount of support in semi-subsistence farms is also quite diverse, but on average it amounts to 25% of the total revenues.

The peculiarities of this group are solidly characterised by the fact that for the majority of farms the proportion of the amount of support constitute 30–45%, but for some farms it exceeds 50%.

The analysis of reasons for the divergence of financial support and the successive results are not studied in the article due to the limited scope set for the papers to be published.

4. Divergence of total revenues and expenditure by farms

The total amount of revenues is calculated dividing all monetary revenues by the total area of the land to be managed. According to the calculations, done the amount of revenues fluctuates between LVL 104.39 per hectare and LVL 1116.59 per hectare.

The grouping of farms and calculations of the average revenues gained by these farms showed that the average amount of revenues in six largest farms constitute 239 LVL ha^{-1} and 465 LVL ha^{-1} in six smallest farms. Several conditions may cause the double difference, though the study and analysis of these conditions is the subject of another article.

In 2004, the expenditure in the group of commercial farms fluctuates between LVL 231.09 and LVL 1269.77 per 1 hectare of the managed land area. The difference in expenditure reaches 5 times. The structure of expenses varies a lot. Many farms have a large or considerable expenditure item comprising a lot of accounts payable in the form of loans and interest payments. For some farms the amount of loans and interest payments reaches hundred thousand lats and exceeds 50% of the total annual expenses. Still there are several commercial farms that run their farm without any loans.

In semi-subsistence farms, the repayment of loans and interest payments amount to only 5–6% of the total expenditure.

5. Divergence of cash balance

The assessment of cash balance: the ratio of cash balance against total expenditure. The results of calculations are included into Table 4.

According to the data of Table 4, it may be concluded that the average cash balance in five smallest commercial

Table 4

Cash balance in extreme commercial farms in 2004

Groups of farms	Average balance, %	Dispersion of balance, %	
		lowest	highest
Five largest farms	11.0	5.5	20.9
Five smallest farms	12.9	10.5	15.0

Source: Farms data and calculations done by the author.

farms is close. The bias lies in the range of – 2.4% – +2.1%. At the same time, in five largest commercial farms it is in the range of –5.5% – +9.9%. More stable situation is observed in the smallest commercial farms, since they have more stable cash balance.

In semi-subsistence farms, the rate of balance is much higher and constitutes 23.9% of the total expenses on average.

Conclusions

1. The proportion of UAA used as arable land in the farms of Zemgale region is very high amounting to 95.5% of the total land area in the mentioned region.

2. The proportion of rented land in specialised commercial farms is very diverse, which under unstable conditions of market economy endangers the stability of farm existence, economic development and operation.

3. Large farms specialised in production of commercially marketable products are mainly engaged in growing of wheat and rape, besides each farm grows sugar beets.

4. Semi-subsistence farms are specialised in the production of labour intense and less mechanised products.

5. Due to the processes of structural divergence the farm revenues fluctuate in a wide range. It is connected with the farm size, its specialisation, types of products, and other conditions.

6. The divergence of financial support relates to the received payments by means of national subsidies, EU SAPARD programme, EU Structural funds, compensation of excise tax paid on fuel, and other financial resources.

7. The research on structural divergence has to be continued and fostered to determine the profundity of impact laid by each factor, to state the indicators and project future development.

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FOOD SCIENCES

INVESTIGATION OF THE QUALITY OF DOUGH WITH GERMINATED GRAIN ADDITIVE

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Abstract

Germinated grains are added to wheat dough with the purpose to promote the biological value of bread. As a result, a new product was obtained with a higher content of protein, fiber, B group vitamins, and vitamins C and E. The task was to investigate gluten quality changes at grain germination time, wheat dough rheological property changes with various wheat, rye and barley amount additions, germinated for a different time. With the purpose to save maximum stability value of gluten, it was ascertained that the germination time of wheat grain could not be more than 24 hours. The best dough quality was obtained with germinated wheat grain additive. Germinated rye and barley grain additive (more than the experimentally ascertained amount) increases dough softening, decreases dough development time and dough stability. Only adding experimentally determined optimal amount of germinated grain, which promotes high quality bread, could produce dough with accepted rheological properties.

Key words: germinated grain, wheat, rye, barley, dough.

Introduction

Innovation in wheat bread technology is germinated rye, wheat and barley grain application (Хоперская et al., 1998). Germinated grains have been added to the wheat dough with a purpose to increase its biological value. The obtained bread has a higher content of proteins, fiber, vitamins of B group, vitamins C and E.

Important factor is dough rheological properties: dough development time, water absorption, dough stability, and quality.

Baking properties of grain were reduced during germination time; therefore it is necessary to determine the optimum grain germination time, when grains have the highest biological value but structure of grains has not considerably changed. It is important to determine the optimum amount of germinated grain additive to dough.

Gluten is the main component characterizing dough quality. Gluten is a strong hydrolyzed gel, which mainly consists of albumen and carbohydrates, fats and minerals. The amount of gluten components depends on the variety of grain, flour type, preparing stage, and dough mixing and rinsing time. Wet gluten of wheat grain consists of *gliadins* and *glutenins* (their ratio is 1:1), rye grain – of *gliadins* and *glutenins* (their ratio is 2:1), *barley* – of *prolamine, glutenins* and *hordeins* fractions. *Gliadins* decrease dough mixing time, whereas *glutenins* – increases it (Казаков, 1989; Ruža, 2001).

The activity of enzymes increases during germination: endohydrolase enzymes (α; β-amylases), proteolytic enzymes, diphenoloxsydase, and catalyse were activated. Stability of gluten depends on the amount of formed *disulfide* bonds *(-S-S-)* and *disulfide* bonds correlation with *sulfhydryl* group *(-SH-)* (Казаков, 1989; Hugh et al., 1998).

Composition of amino acids is a very important aspect for wheat grain. In the central part of a grain, the amount of amino acids is higher compared with periphery: *isoleucine* is 6–7%, *leucine* is 8–9%, and *phenylalanine* – 3–4%. Albumin of aleurone contains more of *tryptophan, lysine,* and *arginine*. The aleurone albumin has a higher food value compared with albumen of endosperm (Казаков, 1989; Hugh et al., 1998). Therefore, in dough preparation technology it is important to use all grain ingredients.

The albumin content in rye grain composition is smaller, while maintenance of essential amino acids is by 1.5 times higher (*lysine* and *threonine*) compared with wheat grain. Rye grain starch gelatinization temperature is lower (+52 – +55 °C) compared with wheat grain; a viscous gel forms from starch, which provides the soft consistency and longer shelf life of rye bread. The amount of riboflavin and vitamin E in rye grain is higher. Physical properties of rye grain gluten are similar to that of wheat grain, it is with lower elasticity and stability. Gluten content in rye grain is 40% from the total amount of albumin. The biggest part of rye grain albumin dissolves in water and low-concentration salt dilutions. The increase of *glutenin* amount promotes strengthening of gluten (Казаков, 1989).

In food industry hull-less barley is acknowledged as more valuable and more economical compared with flaky barley. The hull-less barley flour has a little darker colour, because compared with flour from soft wheat it has a higher maintenance of ash value, higher protein and β-*glucans* content. Soluble dietary fiber, mainly β-*glucans,* provides the promoted viscosity; as a result, digestion, cholesterol and fat absorption were decreased (Bhatty, 1999; Bengtsson et al., 1990; Newman et al., 1991). A higher content of natural antioxidant tocopherol and tocotrienols, as well as maintenance of E vitamin, was established in barley grain, compared with wheat and rye grain (Holasova et al., 1998). The properties of barley gluten, similarly to rye grain gluten, are equalized to wheat grain gluten with poor quality. The
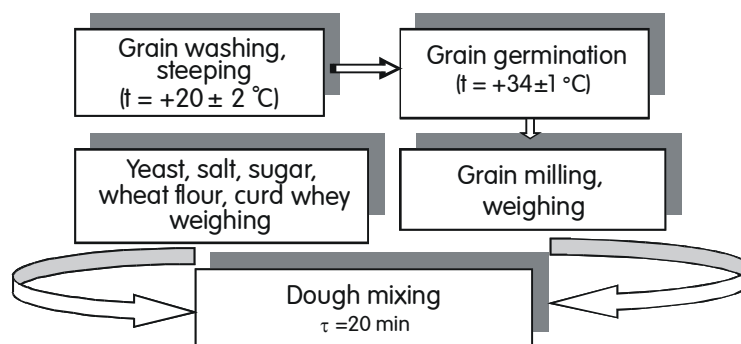
Fig. 1. Dough preparation technology.

proteolytic enzyme *paphain* activity deteriorates the quality of gluten (Казаков, 1989).

All-round complex rheological description of wheat dough can be extracted by the faringograph. Duration of dough forming, dough stability and influencing stage in a fixed period of the experiment is possible to control, as well as water absorption of flour is possible to define. The faringograph registers dough forming and its property changes in continued mechanical action time, describing it as continuous graphical representation (Козубаева, 2005*).

Methods and materials

In our experiments, as a germinated grain addition to wheat dough rye, wheat and barley grain with a different germination time (to 36 hours) and different added amount (25–50% from the amount of flour) were used.

The research was accomplished on grains of wheat (variety 'Kontrast'), rye (variety 'Voshod') and hull-less barley cultivated in Priekuli Plant Breeding Station in Latvia, water, yeast, sugar, salt, curd whey and wheat.

Gluten quality and maintenance were investigated by standard method *LVS 275*.

Dough rheological properties were investigated by faringograph *„Brabender"* using standard method *ICC – 115/1*.

Rye, wheat and barley grain were washed and dunked before germination. Grains were germinated in climatic camera at optimum germination temperature of +34±1 °C,

relative air humidity – 82 ± 1%, germination time – 24 and 36 hours. Dough with germinated grain additive was made using new technology (Fig. 1).

Wheat dough without germinated grain additive was used as a control dough sample.

Results and discussion

Un-germinated wheat grains and germinated for 12, 24 and 36 hours were tested. It was observed that the amount of dry gluten (in germinated 24 hours wheat grains) decreased from 25.4% to 3.8%, gluten index from 96.14% to 38.00%, and gluten hydratation properties from 213.58 to 171.43% (comparing with control grains) (Table 1). After wheat grain germinating time for 36 hours, gluten was not detected. Gluten was found neither in germinated nor un-germinated rye and barley grains.

Germinated for 24h grains were used because, for example, comparing with bread without germinated grain additive the bread with germinated wheat grain addition has an elevated content of B_1 (by 75%), B_2 (by 88.5%), thiamine (by 67.5%), E (by 62.2%), and C (by 42.8%) vitamins.

It could be explained mainly by the existing higher amount of *gliadins*, as well as diminished correlation between *disulfide bonds* and – *SH-* groups in germinated rye grains and *paphain* activity in barley grains (Казаков, 1989; Hugh et al., 1998).

Analyzing dough properties by farinograph it was observed that the quality value of the control dough sample

Table 1

Gluten quality changes during wheat grain germination time

Wheat grain	Dry gluten, %	Gluten index, %	Gluten hydratation properties, %	Quality group	Gluten characterization
0 h	25.4	96.14	213.58	III	Unsatisfactorily strong
12 h	7.7	89.61	208.00	I	Qualitative - very qualitative
24 h	3.8	38.00	171.43	III	Unsatisfactorily weak
36 h	-	-	-	-	Gluten did not appear

*Козубаева. Изучение реологических свойств теста из диспергированного зерна пшеницы. (http:www.apk-inform/showart.php?id=6300:lastrewievon24.02.05).
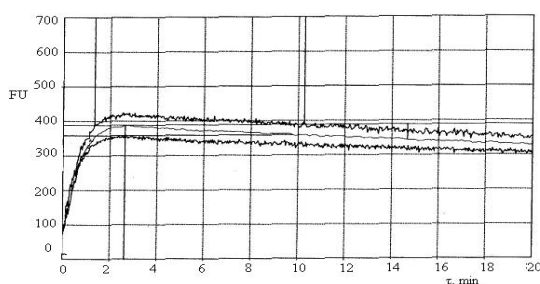
Fig. 2. Farinogram of the control dough sample.

was 98 FU units. It means that the analyzed dough sample had good quality (Fig. 2). Value of dough stability was 18.9 minutes, dough making quality – 46 FU, degree of dough softening – 389 FU with water absorption of 56.9%, and dough development time – 2.7 minutes.

The dough quality number with addition of wheat grain germinated 24 hours increased to 200 FU (Table 2) compared with the control dough sample. It was predicted that bread with this grain addition would be of good quality. Dough stability was not relevant compared with control dough sample. Dough consistency with water absorption value about 43.3% was 392 FU, dough development time – 2.7 minutes (Fig. 3a). The dough quality number with wheat grain addition germinated for 36 hours (Fig. 3b) decreased substantially to 22 FU, dough development time – to 1.5 minutes (Table 2). As indicated in the literature, quality of gluten changes by partial albumin proteolysis. *Disulfide* bond decrease and *–SH-* group increase is observed. Hidden *disulfide* bonds (*albumins* and *globulins*) mainly have cleaved. *Disulfide* bonds of grains germinated about one day splited only by 19%, but hidden *disulphide bonds* remained without a change, which demonstrates insignificant gluten quality changes. *Disulfide* bonds of grain germinated for more than 24 hours decreased by 64%, hidden *disulfide* bonds – by 58%, which shows significant gluten disaggregation (Казаков, 1989). Dough consistency with this grain additive was 532 FU, and water absorption – 41.7%. It was predicted that bread made from this dough

would be with sticky mildness, lowered elasticity, and sweetish taste.

The following experimental results were obtained by adding germinated rye grain to wheat dough. Dough quality number with a 24-hour germinated rye grain additive decreased by 76.53% compared with control dough sample. The value of dough stability was low, similar to dough with wheat grain additive germinated 36 hours (Table 2). Though the value of dough development time was satisfactory – 121 FU, dough development time was by 52% less than that of the control dough sample and the dough sample with a 24-hour germinated wheat grain additive (Fig. 4a). Differences between rheological properties of experimental dough samples and control sample did not influence bread quality significantly.

Dough quality of the sample with grain additive germinated 36-hour decreased (Table 2). It indicates that bread with this grain additive would be of good quality. Dough stability was very low; dough development time was only 1.2 minutes (Fig. 4b). It could be explained with the high enzyme activity of starch in germinated rye grain; as a result the content of water-soluble compounds and amount of dextrins and reducing sugars increased. These transformations considerably retrograde the cooking properties of rye grain.

The dough quality number with hull-less barley additive germinated for 24 hours was by 73.5% lower compared with the control dough sample (Table 2) (it was rel-

a

b
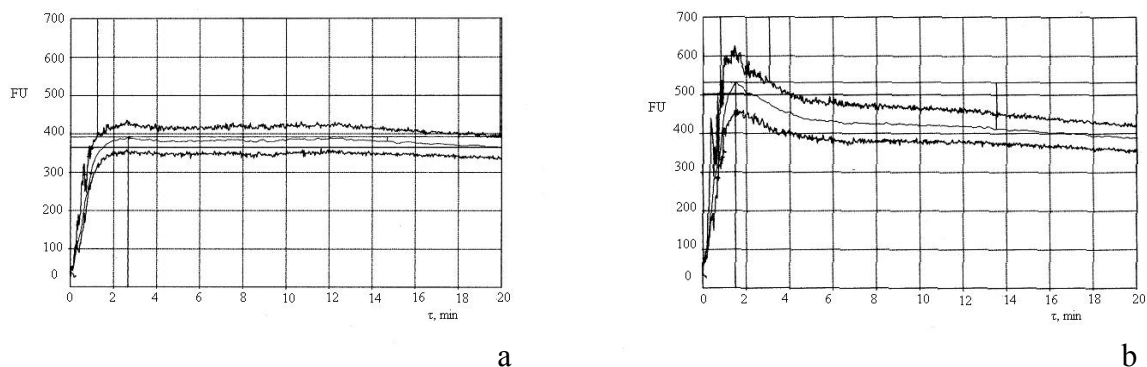
Fig. 3. Farinograms of dough samples with addition of wheat grain germinated 24 (a) and 36 (b) hours.

a   b
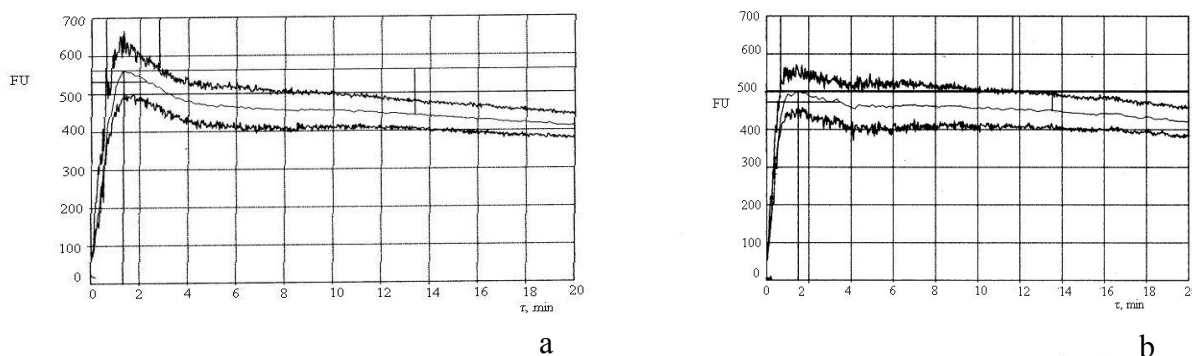
Fig. 4. Farinograms of dough samples with addition of rye grain germinated 24 (a) and 36 (b) hours.

evant change). Dough stability was not similar to dough stability value for the control dough sample, and it was 3.3 minutes. The quality of bread with this grain additive would be satisfactory (Fig. 5a). Dough development time value of wheat dough with germinated hull-less barley grain additive is similar to dough development time for the sample with a 24h germinated rye grain additive. Dough quality number with addition of hull-less barley grain germinated 36 hours decreased by 75.5% compared with the control dough sample, dough development time and degree of dough softening was not satisfactory (Fig. 5b). Therefore it is foreseen that the bread quality with this grain additive will be unsatisfactory.

a   b
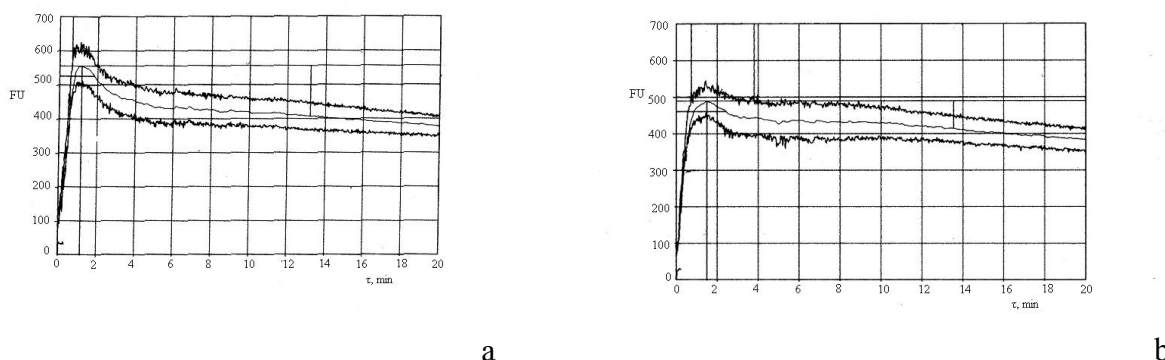
Fig. 5. Farinograms of dough samples with addition of hull-less barley grain germinated 24 (a) and 36 (b) hours.

Table 2

Data obtained by farinograph

Parameters	Control sample	With germinated wheat grain addition		With germinated rye grain addition		With germinated barley grain addition	
		24h	36h	24h	36h	24h	36h
Consistency, FU	389.0	392	532	562	556	503	490
Water absorption, %	56.9	43.3	41.7	42.2	42.0	39.3	40.4
Development time, min	2.7	2.7	1.5	1.4	1.2	1.5	1.5
Stability, min	18.9	18.7	2.3	2.2	1.3	3.3	3.1
Degree of softening, FU	46.0	11	120	121	149	66	76
Quality number	98.0	200	22	23	18	26	24

Conclusions

1. The optimum stability of gluten could be provided by wheat grain germinated for not more than 24 hours.

2. Germinated 24-hours wheat grain additive can improve the quality of dough.

3. The additive of 24-hours germinated rye and barley grain increase dough softening value, decreases dough development time.

4. Rheological properties of dough with an optimum germinated grain addition satisfy the dough quality standard requirements.

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HEDONIC EVALUATION OF WHEAT BREAD WITH BERRIES MARC

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Abstract

The aim of the present study was to investigate the application possibilities of berries marc in wheat bread making to improve its quality. Sensory evaluation was used to determine the liking degree of bread with berries marc. Twenty samples of wheat bread with raspberries, white currants, gooseberries and seabuckthorn marc were produced by using standard technology. A 9 point hedonic scale was used to find out the degree of liking. The sensory data were analyzed using analysis of variance (ANOVA) and Tukey's test. The results of hedonic scaling show that berries marc (5–10% of the flour mass) can be used in baking wheat bread.
Key words: marc, seabuckthorn, sensory analysis.

Introduction

Bread baking has old traditions; nevertheless it is still an actual issue to meet the needs and wishes of the consumers in providing them with tasty and varied wheat bread. Some scientific researches from the previous century testify that the use of bread in everyday food and its nutritional value are very important (Ауэрман, 2003).

Bread is the only foodstuff that people do not get bored with when eating it every dayand it is the main energy source. By eating 400–500 grams of bread in twenty-four hours a person provides himself with 30-38% of energy from the total energy quantity (Казанская,1997; Шепелев, 2001). In pursuance of the calculated advisable quantity of bread to be used in food, each person in Latvia has to eat 42.6 kg of rye bread, 33.2 kg of wheat bread, and 8.5 kg of fine rye bread (Pirksts, Rozenberga, 2003).

As the tendency to use wheat bread, which is made of high milling flour, is growing, it is necessary to improve its growing, it is necessary to improve its nutritional value (enrich with fibres, mineral substances, and vitamins) and sensory parameters. In order to raise the nutritional value of wheat bread, scientists advise to add wheat bran, different seed mixtures, carrots, marc of swedes and cabbages, oatmeal and buckwheat flour (Kļava, 2004; Zariņš, Neimane, 1999).

One of the possibilities, which still has not been used, is the use of berries marc because it contains insoluble fibres, unsaturated fatty acids, antioxidants especially vitamin E, carotenoids, vitamin C and others that would improve the quality of wheat bread (Самсонова, Ушева,1990).

No scientific researches on the influence of raspberries, white currants, gooseberries and seabuckthorn marc on the sensory properties of wheat bread are carried out in Latvia, therefore the aim of the paper was:
- to determine the optimal servings of berries marc in wheat bread recipes;
- to estimate the degree of liking of new bread products.

Materials and methods

Twenty samples of wheat bread with raspberries, white currants, gooseberries and seabuckthorn marc are used in sensory analysis. These samples were made and baked in experimental bakery of S/C "Dobeles Dzirnavnieks" in accordance with the recipes and technological schemes of the bakery. An electric cooker "Deltaforni" (Italy), which consists of sections and has a vapour feed, was used to bake the wheat bread sample.

The raspberries, white currants, gooseberries and seabuckthorn marc are obtained from raspberries, white currants, gooseberries and seabuckthorn grown in Dobele Horticultural Plant Breeding Experimental station gardens. The berries are frozen at –18 °C, and then juice is liquidized with the juicer "VORAN Basket press 60" under the pressure of 300 bars. The obtained marc is dried in ISO ORAKAS at 40 °C for 48 hours until the humidity content in marc is 9%. Before raspberries, white currants, gooseberries and seabuckthorn marc is added to dough, it is ground in the grinder.

The hedonic scale of affective methods was used to carry out the sensory estimation of the samples; it helps to

Table 1

Wheat bread samples prepared for sensory evaluation

Bread samples	Used berries marc	Amountof marc added (% of flour mass)
A, B, C, D, E	Raspberries	5, 10, 15, 20, 25
A_1, B_1, C_1, D_1, E_1	White currants	5, 10, 15, 20, 25
A_2, B_2, C_2, D_2, E_2	Gooseberries	5, 10, 15, 20, 25
A_3, B_3, C_3, D_3, E_3	Seabuckthorn	5, 10, 15, 20, 25
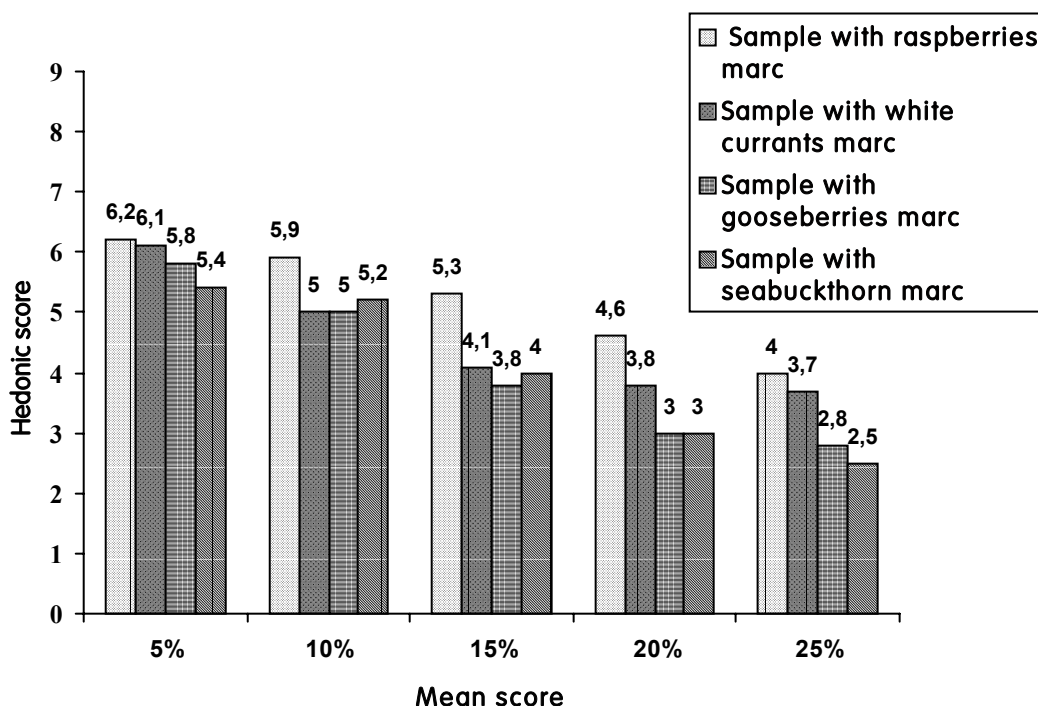
Fig. 1. Average hedonic evaluation of wheat bread with raspberries, white currants, gooseberries, and seabuckthorn marc.

evaluate the wheat bread degree of liking. The nine point hedonic scale was used here (Strautniece, 2004). The analysis of variance (ANOVA) and Tukey's test (O'Mahony, 1986) were used to analyze the results of sensory evaluation.

The panellists were given equally cut wheat bread pieces (the length of the edge – 1 cm), they were arranged in small bowls that were coded with three figure numbers. The panellists also got a questionnaire. The evaluation took place in the laboratory of food sensory evaluation, Faculty of Food Technology, Latvia University of Agriculture, in an individual evaluation booth. Altogether 25 panellists – 21 females, 4 males (mean age 22) – took part in the evaluation.

Results

The sensory evaluation results are shown in Figure 1 and summarized in Tables 2, 3, 4, and 5.

The findings show that the average estimation in hedonic scale of wheat bread samples with raspberries

marc is 4–6.2 (dislike little – like slightly), the average estimation in hedonic scale of wheat bread samples with white currants marc is 3.7–6.1 (dislike moderately – like slightly), but with gooseberries and seabuckthorn marc – 2.5–5.8 (dislike very much – like slightly). Samples A_1 and A_2 (5% raspberries marc and 5% white currants marc) were assessed as having the highest degree of liking.

In accordance with the results of dispersion analysis: $n_1 = 4$ (df wheat bread), $n_2 = 96$ (df error), $p = 0.05$, we get that $F_{(critical)} = 2.45$. As $F_{(calculation)} = 16.0 > F_{(critical)} = 2.45$. The conclusion is that there are significant differences betweenthe liking of the estimated wheat bread samples.

The results of Tukey's test show that the panellists like samples A, B and C (5%, 10% and 15% of raspberries marc) equally.

In accordance with the results of dispersion analysis: $n_1 = 4$ (df wheat bread), $n_2 = 96$ (df error), $p = 0.05$, we get that $F_{(calculation)} = 16.3 > F_{(critical)} = 2.45$. The conclusion is that

Table 2

Results of analysis of variance of hedonic estimation of wheat bread samples with raspberries marc

Source of Variation	Degree of freedom, df	Sum of squares SS	Mean square MS	Variance ratio, F
Wheat bread	4	82.6	20.7	16.0
Panellists	24	143.2	6.0	4.6
Error	96	124.2	1.3	
Total	124	350		

p<0.05.

Table 3

Results of analysis of variance of hedonic estimation of wheat bread samples with white currants marc

Source of variation	Degree of freedom, df	Sum of squares SS	Mean square MS	Variance ratio, F
Wheat bread	4	99.7	24.9	16.2
Panellists	24	159.4	6.6	4.3
Error	96	147.9	1.5	
Total	124	407.0		

p<0.05.

there are significant differences between the degree of liking of the estimated wheat bread samples with white currants marc.

The results of Tukey's test show that the panellists like sample A_1 (5% of white currants marc) the best of all wheat bread samples, then follow B_1 and C_1 (10% and 15% of white currants marc), and there is not any difference in the degree of liking between them.

In accordance with the results of dispersion analysis: $F_{(calculation)} = 23.4 > F_{(critical)} = 2.45$. The conclusion is that there are significant differences between the degree of liking of the estimated wheat bread samples.

The results of Tukey's test show that the panellists like samples A_2 and B_2 (5% and 10% of gooseberries marc) the best, then come C_2, D_2 and E_2 with 15%, 20% and 25% of gooseberries marc. The amount of the added marc increases the intensity of sour taste in the wheat bread samples, which reduces the degree of liking of the estimated samples.

There are significant differences between the degree of liking of the estimated wheat bread samples with sea buckthorn marc ($F_{(calculation)} = 32.9 > F_{(critical)} = 2.45$).

The results of Tukey's test show that the panellists like samples A_3 and B_3 (5% and 10% of seabuckthorn marc) equally. Then come C_3, D_3 and E_3 (with 15%, 20% and 25%); there is no difference in liking between them, these bread samples have a distinct sour taste.

The sensory evaluation shows that the intensity of sour taste influences the degree of liking of the estimated wheat bread samples, which depends on the amount of the added marc.

Conclusions

1. The results of hedonic estimation show that 5% and 10% of raspberries, gooseberries and seabuckthorn marc (from the flour mass) and 5% of white currants marc (from the flour mass) can be used in baking wheat bread.

2. The results of hedonic evaluation will be used when carrying out the research concerning the influence of marc on the dough quality.

Table 4

Results of analysis of variance of hedonic estimation of wheat bread samples with gooseberries marc

Source of variation	Degree of freedom, df	Sum of squares SS	Mean square MS	Variance ratio, F
Wheat bread	4	17.4	43.6	23.4
Panellists	24	186.7	7.8	4.2
Error	96	178.4	1.9	
Total	124	439.5		

p<0.05.

Table 5

Results of analysis of variance of hedonic estimation of wheat bread samples with seabuckthorn marc

Source of variation	Degree of freedom, df	Sum of squares SS	Mean square MS	Variance ratio, F
Wheat bread	4	164.8	41.2	32.9
Panellists	24	110.1	4.6	3.7
Error	96	120.0	1.3	
Total	124	394.9		

p<0.05.

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β-GLUCAN IN HYDROLYSED SOLUBLE AND INSOLUBLE OAT FRACTIONS

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Abstract

Oats contain more β-glucan (2–7%) than other croppers. β-glucan is the most essential water-soluble dietary fiber. It lowers cholesterine level in blood as well as stimulates elimination of carcinogens from the body. In order to enlarge possibilities of use of oats in a diet, they can be separated in water-soluble and insoluble fractions.

The aim of the present study is to determine the amount of β-glucan in hydrolysed oat soluble and insoluble fractions.

Gelatinized, hydrolysed and steeped oatmeal prior to hydrolyse, which was separated in water-soluble and insoluble fractions, was used in experiments.

Not more than 6% of gelatinized (non-hydrolysed) oatmeal dry matter dissolved in water. The outcome of fermentative hydrolysed dry matter of water-soluble oatmeal was 40–52%.

The content of β-glucan in the soluble and insoluble oatmeal fraction was determined by using McCleary method. The content of β-glucan in the soluble fraction of gelatinized oatmeal decreased for 78% in comparison to the content of β-glucan in oatmeal used in the experiments. The content of β-glucan in the soluble fraction of hydrolysed oatmeal decreased for 8.1% to 9.2%, and increased for 35–42% in the insoluble fraction if compared with the content of β-glucan in oatmeal.

Key words: oats, modified oats, bread.

Introduction

Among other croppers (wheat, rye), oats are of a special importance regarding human diet. Historically, oats have been characterized as a digestive and dietary product (Noorden, 1903; Noorden et al., 1920). Oats contain high-value proteins in which the percentage of amino acids is higher than in other croppers (Baltess, 1998). In comparison to other croppers, oats contain more high-value lipids (Belitz et al., 1992). Oat oil contains oleic acid and essential linoleic acid in similar amounts. There is a considerable amount of antioxidants Δ^5 avenasterin and tocopherols - in oat lipids (Hampshire, 1993; Barnes, 1982). However, the most important compound than others in oat is β-glucan (lichenin).

β-glucan is the most important fiber agent of oat. β-glucan on average makes 4.7% in oat endosperm and 44% of all the endosperm ballasts (Gannßmann, 1993). Oat bran contains 9.2% of β-glucan, and also this amount is 44% of all the oat bran ballasts.

More than fifty years ago, Morris (Morris, 1942) and Letzig (Letzig, 1951) extracted oat muciloginous substance – lichenin (β-glucan) and characterized it as a water-soluble macro-molecular polysaccharide. In 1995 (Acker et al., 1955), the structure of oat lichenin was described – a polysaccharide in which glycose units are linked by (1–3) and (1–4) β-glycoside bonds. Proportion of glycoside bonds β (1–3) and β (1–4) in oats is respectively 1:2.6 (Davidson et al., 1991).

β-glucan being in the oat composition has a positive physiological effect. The effect of oat β-glucan on lowering of cholesterol level in human and animal blood is being widely investigated (Anderson et al., 1986; McDonald et al., 1992; Shinnick et al., 1991; Shinnick et al., 1993). Significant is also the effect of oat and β-glucan on diabetes (Wood, 1991; Wood, 1993).

The conclusion follows from the above mentioned that oatmeal and β-glucan in it is an important part of human diet. Unfortunately, oats are used not sufficiently in human diet nowadays.

In order to enlarge possibilities of use of oats in human diet, the modern technologies offer possibilities to modify oat grains, meal or flour. One of oat modification directions is the fermentative hydrolysis of gelatinized oat starch as a result of which starch is decomposed in low-molecular dextrines, maltose and glycose, i.e. reducing sugars which dissolve in water (Gramatina et al., 2002).

Oat hydrolysate can be separated into water-soluble and insoluble fractions thus enlarging its possibilities of use (Gramatina et al., 2003). Application possibilities of the soluble fractions of hydrolysed oat meal in preparation of different juice beverages have been investigated (Gramatina et al., 2002; Gramatina et al., 2004).

Taking into consideration all above mentioned, the tasks in this work were set as follows:

1) to determine the dry matter outcome of the soluble fraction of fermentative hydrolysed oat and to compare it with dry matter outcome of the soluble fraction of gelatinized oat;

2) to determine amount of β-glucan in the soluble and insoluble fractions of gelatinized and hydrolysed oat.

Materials and methods

Research was performed in the Research Laboratory of Food Technology Department at the Faculty of Food Technology, Latvia University of Agriculture (LLU) and in the Agrochemical Analyses Laboratory of LLU.

For preparation of gelatinized oat, oatmeal produced by ISC "Rīgas Dzirnavnieks" was used; for preparation of hydrolysed oat – oatmeal by ISC "Rīgas Dzirnavnieks" and "Valdo" was used. "Rīgas Dzirnavnieks" oats meal was used for steeping for 2 hours at temperature 38 °C and after that hydrolysed. Gelatinized and hydrolysed oats were prepared from 200 g of 12% oatmeal – water solution (24 g of
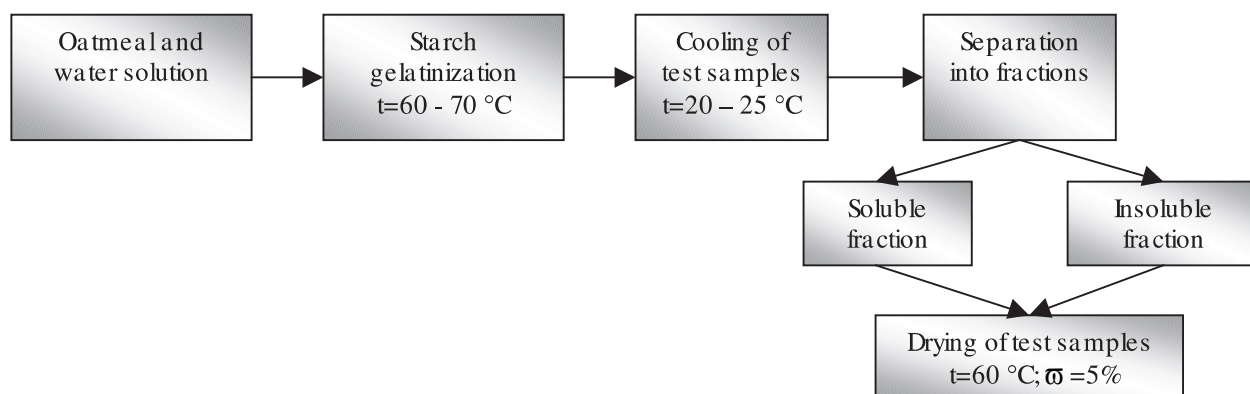
Fig. 1. Technological scheme of preparation of gelatinized oats.

oatmeal and 176 ml of water). For oat starch, hydrolisation were used commercial enzyme Amylosubtilin G3x (α amylase, ISC "BIOSINTEZE", Lithuania).

The technological scheme of preparation of gelatinized oat is presented in Figure 1.

Concentration and hydrolyse conditions of the enzyme Amylosubtilin G3x were chosen the ones to make possible a homogeneous maturation of oat mass and a complete starch gelatinization as a result of which a maximum oat starch modification into reducing sugars would be obtained. The technological scheme of preparation of hydrolysed oat is presented in Figure 2.

The ferment was inactivated at the end of hydrolysation process by increased temperature. For separation of the gelatinized and hydrolysed oats into fractions, a sieve was used (meshes 1.00 · 1.00 mm). After separation into fractions, the soluble and insoluble fractions of oat extracts were dried at temperature of 60 °C until a homogeneous test sample mass (ω = 5%).

The obtained test samples were grinded and the moisture content was determined using the standard method 6496. The amount of b-glucan in dry matter was determined using McCleary method (ICC Standard Method No. 168).

The experiments were carried out in five repetitions. The data were analysed using the standard error method with Microsoft Excel.

Results and discussion

The obtained outcome of the gelatinized and hydrolysed oat separation into soluble and insoluble fractions are presented in Table 1, but the amount of dry matter of the soluble fraction is presented in Table 2.
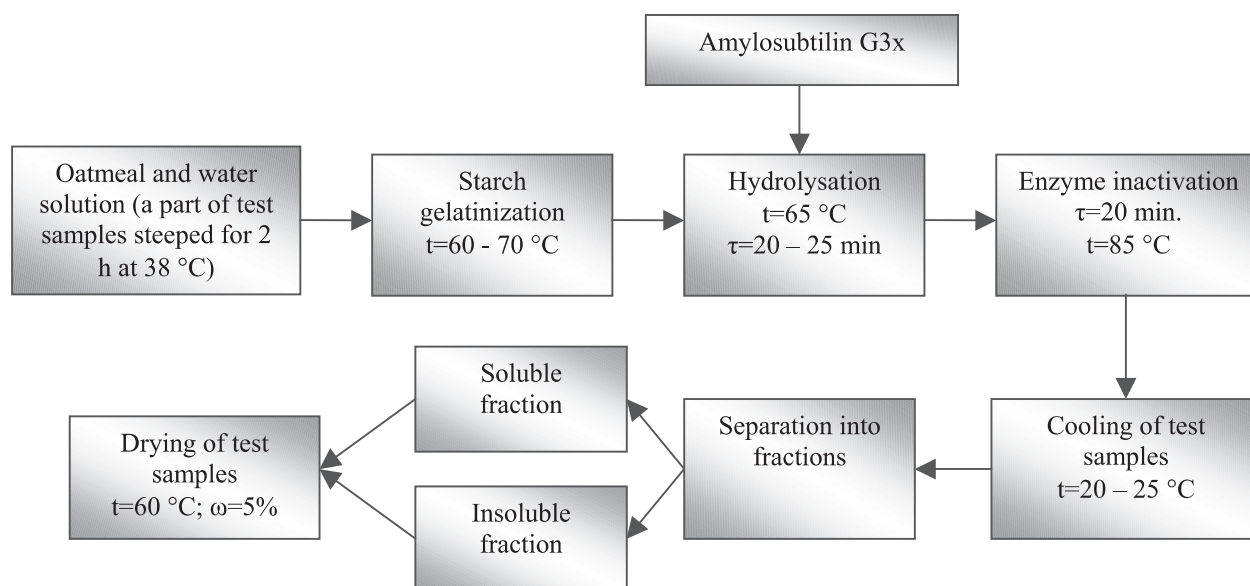
Fig. 2. Technological scheme of preparation of hydrolysed oats.

Table 1

Outcome of the soluble and insoluble fractions of the gelatinized and hydrolysed oats (g and %)

Test samples	Soluble fraction		Insoluble fraction	
	Outcome, g	Outcome, %	Outcome, g	Outcome, %
	"Rīgas Dzirnavnieks"			
Gelatinized oat	104.56±0.08	52.3±1.21	84.90±0.03	42.5±0.2
Hydrolysed oat (without prior steeping)	135.86±0.2	67.9±0.5	51.20±0.6	25.6±0.68
Hydrolysed oat (with prior steeping)	147.00±0.92	73.5±0.64	38.50±0.59	19.3±0.5
	"Valdo"			
Hydrolysed oat (without prior steeping)	130.14±0.75	65.07±0.85	55.59±0.3	27.8±3.5

Table 2

The content of dry matter in the soluble fraction of gelatinized and hydrolysed oats (g and %)

Test samples	Outcome of dry matter in the soluble fraction		
	Amount of dry matter, %	Amount of dry matter, g	Outcome of dry matter, % (against oatmeal)
	"Rīgas Dzirnavnieks"		
Gelatinized oat	5.00±0.1	5.2±0.14	21.8±0.06
Hydrolysed oat (without prior steeping)	8.05±0.21	10.9±0.03	45.6±0.45
Hydrolysed oat (with prior steeping)	8.50±0.06	12.5±0.02	52.1±0.05
	"Valdo"		
Hydrolysed oat (without prior steeping)	7.87±0.02	10.2±0.07	42.6±0.15
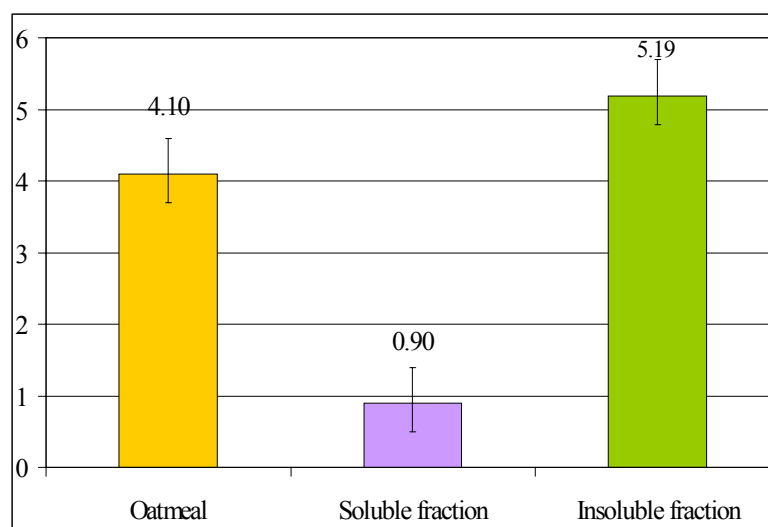
Fig. 3. The amount of β-glucan (%) in oatmeal and in the soluble and insoluble fractions of gelatinized oat.
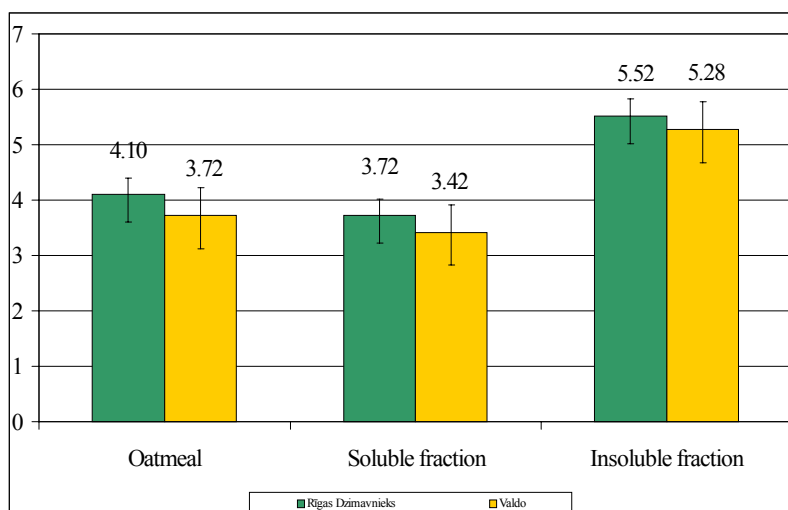
Fig. 4. The amount of β-glucan (%) in oatmeal and in the soluble and insoluble fraction of hydrolysed oat.

The results in the table 1 show that the outcome of the soluble fraction of hydrolysed oat is higher for 10–20% than the outcome of the soluble fraction of gelatinized oat. But the given results in table 2 show that the outcome of dry matter of the soluble fraction of gelatinized oat is only 21.8%. The outcome of the soluble fraction of hydrolysed oat is more than 40%. However, the outcome of the steeped and then hydrolysed oats is more than 50%. The obtained results could be explained by the fact that gelatinized oats like others gelatinized cereals products are poor dissolved in water. Because of hydrolysis, starch is decomposed into water-soluble compounds (dextrines, maltose, glycose), and this explains a greater amount of outcome of dry matter of hydrolysed oat in comparison to gelatinized oat.

The amount of β-glucan in oatmeal and in the soluble and insoluble fractions of gelatinized oat is presented in Figure 3.

The obtained results show that in the soluble fraction of gelatinized oat, the amount of water-soluble β-glucan is unexpectedly low if compared with oatmeal. The amount of β-glucan in the soluble fraction of gelatinized oat has decreased for 78%, and has increased for 26% in the insoluble fraction. Such results prove that it is not possible to obtain a considerable increase of the amount of β-glucan in the soluble fraction by use of gelatinization.

The amount of β-glucan in oatmeal and in the soluble and insoluble fractions of hydrolysed oat is presented in Figure 4.

The obtained results show that in the soluble fraction of hydrolysed oat, the amount of β-glucan has decreased for 8.1–9.2% if compared with oatmeal, and has increased for 34.6–41.9% in the insoluble fraction. Thus, the conclusion follows that using enzyme Amilosubtilin G3x for starch hydrolysis is not sufficient for the most part of β-glucan to move to water solution. However, it was managed to obtain a considerable increase of β-glucan in the soluble fraction when hydrolysing oat starch.

The amount of β-glucan in oatmeal and in the soluble

Fig. 5. The amount of β-glucan (%) in oatmeal and in the soluble and insoluble fractions of steeped and then hydrolysed oat.

and insoluble fractions of steeped and then hydrolysed oat is presented in Figure 5.

From the obtained results follows, that with using of prior steeping of oatmeal the amount of β-glucan in the soluble fraction increases for 5.1%.

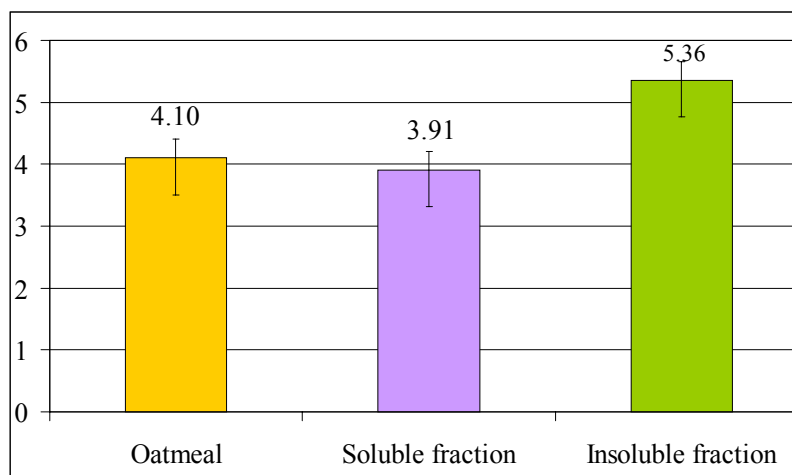The obtained results advance the hypothesis that the amount of β-glucan in soluble fraction will increase if it is possible found optimal steeping form of oatmeal before hydrolysis.

Conclusions

1. Separation of gelatinized oatmeal into water-soluble and insoluble fractions and its further use is not per-spective, because only a little outcome of the soluble dry matter with a little amount of β-glucan in it is obtained.

2. In hydrolysation of oatmeal starch, the outcome of dry matter of the soluble fraction increases considerably (41-52%) in comparison to the outcome of dry matter of the soluble fraction of gelatinized oat.

3. Oat meal hydrolysis provides almost proportional amount of β-glucan in the water-soluble fraction.

4. A prior steeping of oatmeal increases the outcome of dry matter of the soluble fraction of hydrolysed oat for 6.5%, but the amount of β-glucan for 5.1%.

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THE COMPARISON OF CHEMICAL POLLUTION BETWEEN ORGANIC AND CONVENTIONAL MILK

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Abstract

In Latvia have not been carried out comparable studies regarding chemical pollution in organic and conventional milk, therefore the aim of the present study was to investigate the level of contamination in organic and conventional milk samples by heavy metals and aflatoxin M_1.

A total of 9 organic bulk milk and 9 conventional bulk milk samples were collected from different regions of Latvia. The content of lead, cadmium, copper, iron, and zinc were detected by flame technique, using atomic absorption spectrophotometer (AAS). The level of aflatoxin M_1 in organic and conventional milk samples was determined by high-performance liquid chromatography.

The means of lead concentration in organic and conventional samples were 0.024 and 0.031 mg kg^{-1} wet weight that exceed the permissible level for such a product. The cadmium content in organic and conventional milk samples is very low and fairly constant in all types of milk. The legally accepted upper limits of iron, copper and zinc are not exceeded by any analyzed milk sample, not even from conventional bulk milk.

The study including heavy metals and aflatoxin M_1 in a range of organic and conventional milk samples found no significant differences between organic and conventional milk (p=0.05) in the level of aflatoxin M_1 and the heavy metals.

Key words: organic and conventional milk, aflatoxin M_1, heavy metals, chemical pollution.

Introduction

The chemical pollution is becoming a current problem in the world. At present there, are some possibilities how to decrease the chemical pollution. One of them is organic agriculture. Organic agriculture is a production management system that aims to promote and enhance the ecosystem, including biological cycles and soil biological activity. It is based on minimising the use of external inputs, for example, pesticides, and represents a deliberate attempt to make the best use of local natural resources. Methods are used to minimize pollution of air, soil and water, although they cannot ensure that products are completely free of residues, because of general environmental pollution (FAO, 2000).

Besides pesticides residues, there are several other chemical hazards associated with foods. Those chemical contaminants are coming from general environmental pollution. Contaminants in animal feeds, such as agricultural and industrial chemicals, heavy metals and radioactive nuclides, can give rise to safety hazards in foods of animal origin. As EC regulations require that livestock, claimed to be produced organically, is fed on organically produced feedstuffs, the potential for contamination with pesticides residues and other agricultural chemicals is greatly reduced compared to the conventional farming methods. However, as pointed above, organic agriculture does not reduce levels of persistent environmental pollutants in organically grown products. These may therefore be present in organic feedstuffs and hence in organic food of animal origin.

Of course, if organic agriculture do not allow using the preservatives for preparation of feed, the risks linked to aflatoxins contamination are higher in organic production than in conventional production. It appears that there are both advantages and disadvantages, regarding the aflatoxins problem in organic agriculture. Included among the advantages are the use of less nitrogen in organic agriculture, and also the use of organic nitrogen. The disadvantages are that, since no herbicides are used in organic farming, there are more weeds, as well as the presence of *Pyralidae* (Lorenzini et al., 2004). However, in organic agriculture it is possible to reduce the presence of weeds and *Pyralidae* by using crop rotations and other agronomic practices. All these products potentially contain mycotoxins.

In Latvia have not been carried out comparable studies regarding chemical pollution in organic and conventional milk, therefore the aim of the present study was to investigate the level of contamination in organic and conventional milk samples by heavy metals and aflatoxin M_1.

Materials and methods

A total of nine organic bulk milk and nine conventional bulk milk samples were collected from different regions of Latvia. The content of lead, cadmium, copper, iron, and zinc was detected in five organic and five conventional bulk milk samples. Aflatoxin M_1 was detected in four organic and four conventional bulk milk samples. The lead, cadmium, iron, copper, and zinc were determined by flame technique, using atomic absorption spectrophotometer (AAS), but aflatoxin M_1 was determined by high-performance liquid chromatography. The mean of obtained results was calculated and compared with the acceptable or regulated maximum levels. Descriptive statistics was carried out to determine the content of heavy metals by Microsoft Windows for Excel software packages.

Results

As it is known, mycotoxins are toxic bioproducts of moulds. The major mycotoxin of importance to milk is aflatoxin M_1 (AFM$_1$) which derives from aflatoxin B (AFB) found on forage. About one-fiftieth of the ingested AFB$_1$ carries over to milk as the AFM$_1$ metabolite. From this data, estab-

The level of aflatoxin M₁ in organic and conventional milk samples

Product	Samples (n)	Level of AFM₁ ±SD (μg kg^{-1})	Maximum level of AFM₁ (μg kg^{-1})	References
Organic milk	4	0.005±0.001	0.05	EC Regulation 466/2001
Conventional milk	4	0.004±0.001	0.05	

lished from feeding trials, it is possible to calculate the upper limit which should be set for feedingstuffs in order to control the AFM₁ levels in milk. These aflatoxins are believed to be carcinogens hence need to be controlled in milk especially that used for infants (Harding, 1999). The level of AFM₁ in organic and conventional milk samples is shown in Table 1.

The obtained results show that no AFM₁ values were not exceeded the permissible level in organic and conventional milk. The study found no significant differences between organic and conventional milk samples.

Milk and milk products play an important role in hu-

man diet and contribute greatly to the diet of the young, therefore concern about the global pollution of the environment has led to many studies of the pathways of heavy metals into milk. The content of heavy metals in organic and conventional milk samples is shown in Table 2.

The comparison of the level of heavy metals and trace elements in organic and conventional milk samples is shown in Figure 1 and Figure 2.

The means of lead concentration in organic and conventional samples were 0.024 and 0.031 mg kg^{-1} wet weight that exceed the permissible level for such a product.

As it is known, the main sources of lead pollution in

The level of heavy metals in organic and conventional milk samples

Heavy metal	Agricultural system	n	Mean±SD (mg kg^{-1} w.w.)	Value		Maximum level of heavy metals (mg kg^{-1} w.w.)
				min	max	
Lead	Organic	5	0.024±0.014	0	0.038	0.02*
	Conventional	5	0.031±0.004	0.025	0.035	
Cadmium	Organic	5	0.006±0.003	0	0.013	0.03**
	Conventional	5	0.007±0.003	0.005	0.012	
Copper	Organic	5	0.230±0.020	0.194	0.258	1.00**
	Conventional	5	0.290±0.050	0.240	0.356	
Iron	Organic	5	1.590±0.620	1.220	2.690	-
	Conventional	5	1.330±0.120	1.149	1.180	
Zinc	Organic	5	4.020±0.540	3.560	4.850	-
	Conventional	5	3.940±0.410	3.690	4.660	

*-EC Regulation 466/2001.

**-292/20.08.1999. Noteikumi par pārtikas piesārņojumu. (http://www.likumi.lv/doc.php?id=18618 resource was used on 21.03.05.).
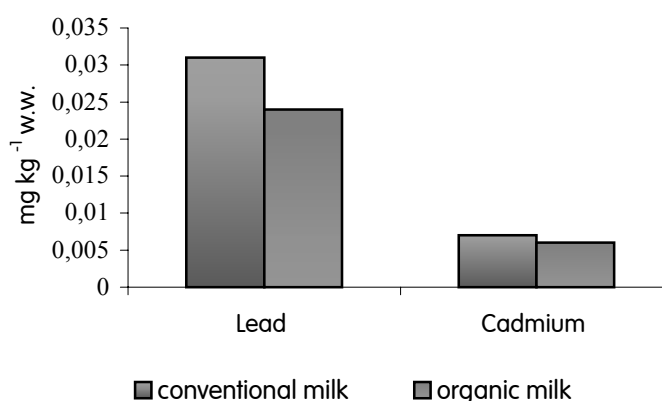

Fig. 1. The comparison of the level of heavy metals in organic and conventional milk samples.
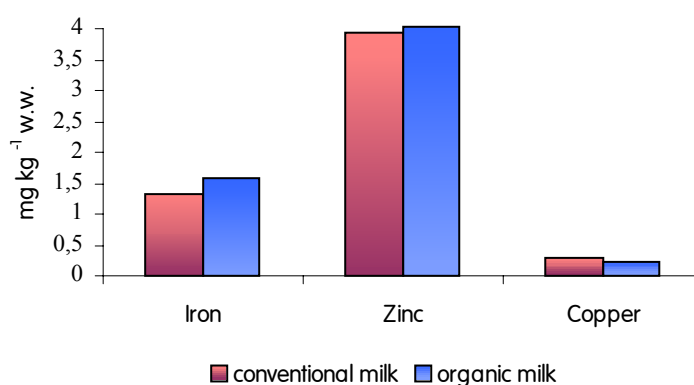
Fig. 2. The comparison of the level of trace elements in organic and conventional milk samples.

the environment are: industrial production processes and their emissions, road traffic with leaded petrol, the smoke and dust emissions of gas-fired power stations, the laying of lead sheets by roofers, as well as the use of paints and anti-rush agents. The lead contamination in organic and conventional milk samples could happen due to feeding the cows with fodder collected from along the road sides and can be controlled by choosing the source of the fodder without lead contamination. From the other side, the cow acts as a very effective biological filter diverting lead from her feed to her bones rather than to her milk.

The cadmium content in organic and conventional milk samples is very low and fairly constant in all types of milk. Cadmium, like lead, is a cumulative poison, i.e. the danger lies primarily in the regular consumption of foodstuffs with low contamination. However, in contrast with lead, the definition of an exact toxicity limit is not possible for cadmium. The decisive point is whether absorption of the existing cadmium actually takes place. This is, firstly, dependent upon the composition of the diet as a whole and, secondly, on the bio-availability of the cadmium compound present (Palmer et al., 1991). Again, as with lead, the cow acts as an effective biological filter and the proportion of ingested cadmium, finding access to milk, is extremely small.

Some heavy metals (the so-called trace elements) are essential in very small concentrations for the survival of all life forms, for example, copper, iron, zinc, and others. It is possible that not all are yet known. Despite this fact, it is often forgotten that in some circumstances, in higher concentrations, these can also be quite toxic, for example, when they are present in an organic compound. As pointed above, zinc and copper are essential elements for our body,

but in very small amounts. The daily intake levels of essential elements are also significantly lower than the recommended desirable levels of 3–5 mg kg^{-1} and 0.5–1 mg kg^{-1} for zinc and copper, respectively. However, the copper content of 0.1–0.2 mg kg^{-1} of body weight has already been found to cause digestive disturbances in sensitive consumers. Iron is an essential element in milk too and it plays an important role for blood. The essential content of iron in milk does not exceed 0.5 mg kg^{-1} (Harding, 1999). The legally accepted upper limits of different heavy metals, except lead, however are not exceeded by any analyzed milk sample, not even from conventional bulk milk.

One the basis of the present results no concern exists for the exposure of cadmium, zinc, iron, and copper from organic and conventional bulk milk samples. Of course, environmental contaminants are not the primary risk factors in nutrition, but unfavorable habits, insufficient hygiene, and natural toxic substances. Foods free from residues (heavy metals) are regarded by the consumer as the norm but not the exception.

Conclusions

1. The means of lead concentration in organic and conventional samples were 0.024 and 0.031 mg kg^{-1} wet weight that exceed the permissible level for raw milk.

2. The legally accepted upper limits of cadmium, copper, iron, and zinc are not exceeded by any analyzed milk sample, not even from conventional bulk milk.

3. The study in the range of organic and conventional milk samples found no significant differences between organic and conventional milk (p =0.05) in the number of AFM$_1$ and level of the heavy metals.

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EFFECTS OF GENDER AND HCG ADMINISTRATION ON SKATOLE LEVELS IN LIVER AND HEPATIC ACTIVITIES OF CYTOCHROMES P4502E1 AND P4502A6 IN PIGS

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Abstract

Accumulation of skatole levels in porcine fat tissue is a major reason for boar taint, an objectionable odour in meat from entire male pigs. In contrast to males, female pigs do not accumulate skatole in increased amounts. Hepatic metabolism is critical for the regulation of skatole. Cytochromes P4502E1 (CYP2E1) and P4502A6 (CYP2A6) are key enzymes involved in skatole metabolism. The objectives of this study were to evaluate the effects of gender and hCG stimulation on the activities of CYP2E1 and CYP2A6. Liver samples were taken at slaughter and analyzed for skatole concentrations, and for activities of CYP2E1 and CYP2A6. It was found that female pigs expressed higher CYP2E1 activity whereas activity of CYP2A6 did not differ between sexes. Skatole levels in the liver were higher in male pigs than in female pigs. Neither skatole levels nor enzyme activities were affected by hCG stimulation. It was concluded that the incidence of boar taint may depend on both the amount of skatole reaching the liver, and the activities of enzymes involved in skatole metabolism.
Key words: pigs, liver, skatole, CYP2E1, CYP2A6.

Introduction

The use of entire male pigs for pork production is limited in European countries regardless of lower production costs, leaner carcass and improved welfare of the animals. The main problem associated with use of entire males is boar taint, an objectionable odour in pork products. Boar taint occurs mainly due to the accumulation of skatole and androstenone in porcine adipose tissue (Dijksterhuis et al., 2000). Indole and androstenol are considered as minor compounds.

Skatole (3-methylindole) is produced from the amino acid tryptophan in the large intestine of pigs of all genders. However, only entire males accumulate high skatole levels in adipose tissue. The reasons for gender-related differences in skatole levels are not clearly understood. Skatole levels in pigs are regulated by hepatic metabolism, and gender-dependent differences in the ability to metabolise skatole might exist. Cytochromes P4502E1 (CYP2E1) and P4502A6 (CYP2A6) are the key enzymes involved in hepatic skatole metabolism (Squires & Lundström, 1997; Babol et al., 1998; Diaz & Squires, 2000), and high skatole levels in porcine adipose tissue are related to low activities of those enzymes (Zamaratskaia et al., 2005). Skatole levels increased with age after an increase in testicular steroids (Zamaratskaia et al., 2004), and this increase might also be due to age-related decrease in enzyme activities (Zamaratskaia et al., 2005). Probably, there is a link between high steroid levels and low enzyme activities.

Androstenone (5-alpha-androst-16-en-3-one) is a steroid produced by the testis of male pigs at puberty (Bonneau, 1982). Androstenone was shown to block the skatole-induced expression of CYP2E1 in an *in vitro* study (Doran et al., 2002). However, it is not known if high levels of androstenone suppress the activities of CYP2E1 *in vivo*, and whether such suppression, if it occurs, might cause increased skatole levels. Treatment with human chorionic gonadotropin (hCG) stimulates androstenone production

in the testis (Carlström et al., 1975; Bonneau et al., 1982). Hormonal stimulation might be used to provoke pigs to increase androgen production, which in turn might suppress the expression of CYP2E1 and subsequently reduce its activity.

To evaluate the potential role of liver metabolism in gender-dependent differences in skatole levels, we measured the activities of CYP2E21 and CYP2A6 in porcine liver microsomes from female and entire male pigs. The effect of hCG stimulation on the activities of CYP2E1 and CYP2A6 in entire male pigs was also investigated.

Material and methods

Animals

A total of 5 female pigs and 32 entire male pigs of a crossbred (Swedish Yorkshire dams x Swedish Landrace sires) were included in the study. All pigs were fed the same commercial diet according to the standard feeding regimen for finishing pigs in Sweden (restricted, 12 MJ ME per kg, digestible CP 13%). Pigs were slaughtered when their live weight (LW) reached an average of 115 kg. Eighteen entire males were treated with hCG (Pregnyl, 30 IU kg^{-1} of body weight) 4 days prior to slaughter to provoke high androgen levels.

Biochemical analyses

Liver samples from all animals were taken at slaughter, frozen in liquid nitrogen and stored at −80 °C until use. Skatole concentrations in the liver were measured by HPLC after extraction with methanol. For enzymatic assays, microsomal fraction was prepared from the liver homogenate by the differential centrifugation as described by Diaz & Squires (2000), and microsomal protein was assayed with a commercially available kit (Bio-Rad laboratories Inc., Hercules, CA, USA) according to manufacturer's instructions. Coumarin 7-hydroxylation was measured to determine the catalytic activity of CYP2A6, and p-nitrophenol hydroxylation was measured to determine the catalytic activity of CYP2E1. Skatole and androstenone concentra-

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Table 1

Activities of CYP2E1 and CYP2A6 (pmol/min/mg protein) in liver microsomes and concentrations of skatole in fat (µg g⁻¹) and liver (ng g⁻¹) ((median and range)

	Female pig	Male pigs		P-value
		no hCG stimulation	HCG stimulation	
Androstenone in fat, µg g⁻¹		0.3^a (0.1–3.0)	2.0^b (0.6–4.9)	0.001
Skatole in fat, µg g⁻¹		0.03 (0.01–0.3)	0.08 (0.01–1.3)	0.140
Skatole in liver, ng g⁻¹	10.6^a (6.8–15.3)	17.3^b (9.7–60.2)	17.8^b (3.0–86.1)	0.020
CYP2E1 activity	250^a (219–364)	174^b (19–384)	126^b (20–386)	0.030
CYP2A6 activity	35 (27–83)	40 (8–71)	27 (4–111)	0.680

The range refers to minimum and maximum values. Values with different superscripts within the row differ at P < 0.05. P-value represents the overall effect of the group evaluated by Kruskal-Wallis test. The pair-wise differences between groups are described in the text.

tions in fat in entire male pigs were measured by HPLC. All biochemical analyses were performed in duplicate.

Statistical analysis

Data were analysed with the Statistical Analysis System, version 8.2 (SAS Institute, Cary, NC, USA). Pigs were divided into three groups according to their sex and treatment (with or without hCG administration). Group 1 included female pigs (n = 5), group 2 – entire male pigs with no hCG administration (n = 15), and group 3 – entire male pigs treated with hCG (n = 17). Differences between groups were estimated using using a non-parametric Kruskal-Wallis test following pair-wise comparisons with Wilcoxon Rank Sum test. Spearman correlation coefficients were calculated to relate the activities of CYP2E1 and CYP2A6 to the concentrations of skatole in fat and liver.

Results

The activity of CYP2E1 was higher in female pigs compared to that of entire males (P = 0.02), whereas no differences in CYP2A6 activity were found between female and male pigs (P = 0.68) (Table 1). Skatole levels in the liver were higher in male pigs than in females (P = 0.01).

The administration of hCG significantly increased androstenone levels in fat. The activities of enzymes were unaffected (P = 0.63 and P = 0.46 for CYP2A6 and CYP2E1, respectively). Skatole levels were affected neither in fat (P = 0.14) nor in the liver (P = 0.86).

Spearman correlation coefficients between the measured variables are given in Table 2. Skatole levels in fat and liver were significantly correlated (Table 2). Activity of CYP2E1 was negatively correlated to skatole levels in both fat and liver. No relationship between CYP2A6 and skatole was demonstrated. Skatole and androstenone levels in fat were correlated.

Discussion

Hepatic CYP2E1 and CYP2A6 play a central role in the metabolism of skatole (Diaz & Squires, 2000). Individual differences in the activities of these enzymes may be an important determinant in the potential of pig to metabolize skatole. It is well known that female and castrated male pigs do not accumulate increased skatole levels (Bonneau et al., 2000). However, reasons for this are not clearly understood. In the present study, the activities of CYP2E1 were significantly lower in entire male pigs compared to that of females suggesting that differences in gender-linked variations in skatole levels might be related to the different rate of skatole clearance by CYP2E1. Interestingly, Skaanild and Friis (1999) reported no gender-related differences in CYP2E1 activities in pigs of approximately 40 kg live weight. These data are challenging. Is gender-linked difference absent in young pigs and develops later on? It should be noted that in our previous study we found that activities of both CYP2E1 and CYP2A6 decreased with age, while skatole levels increased (Zamaratskaia et al., 2005). It is, therefore, likely, that CYP2E1 activities might be similar in young pigs of both genders and becomes sexually differentiated due to a decrease of CYP2E1 activity in male pigs around the time of puberty. This might be an explanation for puberty-related increase in skatole levels in entire male pigs. This, however, remains to be confirmed, and factors responsible for decrease in enzyme activity in pubertal pigs need to be

Table 2

Spearman correlation coefficients between measured variables in fat (n=32) and liver (n=37)

	Skatole in fat	Skatole in liver	CYP2E1	CYP2A6
Skatole in liver	0.40*			
CYP2E1	−0.45**	−0.31*		
CYP2A6	−0.23	0.02	0.28	
Androstenone in fat	0.49**	−0.11	−0.31	−0.26

*Levels of significance: *P < 0.05; **P < 0.01.*

EFFECTS OF GENDER AND HCG ADMINISTRATION ON SKATOLE LEVELS IN LIVER AND HEPATIC
ACTIVITIES OF CYTOCHROMES P4502E1 AND P4502A6 IN PIGS

Galia Zamaratskaia, Gang Chen, Kerstin Lundström

elucidated. These factors might include physiological changes that occur during puberty.

Process of puberty is herald by increased production of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). The binding of LH to the receptors on the surface of the Leydig cells results in the induction of steroidogenic enzymes and increased levels of testicular steroids including androstenone (Squires et al., 1993). HCG acts in the body like LH, stimulating the Leydig cells to produce hormones and androstenone (Carlström et al., 1975; Bonneau, et al., 1982). Androstenone might be involved in the regulation of skatole metabolism (Babol et al., 1999; Doran et al., 2002). It was suggested that high androstenone levels might block skatole-induced expression of CYP2E1 (Doran et al., 2002). In our study, the increase in androstenone levels after a single hCG-injection caused no changes in the activities of CYP2E1 and CYP2A6, and skatole levels were unaffected in both fat and liver. These results do not support the hypothesis of a key role for testicular steroids in skatole metabolism. However, in the present study skatole levels and enzyme activities were measured shortly after hCG stimulation. It is not known how long time it takes for steroids to influence skatole levels. Additionally, hCG stimulation causes only a short-term increase in the secretion of testicular steroids (Carlström et al., 1975). The absence of

hCG effect on the enzyme activities might therefore be explained either by the short period between hCG injection and sampling, or by the short duration of hCG effect on testicular steroids. The involvement of other factors in the regulation of skatole levels cannot be excluded.

Significant correlation between skatole levels in fat and liver confirmed that hepatic metabolism is an important factor regulating skatole levels in fat. Skatole levels in the liver influenced mainly by skatole production, absorption and skatole metabolic rate. Skatole production and absorption determines how much skatole will reach the liver, and metabolism determines how fast skatole metabolites will be formed and removed from the liver.

Conclusion

Activity of CYP2E1 in porcine liver microsomes was higher in female pigs compared to that of entire males. Skatole levels in fat and liver were correlated. The occurrence of boar taint, therefore, is dependent on both skatole levels, which reach the liver, and the activities of enzymes involved in skatole metabolism.

Single hCG-injection dramatically increased androstenone levels, whereas skatole levels in fat and liver remained unchanged. Activities of CYP2E1 and CYP2A6 were not affected by a single hCG injection.

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THE DYNAMICS OF GROWING OF *BIFIDOBACTERIUM LACTIS* IN SUBSTRATE ENRICHED WITH LACTULOSE

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Abstract

Lactulose is recognized world-wide as one of the most clinically reliable bifidogenic factor. Lactulose is used in various types of food products (infant formula, baby food, confectionary, soft drink, milk products) and also pharmaceutically to improve hepatic encephalopathy and constipation (Mizota, 1996; Strohmaier, 1998). The objective of this study was to investigate the influence of concentration of lactulose on growing of *Bifidobacterium lactis* in milk.

A bifidogenic factor, lactulose was added (1, 2, 3, 4 and 5%) into 100g of milk. The milk samples were inoculated with *Bifidobacterium lactis* (BB-12, Chr. Hansen, Denmark) and incubated at 38 °C for 16 hours.

Lactulose as a prebiotic influences the growth of bifidobacteria in milk. Trends of development of acidity in the milk samples with or without lactulose were not similar. Laboratory studies have generally shown that growth of *Bifidobacterium lactis* in milk depends on the concentration of lactulose. Data on the final cell count in fermented milk indicates that increasing the lactulose concentration from 2% to 3% enhanced the growth of the *Bifidobacterium lactis*, whereas no significant difference between lactulose concentration 4–5% and control sample was observed.

Present results furthermore indicate that finding combination of prebiotic and probiotic pairs where the prebiotic would benefit the specific probiotic strain, e.g. during production and formulation into foods, is not a simple task.

Key words: lactulose, bifidogenic factors, bifidobacteria, milk.

Introduction

In the area of functional food there is currently considerable interest to increase the number of "beneficial" microorganisms in milk products that may confer health benefits to the consumer.

Food manufacturers use two strategies to achieve this goal. The direct approach is to supply the fermented dairy products such as yoghurts with live preparations of the microorganisms. In this case one of the perceived difficulties with probiotics is that after ingestion, a substantial proportion of them are killed by adverse conditions: stomach acid, bile salts, pancreatic enzymes, in upper gut before they reach the colon where the main population of bacteria resides (Saxelin et al., 1999). The other approach has been taken that non-digestible carbohydrate food supplements are given in products. They support and stimulate the growth of lactic acid bacteria in the colonic microflora. These food components have been termed prebiotics.

Prebiotics are defined as nondigestible food that may beneficially affect the host by selectively stimulating the growth and/or the activity of a limited number of bacteria in the colon (Gibson et al., 1995). Thus, to be effective, prebiotics must escape digestion in the upper gastrointestinal tract and be used by a limited number of the microorganisms comprising the colonic microflora. Prebiotics are principally oligosaccharides, e.g. fructo-oligosaccharides, galacto-oligosaccharides, lactulose, inulin, and also polysaccharides such as certain forms of resistant starch.

Several studies have indicated that these sugars are not degraded in the upper gastrointestinal tract and reach the colon in an intact form and are utilized by colonic microflora. They mainly stimulate the growth of bifidobacteria, for which reason they are referred to as bifidogenic factors (Vuyst, 2000). Inulin and fructo-oligosaccharides are now the most widely used prebiotics. Lactulose is recognized world-wide as one of the most clinically reliable bifidogenic factors. Lactulose is a disaccharide comprised of the sugars D-galactose and D-fructose. The sugars are linked by a beta-glycosidic linkage, making it resistant to hydrolysis by human digestive enzymes. Besides, during heating of milk, lactose may isomerise into lactulose. Lactulose is formed in fairly large quantities, from 300 to over 1000 mg l^{-1} in sterilized milk (Walstra, Geurts, Noomen et al., 1999). Therefore, lactulose is not only a semisyntethic disaccharide, but a native component in thermally processed milk and also important factor for growth of bifidobacteria in milk.

Also, the further development of synbiotics may improve the effectiveness of probiotic strains and appropriate health-stimulating substrates, in particular reaching an increased number of ingested bacteria reaching the colon in a viable form. As we know, synbiotics are defined as a mixture of probiotics and prebiotics that improve the survival and implantation of live microbial dietary supplements in the gastrointestinal tract, either by stimulating the growth or by metabolically activating the health promoting bacteria (Gibson et al., 1995; Lewis et al., 1998).

However, less is known about the interaction between different combinations of probiotics and prebiotics, although this is necessary to have a rationale for selecting different probiotics and prebiotics and developing efficacious synbiotics. Moreover, it is essential that these components be developed as the active ingredients of the food products that are ultimately intended for human consumption, in particular when probiotic, prebiotic or synbiotic is considered a food ingredient or food supplement (Vuyst, 2004).

The objective of this study was to investigate the influence of concentration of lactulose on growing of bifidobacteria in milk.

Materials and methods

The research was performed in the microbiological laboratory of the Department of Food Technology of Latvia University of Agriculture.

The strain of *Bifidobacterium lactis* (freeze – dried starter culture Bb-12, Chr. Hansen, Denmark) was used. During the experiments, the culture was maintained at – 18 °C.

The lactulose syrup (Duphalac®, Netherland) was used as a bifidogenic factor for growing of bifidobacteria in milk. The composition of the syrup of lactulose was as follows (%): lactulose – 67, lactose – less than 6, galactose – less than 10.

The *Bifidobacteria lactis* was incubated in milk. Different lactulose contents (1, 2, 3, 4 and 5%) were added individually in the 100 g milk. The *Bifidobacterium lactis* were inoculated with 2 ml of milk suspension (about $1*10^6$ bifidobacteria) and cultured at 36 °C for 16 hours. During the incubation after each 2 hours, the increase of bifidobacteria was estimated by cell count techniques. The acidity (Therner degree, °Th) of fermented milk was determined by titrimetric method using 0, 1 M NaOH solution.

Fermentations were performed in triplicate, and the analyses were carried out in duplicate. The data given here are the mean values of the measurements.

Results and discussion

In contrast with lactobacilli, bifidobacteria exhibit a weak growth in milk or do not grow at all in milk. The addition of growth promoting factors, such as vitamin-enriched protein hydrolysates, or sources of carbohydrates, for example lactulose, in milk stimulates growth of bifidobacteria (Modler, 1994). The obtained results are given in Figures 1 and 2, respectively.

The rate of acid development is a critical factor in milk fermentation by bifidobacteria. Also the chemical composition of the fermentation medium for growth (for instance, the carbohydrate source, total solid content, availability of nutrients and growing parameters, dissolved oxygen content), the cultivation conditions (for instance, the level of inoculation, the incubation temperature, the fermentation time), final acidity, etc. may affect the viability of probiotic organisms in fermented products. With increased substrate level (4% and 5%) in milk, growth of acidity was poorer. Trends of development of acidity in the milk samples with or without lactulose were not similar.

The study has shown that oligosaccharides such as lactulose, when included in milk, stimulate the growth of bifidobacteria in fermentation process. Laboratory studies have generally shown that growth of *Bifidobacterium lactis* (BB-12, Chr.Hansen) depends on the concentration of lactulose in milk. The lactulose concentrations of 2% and 3% still were the best, and the difference to control sample was larger compared to the experiment with the 5% lactulose concentration. With increased concentration of lactulose (4–5%), growth of bifidobacteria was poorer. Data on the final cell count in fermented milk indicates that increasing the lactulose concentration from 2% to 3% enhanced the growth of *Bifidobacterium lactis*, whereas no significant difference between lactulose concentration 4% and 5% and control sample was observed.

Shin, Lee, Petska, and Ustunol (2000) were able to show that adding large quantities (5%) of galacto-oligosaccharides and especially fructo-oligosaccharides to skimmed milk enhanced the survival of the two *Bifidobacterium* strains. Since we studied different prebiotic (lactulose) and *Bifidobacterium lactis,* our results are not comparable to the results of Shin et al. (2000). However, the possibility that by using larger quantities of prebiotic (5% in
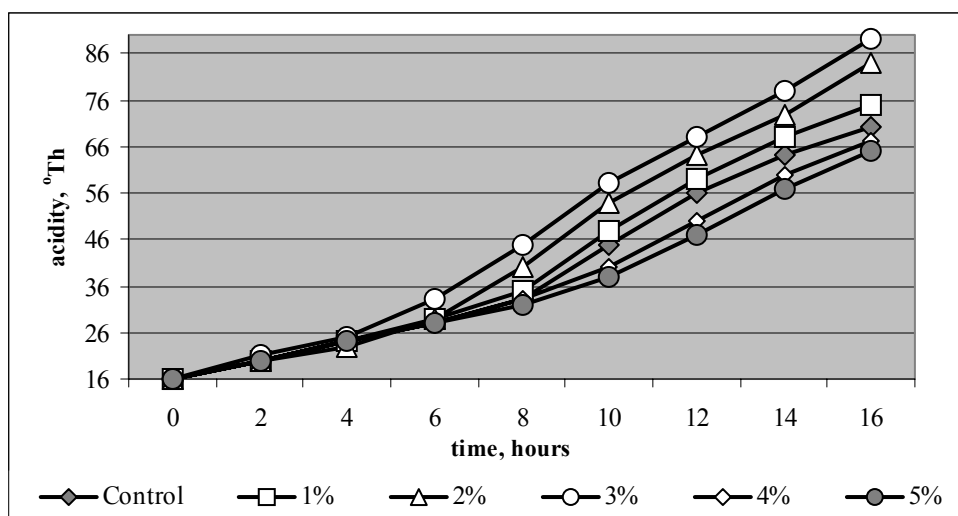
Fig. 1. The rate of acid development in milk fermentation by bifidobacteria.
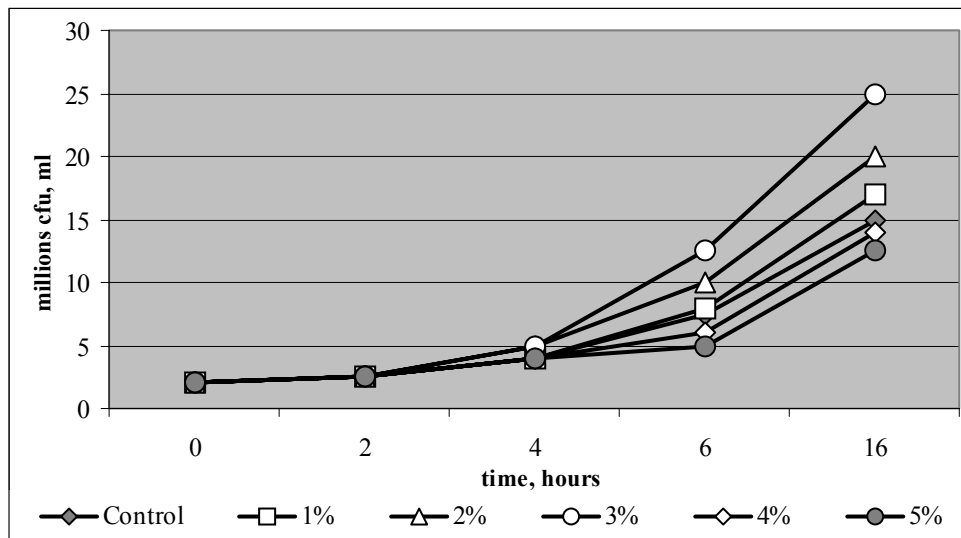
Fig. 2. The dynamic of growing of Bifidobacterium lactis in substrate enriched with lactulose.

the present study) a more pronounced effect on the properties of the tested *Bifidobacterium lactis* could have been detected cannot be ruled out.

Present results furthermore indicate that finding combination of prebiotic and probiotic pairs where the prebiotic would benefit the specific probiotic strain, e.g. during production and formulation into foods, is not a simple task.

Conclusions

1. Trends of development of acidity in the milk samples with or without lactulose were not similar.

2. The concentration of lactulose has important implication on growing rate of bifidobacteria in milk.

3. The increase in the concentration of lactulose over 3% in milk demonstrates the prevention of growing of bifidobacteria in milk.

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THE DYNAMICS OF VITAMIN C AND TOTAL CAROTENES CONTENT IN PASTEURIZED SEA-BUCKTHORN JUICE

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Abstract

To select new sea-buckthorn hybrids and forms with increased content of biologically active substances, breeding work with sea-buckthorn hybrid seedlings is carried out in Latvia. The aim of this research was to study the vitamin C and total carotenes content in sea-buckthorn juice and its stability at different pasteurization temperatures with several durations. For study 6 sea buckthorn hybrids from 3 hybrid families were used. Vitamin C and total carotenes were determined in freshly made juice and with pasteurization at 65 °C, 75 °C and 85 °C for 30, 20 and 10 minutes respectively. After processing the data obtained, it was found that vitamin C and total carotene content did not alter significantly depending on pasteurization temperature and duration. For further research 3 sea-buckthorn hybrids have been selected with the highest content of vitamin C and total carotenes.
Key words: sea-buckthorn, vitamin C, carotenes, pasteurization.

Introduction

During the last decades sea-buckthorn has evolved from a little known wild shrub into a rather well established fruit crop, and has become popular in Latvia. Although it is listed among untraditional crops, it is considered as one of the most important plants found in nature, containing many and various biologically active substances (Beveridge et al., 1999). As already published (Beveridge et al., 1999; Prokkola, Mäyrä, 2003; Netzel et al., 2003), fresh sea-buckthorn fruits contain a significant amount of vitamins C, E, K_1, as well as P and B group vitamins, carotenes, organic acids, polyunsaturated fatty acids, phenolic compounds, microelements, and minerals.

Especially high is the content of vitamin C in sea-buckthorns, which is found in berries in its free form not in combined form. For this reason, the vitamin is easily and quickly consumed by the organism. Besides, unlike such well-known berries as black currants and rosehips, they do not contain the enzyme ascorbinoxidase, which destroys vitamin C. So the vitamin C remains stable and is well preserved in processed products. It is known that the human organism uses the ascorbic acid more fully and effectively together with vitamin P and β-carotene (Нечаев et al., 2003). These compounds interact to mutually strengthen the effect of each other and, according to literature data (Нечаев et al., 2003), are considered as natural antioxidants. The concentration of vitamin C in the sea-buckthorns can vary from 350 mg % in berries grown in Europe to 2500 mg % in varieties and hybrids cultivated in China (Bernàth, 1992). Studies confirm the stability of vitamin C in different processed products – juice, syrup, and jelly (Prokkola, Mäyrä, 2003).

The content of total carotenes in sea-buckthorns depends on the variety, the stage of fruit ripeness, as well as the climatic conditions. The highest content is found in orange-red and red berries. Fresh berries can contain 11 to 40 mg % of carotenes (Bernàth, 1992). The average content of carotenes in sea-buckthorn oil is 200 mg % but it can reach even 600 mg % and more, depending on the berry quality and maturity. β-carotene (provitamin A) is one of the most important components in sea-buckthorn berries, which has antioxidant properties. Vitamin A is used by the human organism only in the presence of fats – in sea-buckthorns it is already contained in oil, and so the consumption of the vitamin is maximally effective.

One of the most popular sea-buckthorn processed products is juice. To extend its storage, the juice has been pasteurized. The pasteurization temperature 65 °C is critical to many harmful microorganisms (yeasts, moulds) (Brūvere, 2000). As the product has been treated at the temperature for 30 minutes, it is not profitable economically and practically. An important question is how the pasteurization temperature influences the stability of biologically active substances in the product, if increased to 75 °C and 85 °C (consequently reducing the treatment time by 10 minutes).

In Latvia breeding work with sea-buckthorns is performed to obtain varieties with a high content of biologically active substances and well-adapted to the local climate. The hybrids have been selected from seedling families. For the berries of sea-buckthorns obtained in the result of breeding, it is necessary to determine their biochemical content, evaluate the amount of biologically active substances and their preservation in processed products. The aim of this research was to study the vitamin C and total carotenes content in sea-buckthorn juice and its stability at different pasteurization temperatures with several durations.

Materials and methods

The research was carried out at the Experimental fruit and berry processing center of Dobele HPBES during 2004. 09. -2005. 03. For the study, 6 new sea-buckthorn hybrids from 3 hybrid families (No. 1, No. 2 from 1. family; No.3, No. 4 from 2. family; No. 5, No. 6 from 3. family; seedlings were from Sweden Balsgard institute) were used. The berries were picked at Baltplant Ltd., Dobele district, Berze, Latvia. They were stored frozen at minus 18 °C. The juice was pressed from defreeze berries at room temperature with a press "Juice-master 42.3", which helps smash the fruit skin

Error Bars show Mean +/- 1.0 SE

Bars show Means
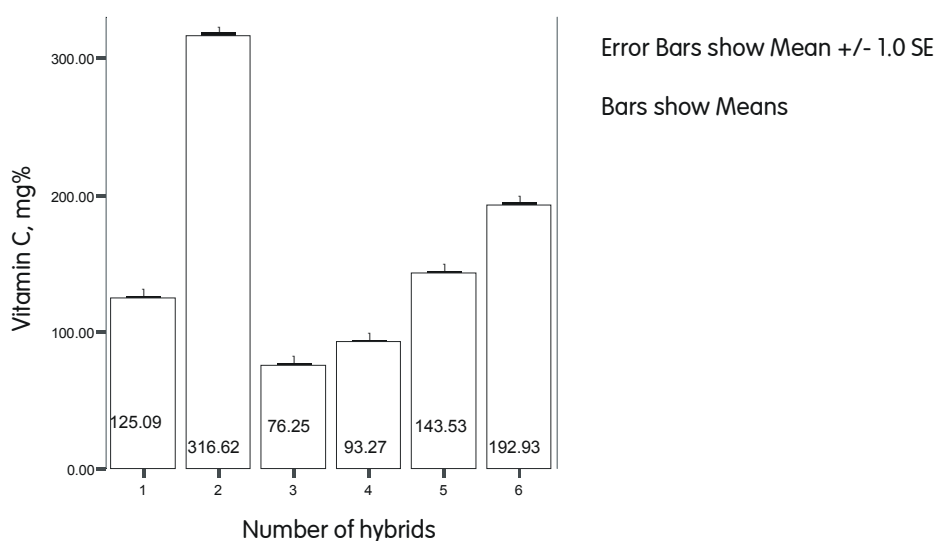
Fig. 1. The content of vitamin C in sea-buckthorn hybrids.

a little. The content of vitamin C and total carotenes was analyzed in freshly pressed and pasteurized juice, at pasteurization temperatures 65 °, 75 ° and 85 °C duration (consequently reducing the treatment time by 10 minutes). "Water Bath WB4" for the juice pasteurization was used. The spectrophotometric method for the analysis of carotene was used, for vitamin C – the iodine method.

The data were analyzed statistically by using SPSS for Windows, MS Excel.

Results

The content of vitamin C in the fruits of sea-buckthorn hybrids varied from 76.24 to 316.62 mg %, while the total carotenes – from 3.78 to 10.83 mg % (Figures 1, 2). The highest content of vitamin C was found in hybrid No. 2 – 316.62 mg %, next hybrids No. 5 and No. 6 contained vitamin C twice less, 143.53 and 157.95 mg % respectively. The highest content of total carotenes was found in hybrid No. 1 and hybrid No. 2 – 10.00 and 10.83 mg % respectively.

After processing the data by dispersion analysis, it can

be concluded that the content of vitamin C and total carotenes does not change significantly depending on the pasteurization temperature and duration (Figures 3, 4).

The study confirms the stability of vitamin C during sea-buckthorn processing, which could be because of the absence of ascorbinoxidase and high level of polyphenols compounds in the berries.

Conclusions

1. For the highest contents of vitamin C and total carotenes were selected hybrids No. 2, No. 6 and No. 5 (vitamin C 316.62, 152.93 and 143.53 mg % respectively; carotenes - 10.00, 10.83 and 7.39 mg % respectively).

2. The total content of vitamin C and total carotenes in freshly made juice does not significantly depend on the pasteurization temperature and holding time.

3. The study confirms the stability of vitamin C during sea-buckthorn processing.

Error Bars show Mean +/- 1.0 SE
Bars show Means
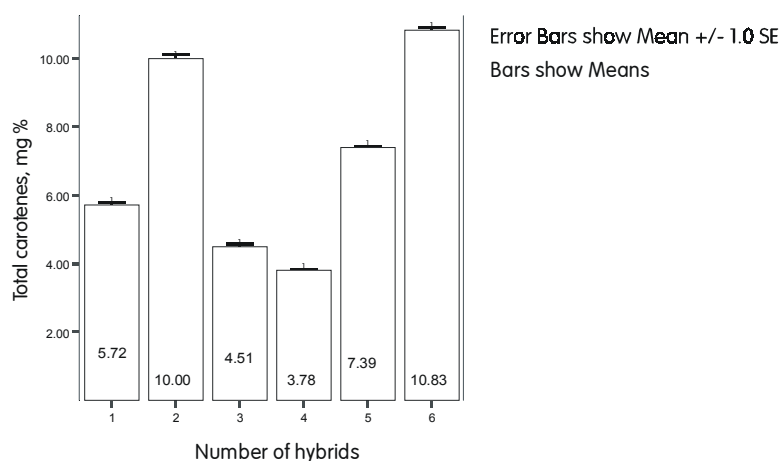
Fig. 2. The content of total carotenes in sea-buckthorn hybrids.
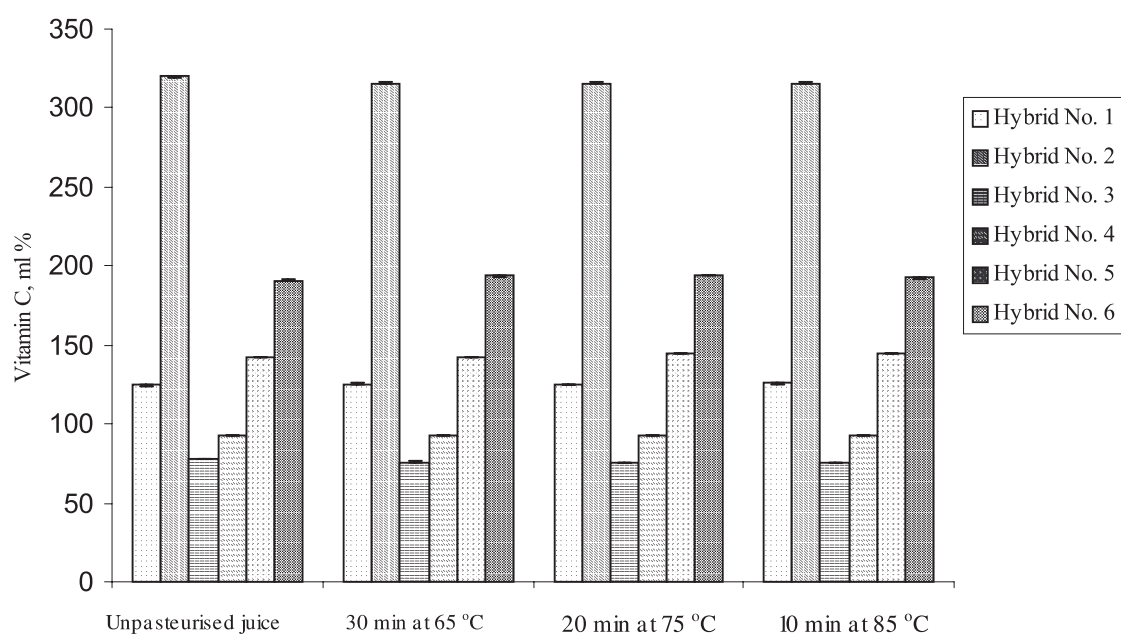
Fig. 3. The content of vitamin C depending on temperature and time of pasteurization.
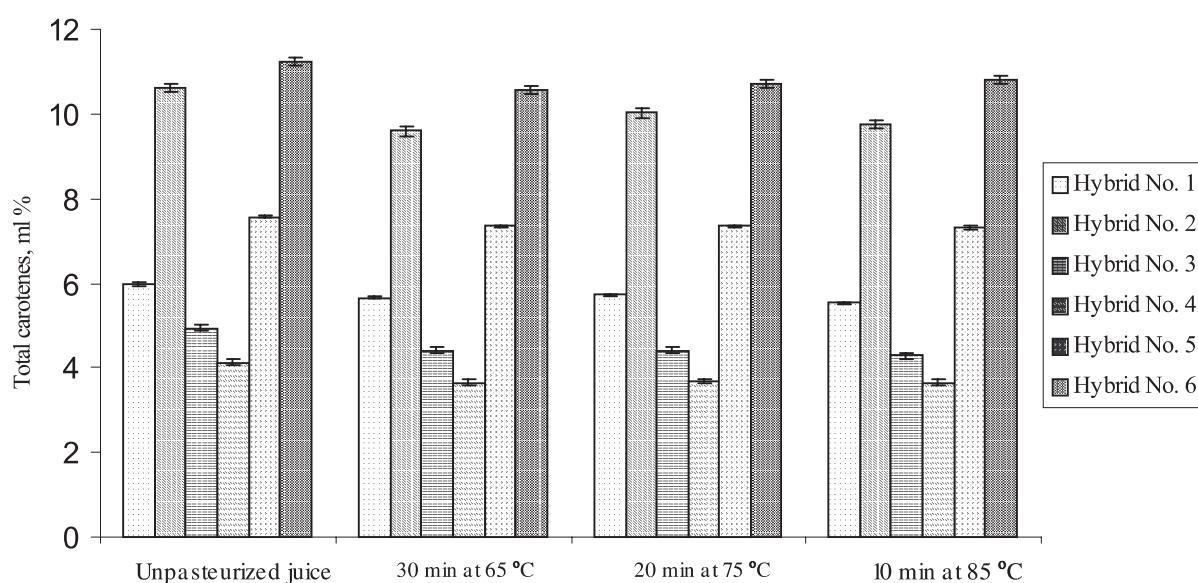
Fig. 4. The content of total carotenes depending on temperature and time of pasteurization.

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THE EFFECT OF SOME INGREDIENTS ON STABILITY OF BUTTER DURING THE STORAGE TIME

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Abstract

The effect of some ingredients on stability of butter during its storage time has been investigated in order to better evaluate the functionality of confectionery. The research established that butter does not contain enough free fatty acids, derived as a result of hydrolysis, to decrease the number of mould and group of *Enterobacteriaceae*, but they hinder the growth of yeast and aerobic mesophilic and facultative anaerobic microorganisms. The quality of the products can be provided and propagation of microorganisms can be hindered by the compounds that are not traditional preservatives, such as vanillin and glucose syrup. A 10% glucose syrup additive worked as the facilitator of the development of microorganisms because it increased growth of aerobic mesophilic and facultative anaerobic microorganisms, 50% of glucose syrup additive worked as the procrastinator of the development of microorganisms.

Key words: food, fat, stability.

Introduction

The characteristic designations of the foodstuffs – "Biological value", "Functionality" – rather solely evaluate the true physiological value of foodstuffs as quite frequently the products that derive during storage and processing are not taken into account (Ozola et al., 2003; Vitola et al., 2004).

A more detailed study of the products used in human food has already been carried out earlier. On the grounds of these studies optimum recommendations on how to improve the biological value of confectionery can be drawn up (Vitola, 2004; Skrupskis et al., 2004).

Nevertheless, there are still a lot of uncertain questions concerning mutual effect of the ingredients of the products and raw materials and especially concerning the processes taking place in products during storing for a long time. The growth of the import and export of the products require and modern food additives and technologies allow to prolong the storage period considerably, at the same time they do not take enough interest in what is formed in these products during storage period (Ozola et al., 2005; Vitola, 2005).

The intention of the author has not been to research the possible harmfulness of these products but the new compounds that form because of the mutual effect of the ingredients present in the products and their possible interaction with the product.

It can be especially intriguing when carrying out research of confectionary made from flour and sugar and which are stored in an open or almost open packaging and therefore are exposed to humidity, oxygen, temperature changes and microorganism effects, which can significantly influence the quality of the products during their (realization) storage period.

So by analyzing the possible biological value, the changes in these biological values should be analyzed as a factor determining its functionality during the storage period.

The biologically active body of compounds and the interaction of the new products that have formed from them could be shown as follows:

The secondary compounds and tertiary compounds (free fatty acids, peroxides) that form from them during storage and technological processing reversibly influence further change (auto oxidation, hydrolysis) of the ingredients used in nutrition, as well as intensify or diminish the activity of the special additives, for instance, intensifies antimicrobial activity (Charteris, 1996).

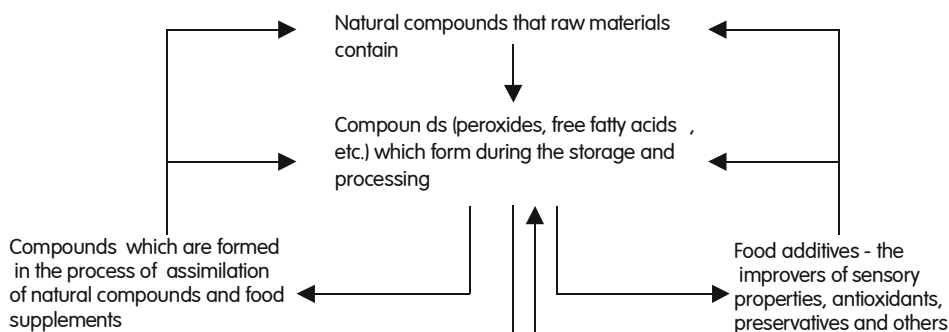Consequently, during storage and processing, com-

Fig. 1. Mutual interaction of ingredients in the foodstuff.

Table 1

Intensity of the formation of peroxides in butter during the storage time

Samples	Peroxides, mmol kg^{-1}	%, per control
Control – butter before storage	0.43	100
1. Butter after storage	0.73	169
2. Butter with 0.05% of vanillin additive	0.91	212
3.Butter with 50 %of glucose syrup additive	0.51	119
4.Butter with 10% of glucose syrup additive	0.35	81
5.Butter with 1% of NaCl additive	0.37	86

pounds can form that reversibly influence not only the biological value and market quality of the product but also the process of other products, i.e. hastens or hinders them.

It was established before that carbohydrate additives can have an effect on the formation of peroxides (Ozola et al., 2005). The research has been continued and the obtained results are demonstrated in Table 1: how the amount of peroxides varies in butter (sample 1) and in butter with additives in it (samples 2, 3, 4 and 5) after they have been stored for 30 days at the temperature of 28 °C, compared to the amount of peroxide in fresh butter (control).

As seen in Table 1, the quantity of peroxides in butter containing carbohydrate (samples 3 and 4) and NaCl additives (sample 5) has not increased as much as in butter which has been stored without additives (sample 1). It is worth mentioning that 10% of glucose syrup additive (sample 4) and NaCl additive has even decreased the peroxide number in butter during the storage period, if compared with fresh butter (control). However the peroxide number has become higher for butter containing vanillin additive. Unlike carbohydrates that also contain aldehyde group, vanillin which contains aldehyde group did not reduce the peroxide number. It might be that aldehyde group as such is not decisive in the regulation process of peroxide formation.

The research suggests that formation of free fatty acids is also affected during the storage period as the additive can facilitate or hinder formation of free fatty acids (Table 2). Table 2 demonstrates how the formation of free fatty acids in butter has been affected by additives when storing butter at 28 °C for 30 to 90 days.

Thus 1% of sucrose additive has hindered formation of free fatty acids in butter during its storage. After 30 days of the storage of butter containing 15% of sucrose there are more free fatty acids in it, but after 90 days there are less free fatty acids compared to butter with no additives. Whereas 50% of sucrose additive has favored formation of free fatty acids in butter after its storing for 90 days.

The mass of free fatty acids in butter containing 1% of NaCl additive stored until 30 days has increased, but after it was stored for up to 90 days it has decreased.

Consequently, the additives substantially affect formation of free fatty acids in food products during the storage period.

Table 3 shows the percentage distribution of free fatty acids in butter and butter with 50% of sucrose additive after it was stored at 28 °C for 150 days. The quantity of free fatty acids in both samples differs greatly.

Such products as peroxides and fatty acids are biologically active compounds and can affect other processes, can favor or hinder perishability of the products during storing and processing. Their quantity can increase due to fat hydrolysis which in its turn should show a certain biological effect.

A lot of new products – fatty acid mono – and diglycerides, as well as free fatty acids are formed as a result of fat hydrolysis.

These products are not unhealthy, although they have a range of new qualities. Monoglycerides work as active ingredients of the surface but some fatty acids are considered to be indistinctive fungicides and bactericides. For instance, caproacid and caprilacid inhibit the growth and development of microorganisms already at 3 mg l^{-1}.

Table 2

The content of free fatty acids in butter during the storage time

Samples	Free fatty acids, % after 30 days of storage	Free fatty acids, % after 90 days of storage
Butter	0.56	0.73
Butter with 1% of sucrose additive	0.55	0.59
Butter with 15% of sucrose additive	0.62	0.63
Butter with 50% of sucrose additive	0.48	1.05
Butter with 1% of NaCl additive	1.0	0.72

Table 3

The content of free fatty acids in % from the total mass (Vitola et al., 2005)

C_x	Fatty acids	Butter	Butter with 50 % of sucrose	The increase or decrease of the share, %
4:0	Butyric acid	3.02	5.75	+ 90.40
6:0	Caproic acid	2.75	5.01	+ 82.18
8:0	Caprylic acid	1.84	3.40	+ 84.78
10:0	Capric acid	4.30	7.43	+ 72.79
12:0	Lauric acid	4.78	7.08	+ 48.12
14:0	Myristic acid	13.23	15.22	+ 15.04
16:0	Palmitic acid	32.79	29.99	- 8.57
16:1	Palmitoleic acid	1.58	1.57	- 0.63
18:0	Stearic acid	11.08	7.44	- 32.85
18:1	Oleic acid	23.57	16.40	- 30.42
18:2	Linoleic acid	1.08	0.72	- 33.33

One of the factors that set the quality of food products is microbial cleanliness of the food product, i.e. to what extent it is possible to prevent infection with undesirable microorganisms while the product is prepared, stored and processed. Microorganisms can get into the product through raw materials, water and air, and also when hygiene and sanitary standards are not observed.

The microbial perishability of food products can cause several negative phenomena because micro-organisms can develop toxic compounds – toxins. Resistance of many microorganisms to high temperatures and acquisition of resistance to chemical compounds is particularly hazardous. Separate bacterial species can form spores that bacteria use to protect themselves from an unfavorable environment. In conditions favorable to spores, a normal cell can be formed in a few hours.

While studying the effect of mould on mice, Gifford, Zimmerman and Gay stated that animals whose food contained mould differed from the contact group with antisocial behavior: they fought, quarreled and did not look after their progeny. Their progeny had different congenital abnormalities.

That means that the foodstuff infected with mould can effect human nervous system badly, which is a serious problem in the society nowadays (Lancet, 1974).

The Cabinet regulation No. 292 adopted 20 August 1999 "Regulations on Food Contamination" in annex 3 "Maximum Admissible Levels of Microbiological Contamination in Food Products and Raw Materials Thereof" concerning butter have determined admissible level for aerobic mesophilic and facultative anaerobic microorganisms and group of *Enterobacteriaceae*, but there are no limit for yeast and mould.

The task of this work is to clear up how/if the factors that are unfavorable for food and have resulted from oxidation and hydrolysis processes effect the growth of mould in butter.

Materials and Methods

Butter was used to carry out the research as it is not only widely used in confectionery but also contains a wide assortment of milk fats and other bioactive compound additives. Butter contains much water and therefore is considered to be the most effective material for carrying out the experiments.

Manufactured sweet cream butter with a 82.5% fat content and 16% water content was used for the experiments.

The following additives were added to butter: 0.05% of vanillin, 1% of NaCl, a 8 °C and incubated for 30 days (average shelf life for butter cookies). After that, microbiological testing was carried out.

Aerobic mesophilic and facultative anaerobic microorganisms (LVS EN ISO 48833: 2003) and group of *Enterobacteriaceae* (The Cabinet Microbiological examination methods for foodstuff, 1999), yeasts, and mould (ISO 7954 - 87) were determined for the samples.

Admissible level for aerobic mesophilic and facultative anaerobic microorganisms and group of *Enterobacteriaceae* for butter have determined in Cabinet Regulation No. 292 in annex 3, Latvian Combined Nomenklature Code 0405.

As the Cabinet Regulation No. 292 do not lay down the admissible level for yeast and mould in butter, the level according to Latvia Combined Nomenclature Code 1905 (The Cabinet regulation No. 292) that concern the product group – sponge cakes, puff pastry, shortcakes, light cakes with filling or whipped cream – are taken into account. If margarine is used for this group the admissible level of mould cannot be more than 50 CFU (colony forming units) in 1 gram, and yeast cannot exceed 100 CFU in 1 gram.

The acquired results have been compared to the level that are determined in this paper.

Results and Discussion

The results of microbiological testing are compiled in Table 4.

After storing butter without additives, its microbiological indicators have been deteriorated, the quantity of aerobic mesophilic and facultative anaerobic microorganisms

Table 4

The results of microbiological testing for butter and butter with additives

Indicators	Butter before storage	After 30 days of storage at 28 °C					Admis-sible level
		Butter	Butter with 0.05% of vanillin additive	Butter with 1% of NaCl additive	Butter with 10% of glucose syrup additive	Butter with 50% of glucose syrup additive	
Mesophilic aerobic and optional anaerobic microorganisms, CFU in 1g	0.5×10^2	2.4×10^4	1.7×10^2	3.1×10^2	1.5×10^5	6.0×10^2	1.0×10^5
Group of *Enterobacteriaceae*	-0.01	+0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Yeasts, CFU in 1g	<10	<10	<10	<10	20	20	100
Mould, CFU in 1g	1.0×10^1	7.0×10^3	5	60	290	<10	50

has increased, also group of *Enterobacteriaceae* can be found, and the content of mould exceeds the acceptable level. Whereas the quality of butter with vanillin additives has not changed at all, and the content of mould is even lower than in fresh butter.

One percent of NaCl additive hinders the propagation of aerobic mesophilic and facultative anaerobic microorganisms, but the quantity of mould exceeds the admissible level that we have determined, although compared to butter without additives the quantity of mould is considerably lower.

It is interesting that the quantity of aerobic mesophilic and facultative anaerobic microorganisms in butter with 10% of glucose syrup additive during its storage period exceeds the level determined by the Cabinet for butter. This sample has a great quantity of mould content in it. But 50% of glucose syrup additive acts as a preservative because microbiological parameters of butter, compared to fresh butter, have not changed. In addition, the quantity of mould has even decreased, as it was in the sample with vanillin additive.

Consequently, development of mould in butter is not harm to human health in confectionery whose essential constituent of the recipe is carbohydrates, for example – fondant sweets.

This research should be continued as it is of interest to find out how the addition of complex additives, such as carbohydrate and vanillin additives, would have worked in butter.

Conclusions

1. Butter does not contain enough free fatty acids, derived as a result of hydrolysis, to decrease the number of mould and group of *Enterobacteriaceae*, but they hinder the growth of yeast and aerobic mesophilic and facultative anaerobic microorganisms. Therefore, antimicrobial effect of free fatty acids is not sufficient to provide the quality of the product.

2. The quality of the products can be provided and propagation of microorganisms can be hindered by the compounds that are not traditional preservatives, such as vanillin, which together with free fatty acids gives synergistic effect by hindering the growth of aerobic mesophilic and facultative anaerobic, group of *Enterobacteriaceae*, yeast, and mould.

3. A 10% glucose syrup additive has worked as the facilitator of the development of microorganisms because it increased the growth of aerobic mesophilic and facultative anaerobic microorganisms, but 50% of glucose syrup additive has worked as the procrastinator of the development of microorganisms and has decreased the growth not only of aerobic mesophilic and facultative anaerobic microorganisms but also the development of yeast and mould.

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DYNAMICS OF PEROXIDE VALUE IN FLAVOURED RAPESEED OIL

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Abstract

Spices are used to season food products. Investigations were carried out to determine dynamics of primary oxidation products in flavoured rapeseed oil depending on used spice, its concentration, storage duration, and sample preparing method. The oil was flavoured with winter savoury *Satureja Montana* L., hyssop *Hyssopus officinalis* L., and marjoram *Oreganum vulgare* L. Results showed that dynamics of peroxide value in flavoured oils were influenced significantly ($p < 0.05$) by all investigated factors – used spice, its concentration, storage duration, sample preparing method, and interaction of these factors, too. Heating of oil in particular cases caused unusual, hard explainable dynamics of peroxide value. It is necessary to investigate optimal conditions of flavouring of oils and components of spices which can influence oxidation of flavoured oils.
Key words: aromatised oil, winter savoury, marjoram, hyssop, peroxide value.

Introduction

Vegetable oils are beneficial due to their nutritional value, content of fatty acids, and cholesterol lowering effect in blood. Variety of oil products could be expanded by flavouring oils with spices. Spices could enhance the flavour of oil and also work as antioxidants or prooxidants.

Comprehensive investigations are completed about spices from the family *Lamiaceae (Labiateae),* a family composed of species with exploitable antioxidant activity (Jayasinhe et al., 2003; Jose del Bano et al., 2003). Oils were flavoured with three spices from plant family *Lamiaceae L.* – winter savoury, marjoram, hyssop. *Satureja Montana* L., or winter savoury, is perennial. Essential oil of winter savoury includes the phenols carvacrol and thymol, as well as p-cymene, linalool, terpineol and various organic acids (Sefidkon et al., 2004). Marjoram is perennial, and contains 0.12–1.2% of essential oils. Major components of essential oil are thymol (up to 50%) and carvacrol (Indriksons E., 1992). Among the herbal or aromatic plants, the hyssop (Hyssopus officinalis L.) is a plant that has not been studied very much. According to some bibliography sources, the hyssop contains more than 1% of volatile oil with maximum content at the offset of flowering stage (Jankovsky et al., 2002). The oils of hyssop could be categorised depending upon their percentage composition of β-pinene, limonene, pinocamphone, and isopinocamphone. The oils were rich in isopinocamphone (5–50%), pinocamhone (3–50%) or contained beta-pinene and limonene (1–60%) as major components (Jankovsky et al., 2002).

There are two methods of oil flavouring – extraction of aromatic compounds with heating and without heating. Extraction without heating means that oil with spices is hold 5-6 weeks at temperature of 4 °C. The similar sensory properties oil obtains after 6 hours, if the spices in oil are heated (Žukauska I., 1997).

Fats and oils undergo pronounced oxidative changes during storage. It is necessary to detect oxidation processes in flavoured oil. The rate of oxidation process can be described by peroxide value, which characterises primary products of autoxidation, mainly hydroperoxides (Matiseks et al., 1998).

The aim of research was to determine dynamics of primary oxidation products in flavoured oils depending on used spice, its concentration (by mass) in oil, storage duration, and sample preparing method.

Materials and methods

The investigations were performed in the laboratory of the Department of Chemistry at the Faculty of Food Technology. Studies were carried out on unrefined (the fraction of phospholipids was separated) rapeseed oil, with initial peroxide value (POV) 1.73 mmol kg^{-1}. As a control was used unheated oil with POV 1.73 mmol kg^{-1} and heated oil with POV 4.22 mmol kg^{-1}.

The oil was flavoured with dried winter savoury *Satureja Montana* L., hyssop *Hyssopus officinalis* L., and marjoram *Oreganum vulgare* L. which were grown in test fields of the Department of Gardening, Faculty of Agriculture of Latvia University of Agriculture.

Flavoured rapeseed oil samples were made using two methods:

- Extraction of spices in oil, holding it for 5 weeks at temperature of 4 °C (extraction without heating), temperature was chosen the same as in home refrigerator. Unflavoured oil was used as control.
- Extraction of spices in oil, heating for 20 minutes at 80 °C, then holding at temperature of 4 °C (extraction with heating). Heated unflavoured oil was used as control.

Concentrations of spices in oil – 10 g kg^{-1} and 100 g kg^{-1}.

The degree of oxidation is described with the peroxide value. The peroxide value in flavoured and unflavoured rapeseed oil was determined by Wheeler method (Matiseks et al., 1998) after 24 hours, 2 and 5 weeks. The results in this work are the average of three measurements. Multiple analysis of variance was performed using SPSS 8.0 for Windows. Significant differences between means were determined by Tukey's test at a level of $p < 0.05$.
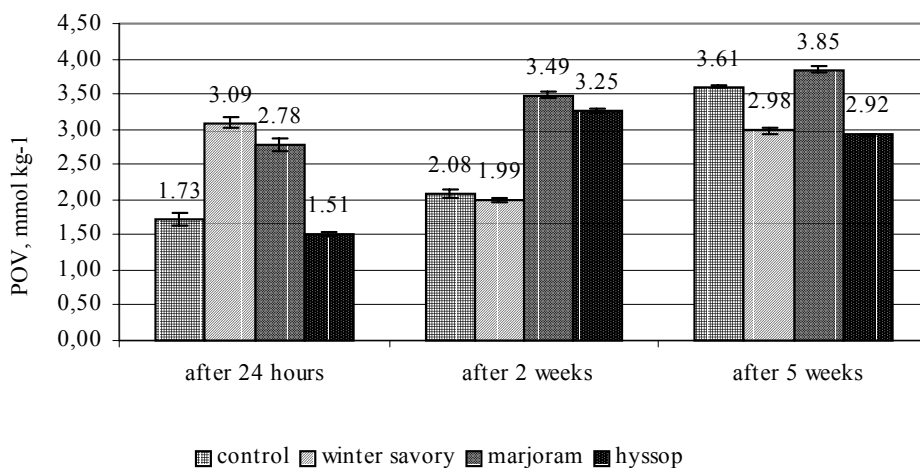
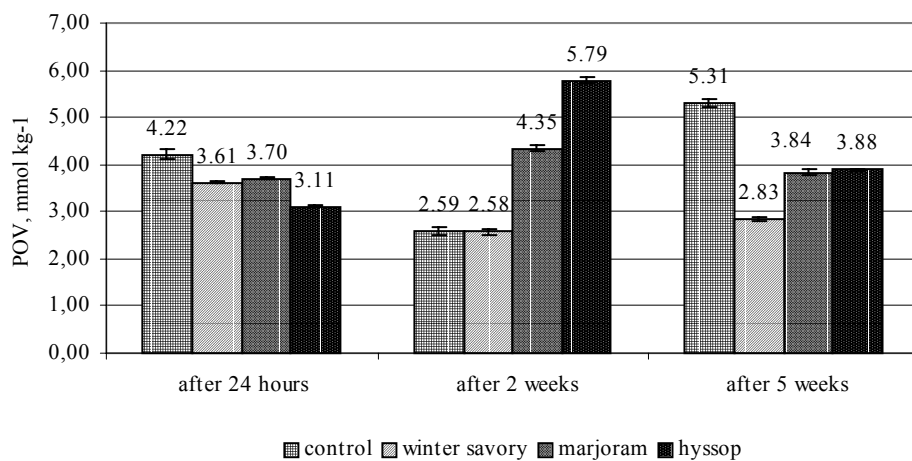Fig. 1. Changes in POV in oil (held at 4 °C) with 10 g kg⁻¹ of spices.

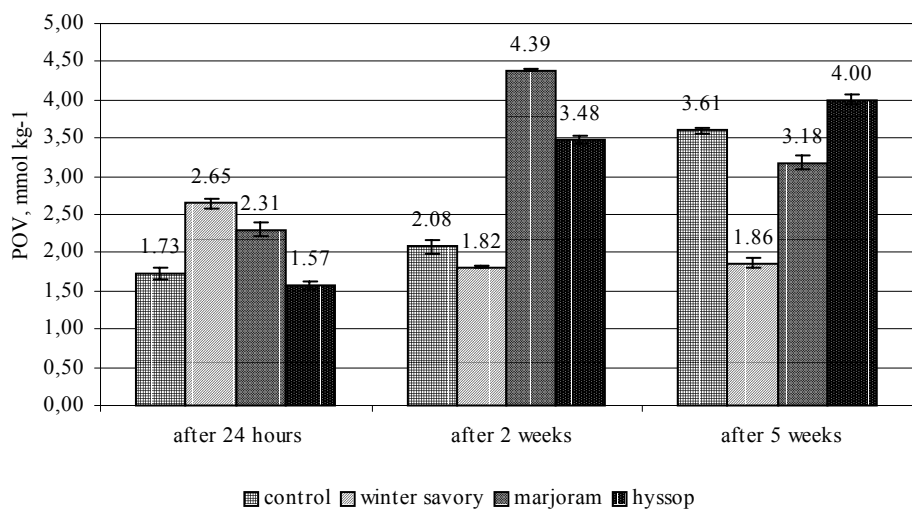Fig. 2. Changes in POV in heated (20 minutes at 80 °C) oil with 10 g kg⁻¹ of spices.

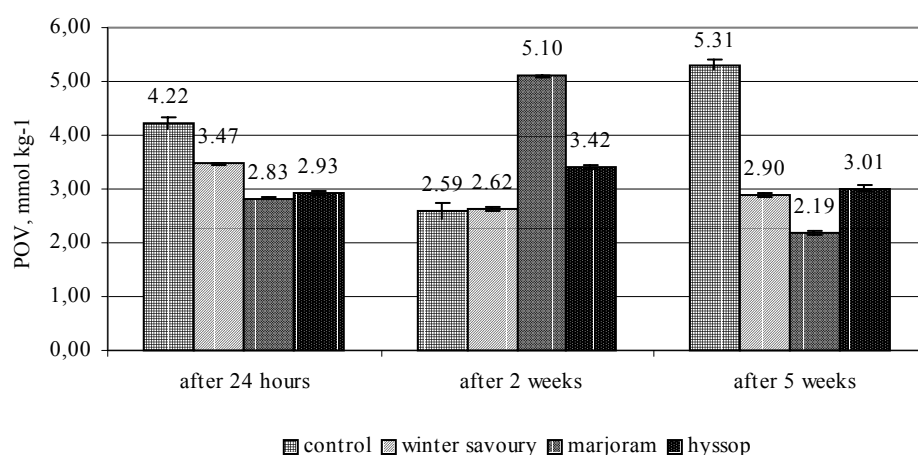Fig. 3. Changes in POV in oil (held at 4 °C) with 100 g kg⁻¹ of spices.

Fig. 4. Changes of POV in heated (20 minutes 80 °C) oil with 100 g kg^{-1} of spices.

Results and discussion

The results are presented in Figures 1–4.

Four factors and their interaction which could influence oxidation of flavoured oils was nominated: used spice, concentration of spices in oil, storage duration and sample preparing method. Results of multiple analysis of variation showed that all factors (method, spice, its concentration, storage duration) and their interaction had significant (p<0.05) influence on dynamics of peroxide value in flavoured oils.

Sample preparing method influenced changes in peroxide value in oil. In unflavoured heated oil after 24 hours, POV increased for 150%, and during all period of investigation it was higher than in unheated oil (Figs. 1 and 2).

After 24 hours in all flavoured oil samples which were obtained with heating, POV were increased for 17–106% compared with unheated oil. Increasing of POV depended on spice and its concentration in oil.

After 5 weeks it is possible to see interaction of three factors – method, spice, and concentration of spices in oil. Different tendencies of dynamics of POV between flavoured oils preparing by both methods were observed:

- Analyses of flavoured oil with 10 g kg^{-1} of winter savoury and with 10 g kg^{-1} of marjoram obtained by both methods showed that POV in these oils did not differ significantly depending on preparation (Figs. 1 and 2).
- In flavoured oils with 10 g kg^{-1} of hyssop and with 100 g kg^{-1} of winter savoury (Figs. 2 and 4), POV was higher in flavoured oils which was obtained with heating, compared with flavoured oils obtained without heating.
- Analysing oils with 100 g kg^{-1} of marjoram and with 100 g kg^{-1} of hyssop, POV was lower in flavoured oils obtained with heating, compared with oils obtained without heating.

The changes in peroxide value in all samples were significant. It is possible to state different trends of the changes in the amount of peroxides:

- During 5 weeks, the peroxide value increases (more or less equable), which could be explained by rapid formation of primary oxidation products (hydrogenperoxides). The rate of primary oxidation products formation is larger than the rate of secondary products. The following increase of peroxide value could be observed in unheated unflavoured oil with 10 g kg^{-1} of marjoram and 100 g kg^{-1} of hyssop (Fig.1 and 3).
- The peroxide value increases after 2 weeks, but decreases after 5 weeks. During the oxidation, peroxide value increases and then declines, because primary products of autoxidation are unstable and they break down to secondary products, forming ketons and aldehydes (Matiseks et al., 1998) The above described distribution could be observed in oils flavoured with marjoram and hyssop, exceptions are unheated oil with 10 g kg^{-1} of marjoram and 100 g kg^{-1} of hyssop.
- The peroxide value decreases after 2 weeks, but increases after 5 weeks. Such trend of distribution can be observed in heated unaromatised oil and in all oils flavoured with winter savoury. Obtained results are very hard to explain only with formation of primary oxidation products.

Dynamics of peroxide value in flavoured oil with winter savoury could be explained with properties of spice phenols. Recent experiments indicate that processing and storage conditions are expected to strongly affect the content and biological activity of phenol molecules (Pinelo et al., 2004). The antioxidant capacity of phenol-containing foods is expected to greatly change during processing as a function of the technological conditions adapted. Plant food contains numerous phenolic substances whose oxidation concomitantly occurs, potentially contributing to unexpected changes in antioxidant activity. Certainly, the ability of phenols to resist oxidative cleavage and polymerise, leading into improvement in the overall antioxidant activity of plant foods, is highly associated with their structure (Pinelo et al., 2004). The peculiar evaluation of the antioxidant activity during phenol oxidation has been attributed to the formation of partially polymerized phenols, which exhibit higher antioxidant activity than non-oxidised phenols or tannins formed in advanced steps of the reaction. In fact, it

is beyond a certain level of molecular complexity (more than four monomer residues), the antioxidant activity of poliphenols would decrease as a consequence of steric hindrance (Lu Y et al., 2000; Saint-Cricq de Gaulejac N.,1999). It could be explained that after 24 hours phenols can not work so efficiently, but during period until 2 weeks, phenols start to polymerise, and can attach peroxides. Polymerisation is in progress and capability of phenols to attach peroxides decreases.

Conclusions

1. Changes in peroxide value in flavoured oil were influenced by all investigated factors – used spice, its concentration, storage duration, and sample preparation method.

2. Multiple analysis of variance showed that interaction of investigated factors was significant therefore it is not possible to determine which factor dominates.

3. In particular cases flavouring caused unusual, hard explainable dynamics of peroxide value. It is very difficult to explain the processes in flavoured oils by investigating only dynamics of primary products of oxidation, therefore it is necessary to study the components of spices which move to oil and could promote or inhibit oxidation of flavoured oils.

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VETERINARY MEDICINE SCIENCES

IMMUNOGLOBULINS AND LACTOFERRIN CONCENTRATION IN MILK AND BACTERIA CAUSING SUBCLINICAL MASTITIS IN DAIRY COWS

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Abstract

Natural defence mechanisms of the mammary gland tissues play a vital role in protecting the gland from infections. The progress of mammary infection depends on the ability of bacterial pathogens to adapt to milk and udder tissues, and on the various virulence factors they activate, as well as on the cow's response. The levels of immunoglobulins (Ig) and lactoferrin (Lf) concentration in the milk from dairy cows with and without subclinical mastitis were determined. In this investigation it was stated that 82.5% of samples were negative, but 17.5% of samples were positive for pathogens. Cows had subclinical mastitis caused by *Coagulase negative* staphylococci observed in 48.60%, *Streptococcus uberis* – 32.10%, *Staphylococcus aureus* – 18.90% of cases in milk samples. There were no significant differences between all classes of immunoglobulins concentration in the milk without pathogens and with pathogens. The lactoferrin concentration was significantly increased for 40.33% in the milk with pathogens.
Key words: milk, somatic cell count, immunoglobulins, lactoferrin.

Introduction

The udder inflammation is one of most widespread diseases in dairy cows in Latvia. In total 6% of cows are affected with clinical mastitis, but with subclinical mastitis - up to 30% and more of all dairy cows [5]. The most important mastitis causing bacteria, isolated from investigated samples in the State Veterinary Medicine Diagnostic Center, Latvia were *Staphylococcus aureus* in 54% samples, *Streptococcus uberis* – 14%, *Esherichia coli* – 10%.

One of the means of decreasing the impact of mastitis on dairy industry is to increase the natural ability of the cow to resist infection. The immune system of the mammary gland consists of both humoral and cellular components. Immunoglobulins, which contain a specific antibody activity against antigenic stimuli, form the humoral component. The cellular component consists of several different cell groups, the most important of which are the macrophages and various lymphocyte subsets. These cell groups are called somatic cells. Somatic cell count is used for characterising mammary gland health status. The cell count of a healthy udder is about 100.000 cells ml^{-1} [4, 7, 10].

Immunoglobulins (Ig) function as the soluble effectors of specific or humoral immune response. Four classes of Ig are known to influence mammary gland defence against bacteria causing mastitis: IgG1, IgG2, IgA, and IgM.

Concentration of the Ig classes varies with stage of lactation and health of the gland. In cow's milk, the concentration (mg ml^{-1}) of IgA = 0.08, IgG1 = 0.58, IgG2 = 0.06, IgM = 0.09. In the inflamed lactating gland, the concentration of Ig increases 2–3 times [9, 12].

The other antibacterial factor of cow's mammary gland is lactoferrin. It is synthesized in polymorphonuclear leukocytes and udder epithelial cells.

In cows milk, lactoferrin is found at concentration of 0.02–0.35 mg ml^{-1}, depending on the time of lactation and mammary gland health status. Maximum lactoferrin concentration is about 20 mg ml^{-1} obtained after 3 to 4 weeks of parturition. In the cases of udder inflammation, the concentration of lactoferrin in milk can increase up to 100 times [4, 10].

The purpose of this study was to evaluate and compare immunoglobulins and lactoferrin concentration in normal milk and milk with bacterial pathogens.

Materials and Methods

Samples for investigations were taken from a dairy herd consisting of 75 Latvian Brown and Holstain cows at different lactation stages and in different lactation cycles. Cows were kept in an uninsulated shed and were milked two times a day. Average milk yield from a lactating cow was 21 liter per day.

A total of 16 cows were selected to represent all the herd. Samples were taken from each quarter 2 times during the shed keeping period and 2 times during the pasture period.

Mammary gland health status was detected by California Mastitis Test (CMT) and by clinical observation. If the CMT results were positive, bacteorological investigations were performed.

Normal and subclinical mastitis milk from 212 quarters was classified as follows: 175 quarter milk samples, which were CMT negative and negative for pathogens, were regarded as normal milk, i.e. milk without pathogens; 37 quarter milk samples, which were CMT positive and positive for different pathogens were grouped as bacteria causing mastitis milk.

The immunoglobulins and lactoferrin in milk were measured using radial immunodiffussion method in the laboratory of the Riga Reproduction Center.

Somatic Cell Count was detected by "Somocaunt" in the laboratory of Riga Dairy Plant.
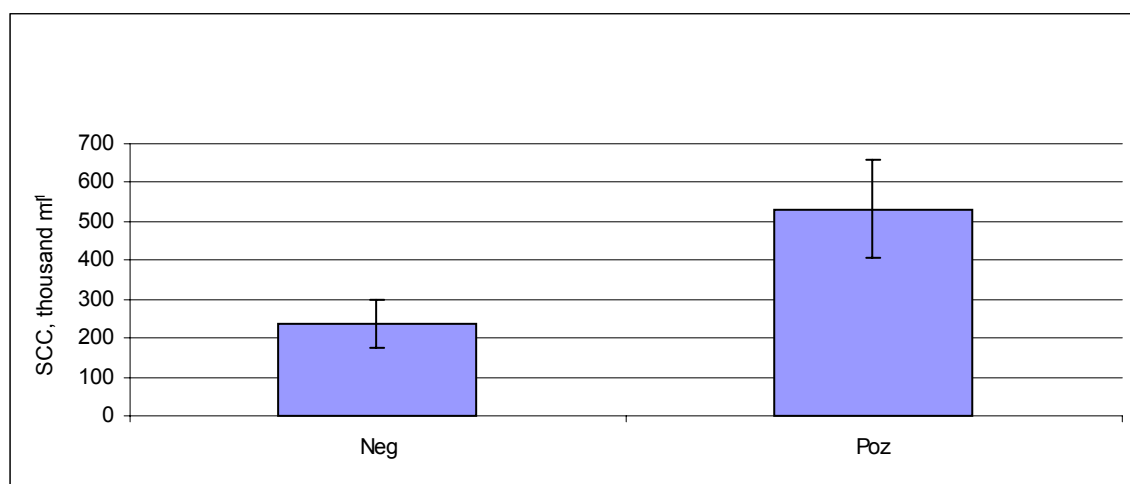
Fig. 1. Comparison of SCC in milk from cows with (Poz) and without (Neg) bacterial pathogens.

Results and Discussion

During the investigations no cases of clinical mastitis were detected. The average somatic cell count (SCC) in the dairy herd was about 355 thousand cells ml^{-1}. The investigation gives evidence that 82.5% of cows mammary gland health status without pathogens was rather good – SCC was 236 ± 278.1 thousand cells ml^{-1}, 17.5% of cows had subclinical mastitis with bacteria presence in the mammary gland and increased SCC – up to 532 ± 120.6 thousand cells ml^{-1} (Figure 1).

The difference between average SCC in milk samples without pathogens and with pathogens was significant (P<0.001).

The most common pathogen in the mammary gland, isolated from infected quarters, was *Coagulase negative staphylococci* found in 48.60% of cases (SCC was increased up to 625 ± 159.3 thousand cells ml^{-1}), *Streptococcus uberis* infection was found in 18.90%, (SCC was increased up to 656 ± 93.0 thousand cells ml^{-1}), and *Staphylococcus aureus* was found in 32.10% of cases (SCC was increased up to 410 ± 110.9 thousand cells ml^{-1}) (Table 1).

It is well reported by different authors that in the case of mammary gland inflammation, somatic cell count in the mammary gland and milk increases significantly [2, 3, 4, 11].

The concentration of each Ig **class** in mammary secretion varies depending on the stage of lactation and infection status of the mammary gland. In healthy glands, the concentration of Ig is low during lactation but increases during inflammation. The inflammatory process reflects the mammary gland immunological response against the invading pathogens [10].

There are different conflicting results of studies about correlation between Ig classes in healthy glands and pathogen affected glands, but this data were based only on milk from acutely infected glands, not for subclinical mastitis, which was the subject of this study.

Comparing Ig concentrations in the milk negative for pathogens and milk positive for pathogens, the following results were obtained (Figure 2). In milk samples without pathogens, **IgG concentration** was 2.12 ng ml^{-1}, and with pathogens – 2.18 ng ml^{-1}. The increase of IgG was not significant – 2.75% (p>0.05).

A.Saran, G.Leitner (2000) and G.Leitner, B.Yadlin (2000) reported that no significant differences in IgG were found among the quarters of the same cow, whether the quarter was infected or not [11, 6]. However, D.L. Watson (1980) reported that specific immunological protection of mammary tissue may be mediated through blood-derived antibody (particularly IgG) and locally synthesized antibody (particularly IgA) or phagocytic cells. This cytophilic antibody (IgG and IgA) can play an important role in enhancing the phagocytic capacity of neutrophils in the mammary gland [13]. Investigations of M.B. Barrio, P.Rainard et al. (2003) suggested that IgG is not opsonic for bovine immune cells

Table 1

Summary of pathogens isolated from cow's quarter milk

Pathogens	Number of samples	% of cases	Average SCC, thousand cells ml^{-1}
Coagulase negative staphylococci	18	48.60	625 ± 159.3
Staphylococcus aureus	7	32.10	410 ± 110.9
Streptococcus uberis	12	18.90	656 ± 93.0
Total	37	100%	532 ± 120.6
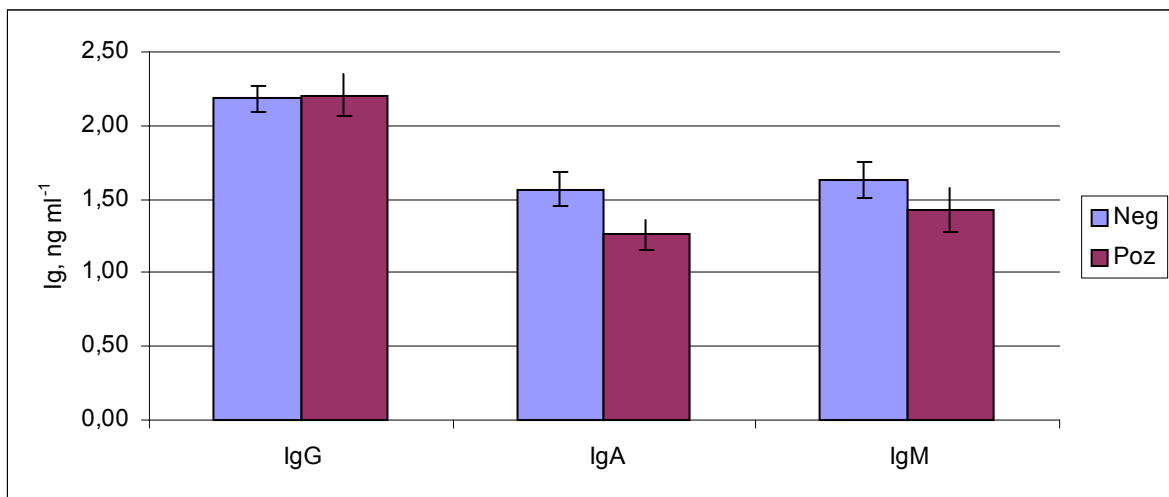
Fig. 2. Comparison of Ig concentrations in milk from cows with and without bacterial pathogens.

except IgG2, and actually milk is relatively low in immunoglobulin compared with sera and other body fluids [1].

In milk without pathogens, **IgA concentration** was 1.57 ng ml^{-1}, and in milk samples with pathogens – 1.26 ng ml^{-1}; the decrease of IgA was not significant – 17.74% (p>0.05).

The results of D.P. Mackie and E.F. Logan (1986) indicated that the IgA and IgM antibodies increase in infected quarter milk during the acute stages of inflammation [9]. M.Sandholm et al. (1995) reported that activity of IgA in mammary gland decreases due to fat globules, and suggested that mostly the production of IgA antibodies is local while IgG evolves the systemic immune system. It is known that IgA is not a good opsonion for phagocytosis and therefore has no significance in bacterial elimination [10].

In milk samples without pathogens, **IgM concentration** was 1.43 ng ml^{-1}, and in samples with pathogens – 1.69 ng ml^{-1}; the decrease of IgM was not significant - 15.38% (p>0.05).

Experiments from M.B. Barrio et al. (2003) indicated

that IgA, like IgG1 and unlike IgM or IgG2, can not be considered as a major opsonion for phagocytosis [1].

In the investigated dairy heard, the changes in all classes of Ig concentration in milk with bacterial pathogens and without them were not significant (Figure 2). It could be due to the lack of acute infected glands. We suggest it is the reason why IgG and IgM did not transfer from blood to udder and milk, and IgA production did not increase in mammary gland tissue.

M.R. Williams and R.Halliday (1980) reported that in antibody production there is a balance between quality and quantity; cows with normally high serum immunoglobulin concentrations generally produce more antibody in response to challenge but this increase only compensates for the relatively lower avidity of their antibody for the antigen [14].

Comparison of Lf concentrations in negative for pathogen and positive for pathogen milk is given in Figure 3.

Lf concentration in samples without pathogens

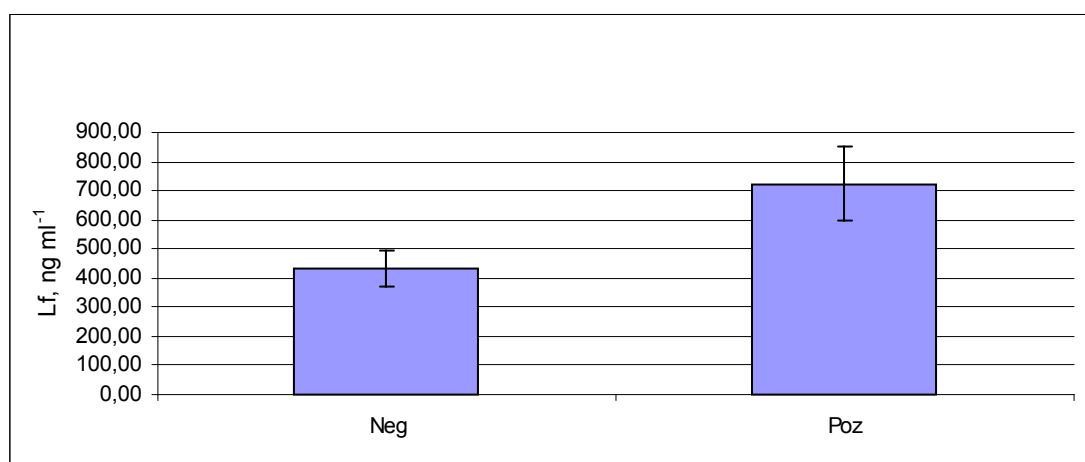

Fig. 3. Comparison of Lf concentrations in milk from cows with and without bacterial pathogens.

was 432 ng ml^{-1}, and in the pathogen causing subclinical mastitis samples – 724 ng ml^{-1}. The changes in Lf concentrations in milk without pathogens and with pathogens was significant – 40.33% (p<0.05). The same results are reported by other authors [2, 4, 8, 10, 11].

Traditionally, Lf has been considered one of the non-specific antibacterial factors in bovine milk. The Lf mediated antibacterial effect is due to its sequestration of iron from the environment where the bacteria reside so that the bacteria are deprived of iron for their growth. However, streptococci, including *S. uberis*, are more resistant to the antibacterial effects of Lf than Gram-negative bacteria, probably because of their low requirement for iron [13].

Results of this investigation show that major role for protection of mammary gland from being infected is played by the cellular immunity and antibacterial factor – Lactoferrin.

Conclusions

1. In the investigated dairy herd, 17.5% of cases were subclinical mastitis caused by C*oagulase negative staphylococci* (48.6%), *Streptococcus uberis* (32.10%) *and Staphylococcus aureus* (18.90%).

2. The sommatic cell count was significantly increased (55.55%) in milk with the presence of pathogens (p<0.001).

3. There were no significant changes in all classes of immunoglobulin concentrations in milk without pathogens and with pathogens.

4. The lactoferrin concentration was significantly increased (40.33%) in milk with pathogens (p<0.05).

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FOREST SCIENCES

THE CHARACTERISTIC OF BIRCH NATURAL WOODLAND HABITATS IN LATVIA

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Abstract

The role of birch natural (NWH) and potential natural (PNWH) woodland habitats for maintaining of biodiversity in Latvia is described and evaluated. The analysis of the proportion of area of birch stands and natural and potential natural woodland habitats by regions, by age structure, and by growing conditions has been done. The distribution of birch natural and potential natural woodland habitats by habitat groups, as well as most often recognized habitat specialists and indicator species is described.
Key words: birch, natural and potential natural woodland habitats.

Introduction

Natural woodlands, which once covered practically all the territory of Latvia, now are changing and at the same time are maintaining the history of thousands of years' long interaction between nature and civilization. A lot of structures, processes and species have disappeared nevertheless many of them still remain. A considerable diversity of plants and animals is found in Latvia, and the ecological values of forests are acknowledged not only on national but also on an international scale. Because of increasing intensity of forest multiple use, more and more attention is being paid to maintaining of forests and its biodiversity values. Latvia also has threat of disappearing of typical for particular region natural woodlands, and the number of plant and animal species depending on them has decreased. For maintaining biological values in forests, certain territories are excluded or have restricted forest management. The fundamental process in recognizing the biodiversity in Latvia is the inventory of natural woodland habitats (woodland key habitats) in state forests, which was carried out from 1997 to 2002 (Bērmanis, Ek, 2003). Recently discussions about the forest management impact on nature values in forests as well as the changes of biodiversity in intensively managed forests have taken place. The viewpoints are conflicting, which proves the lack of understanding of biodiversity and its processes as well as lack of data and analysis of the current situation.

The birch, a tree of the northern hemisphere, as well as Scotch pine is the oldest tree in the territory of Latvia in the postglacial period. The birch stands in Latvia are formed by two species *Betula pendula* Roth. (sin. *B.verrucosa* Ehrh.*)* and *Betula pubescen*s Ehrh. The birch stands are widespread in unmixed and mixed forests, in bogs and mires and in abandoned agricultural lands. They occupy ~ 28.4% of the forests in Latvia. In the temperate climate zone, a birch is universal pioneer species, which spreads in any site (Strods et al., 1999**).** Rapid development, abundant seed production, ability to occupy vacant dry and wet sites is characteristics of light-demanding birch. Such features reflect the biology of species creating the stages of prema-

ture and variable vegetation and make room in the further development for other – more demanding species. *Betula pendula* grows only in soils rich in nutrients, forming small birch stands/groups in a cultural landscape. *Betula pubescen*s forms prime plant societies in wet forests, in soils medium rich in nutrients or poor soils (Lange et al., 1978; Priedītis, 1999). Latvia is located in the transition zone of northern coniferous and southern deciduous forests combining their qualities. During successions in northern forests, the structure of forest tree species is changing. The mature coniferous forests replace the birch forests characteristic of initial stages in the forests. Natural forests provide a great diversity of ecological niches due to gradual continuous changes. Consequently, the natural forests are the mosaic of different habitats where the size and shape of each fragment are affected by such factors as qualities of soil, relief, microclimate, and local history of fire and storm impact (Hallanaro et al., 2001). The natural conditions of widespread wet forests are prescribed by the location of Latvia in the lowland (predominate 40–200 m over the sea level) and the features of water flows (inter alia a lot of underground waters). The migration of species characteristic of deciduous forest goes in two main directions – by coastal and valleys of rivers (Priedītis, 1999).

The biological age of birch is reached in just 150 years. Though overgrown birch stands and structural elements there are such elements as snags and decaying trees that exist as habitats for many lichens, mosses, polypores, insects as well as birds and mammals (Ek et al., 2001). Rare and protected species are connected with birch (Lārmanis, 1999; Padomi meža saimniekam, 2000; Kabucis, 2000).

The aim of the research work is to describe and evaluate the role of birch natural and potential natural woodland habitats in maintaining the biodiversity in Latvia.

Methods

"The methodology of inventory of woodland key habitats" is used in the inventory of birch natural and potential natural woodland habitats (Lārmanis et al., 2000; Ek et al., 2001).

The natural woodland habitat (further NWH) is a habitat where the habitat specialists are found or at present possible and which disappear in economically managed forests. The potential natural woodland habitat (further PNWH) is a habitat, which is managed by maintaining biodiversity for example in birch stands in the span of 10 years could become the NWH.

The criteria of natural woodland habitats are:

- tree species, their age and stand structure (dominant species – birch, age – from 81 years, the proportion in stand - 50%). The registers of forest stands to fulfill the criterion are obtained from database " Meža fonds" ("Forest Fund");
- indicator species (further IS – ecological specialized species with high demands of environment and their presence indicates specific features in forest);
- habitat specialists (further HS – species, whose existence depends on a definite habitat and which will disappear in the case of unsuitable management of habitats);
- structural elements (structures in forests important for species, for example, old trees, snags, decaying trees).

The analysis of birch stands is carried out using the forest statistics of the State Forest Service. The selection of birch NWH and PNWH in the territory of Latvia is carried out using a database VATSLBIO containing the information of each NWH and PNWH – figures of inventory, the history of stand management, found IS and HS, structure elements, and appropriate activities for maintaining biodiversity are noted there.

Microsoft Excel is used for computerized data processing and the illustration of results.

Results

The proportion of birch NWH and PNWH areas

The total area of birch stands (birch as the dominant species) in Latvia is 573338.1 ha. The biggest areas of birch stands are in the following regions: Liepāja (53691.8 ha or 9.4% of the total area of birch stands), Limbaži (51223.1 ha or 8.9%), Madona (49972.0 ha or 8.7%), Aizkraukle (45344.3 ha or 7.9%), Jēkabpils (44882.8 ha or 7.8%), and Cēsis region (41029.1 ha or 7.1%). The birch natural woodland habitats make up 23.5% of the total area of all recognized NWH and PNWH in Latvia (the total area of NWH and PNWH is 48848.0 ha, but of birch NWH and PNWH is 11463.9 ha: accordingly NWH – 8739.8 ha un PNWH – 2724.1 ha). The biggest proportion of birch NWH and PNWH area is in Gulbene (2.7%), Daugavpils (2.5%), Dobele (1.9%), Jelgava (1.8%), and Ogre regions (1.5%) (Figure 1). The proportion of birch NWH and PNWH area to birch stands in Latvia is 20%.

The proportion of birch NWH and PNWH age structure

The areas of birch stands dominate at the age of 31–80 years, but the biggest areas are at the age of 51–60 years (189408.3 ha). The area of birch stands decreases after 81 years, which is explained by active logging.

The birch NWH and PNWH is dominant at the age of 81–100 years (5451.1 ha). Though appearance of birch NWH and PNWH areas are at the age of up to 10 years (147.5 ha),
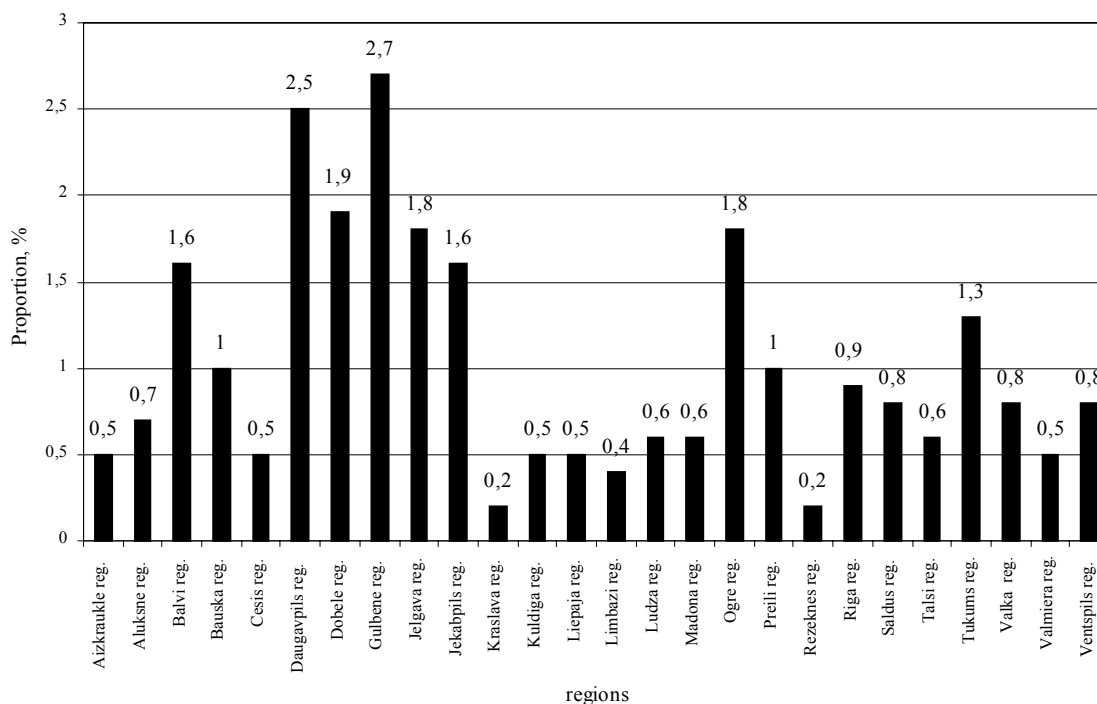
Fig. 1. The proportion of birch NWH/ PNWH areas in regions of Latvia.
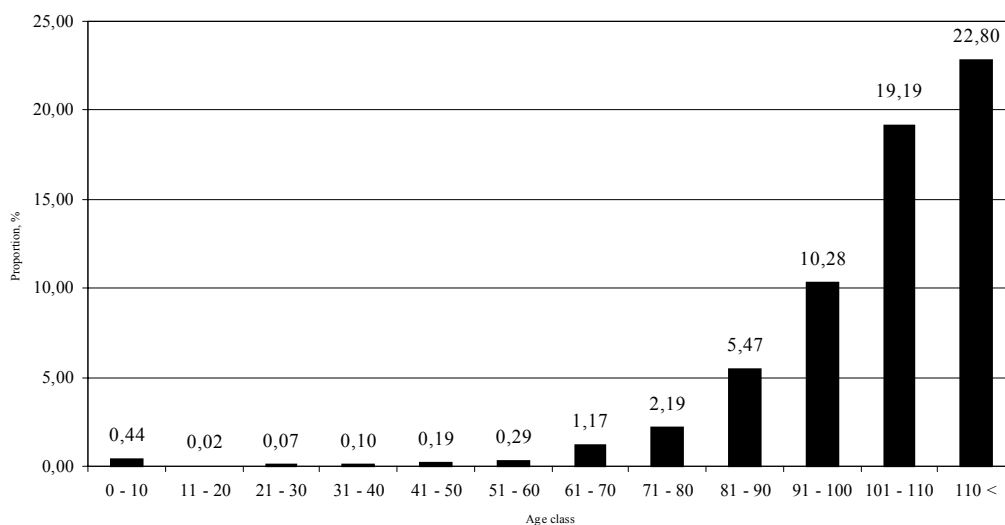
Fig. 2. The proportion of birch NWH/ PNWH age structure.

which is explained by the presence of old trees in young forest stands, important for biodiversity – the existence of IS and HS. The proportion of birch NWH and PNWH areas rapidly increases at the age of 81–110 years, and reaches 22.8% in a hundred year old and older stands (Figure 2). The increasing trend of proportions in old stands shows that the most important stands for maintaining biodiversity are from age 100 years and older.

The proportion of birch NWH and PNWH forest growing conditions

The birch stands are found in all types of forest growing conditions. The biggest proportion of birch stands distribution by edaphic rows (Figure 3) is in dry forests 41.0%, then follows swamp forests (18.0%) and forests on drained peat soils (15.3%). Moist forests and forests on drained mineral soils take up similar areas (accordingly 13.2% and 12.5%).

The birch stands take up small places disturbed by environmental and anthropogenic factors in long-lasting forests – very typical for today's landscape of Latvia especially in agricultural regions. The birch stands in wet soils form long-lasting forests. The birch stands in the richest types of forest conditions – Oxalidosa, Hylocomiosa and Aegopodiosa – have the best quality. The birch stands dominate in Oxalidosa (172295.7 ha or 30.1% of the total area of birch stands), Hylocomiosa (131151.4 ha or 22.9%), Caricoso-phragmitosa (74907.4 ha or 13.1%), Dryopterioso-caricosa (66399.2 ha or 11.6%), and Oxalidosa turf.mel. (60737.7 ha or 10.6%).

Also the birch NWH and PNWH are found in all types of forest conditions. The biggest proportion of the birch NWH and PNWH is in Dryopteriosa (5.01%), Aegopodiosa (4.75%), Filipendulosa (4.07%), Callunoso-sphagnosa (3.53%), and Dryopterioso-caricosa (3.11%) (Figure 4), which
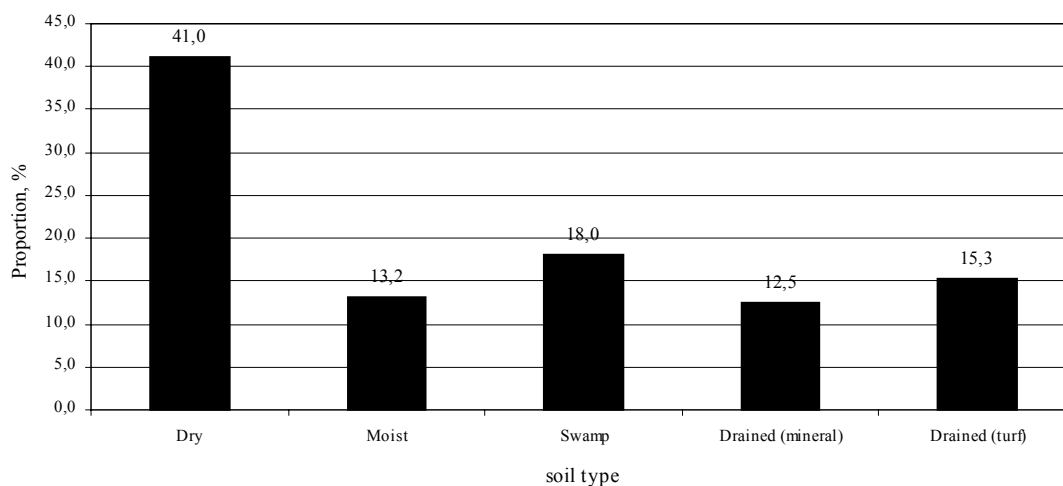
Fig. 3. The distribution of birch stands by edaphic rows.
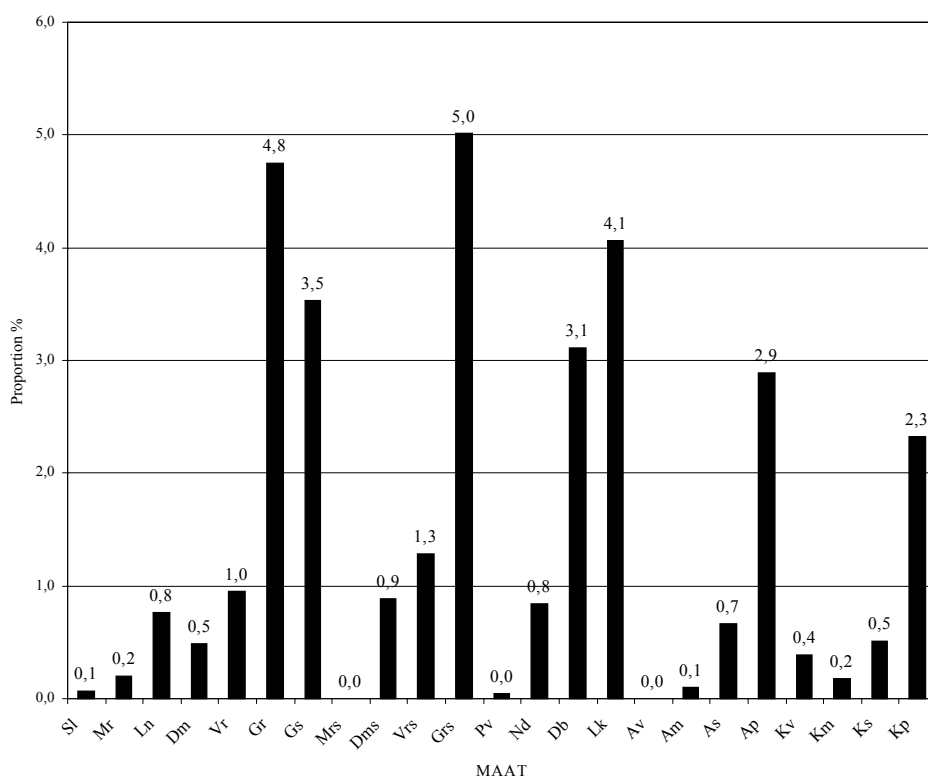
Fig. 4. The proportion of birch NWH/PNWH by types of forest conditions (MAAT:
Sl. – Cladinoso-callunosa; Mr – Vacciniosa; Ln – Myrtillosa; Dm – Hylocomiosa; Vr – Oxalidosa; Gr – Aegopodiosa; Gs – Callunoso-
sphagnosa; Mrs – Vaccinioso-sphagnosa; Dms – Myrtilloso-sphagnosa; Vrs – Myrtilloso-polytrichosa; Grs – Dryopteriosa;
Pv – Sphagnosa; Nd – Caricoso-phragmitosa; Db – Dryopterioso- phragmitosa; Lk – Filipendulosa; Av – Callunosa mel.;
Am – Vacciniosa mel.; As – Myrtillosa mel.; Ap – Mercuraliosa mel.; Kv – Callunosa turf. mel.; Km – Vacciniosa turf. mel.;
Vs – Myrtillosa turf. mel.; Kp – Oxalidosa turf. mel.).
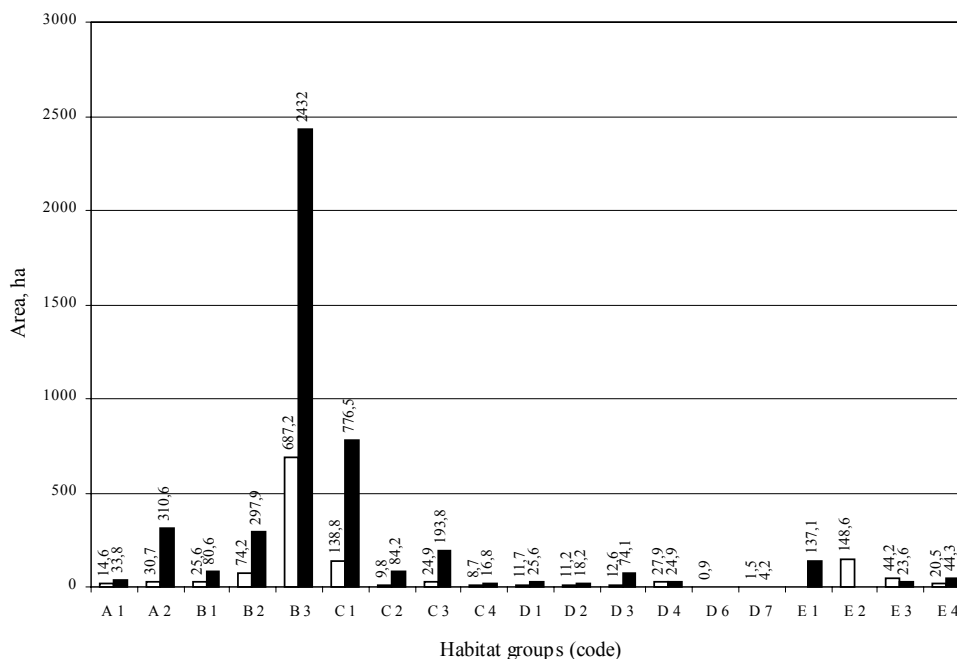
Fig. 5. The distribution of birch NWH and PNWH by habitat groups (habitat groups:
A1– coniferous forest; A2 – mixed coniferous-deciduous forest; B1 – broad-leaved forest; B2 – aspen forest; B3 – other deciduous
forest; C1 – wet black alder forest; C2 – wet spruce forest; C3 – wet pine and birch forest; C4 – wet broad-leaved forest; D1 – ravine
forest; D2 – slope forest; D3 – riparian forest; D4 – spring forest; D6 – calcareous fen or meadow; D7 – bog-forest mosaic;
E1 – fire-scarred forest; E2 – biologically valuable places for beavers; E3 – single giant tree; E4 – wind-fallen forest).

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is explained by the lack of economical management of wet forests. The important areas of birch NWH and PNWH in such types of forest conditions as Mercuraliosa mel. and Oxalidosa turf.mel. show the significance of birch in maintaining the biodiversity in anthropogenic reformed forest ecosystems.

The distribution of the birch NWH and PNWH areas by habitat groups

The birch NWH and PNWH areas are found in several habitat groups (Figure 5):

- other deciduous forest (habitat code B3; 5691.1 ha or 49.6% of the total area of birch habitats) – natural stands regenerated by pioneer species of deciduous trees in places of former deciduous or mixed coniferous–deciduous forests, harvested in the initial period of intensive forestry;
- wet black alder forest (habitat code C1; 2332.9 ha or 20.3%) – naturally regenerated stands, medium rich in species on wet peat soils, black alder and both birch species are in the tree storey;
- mixed coniferous–deciduous forest (habitat code A2; 691.4 ha or 6.0%) – naturally restored coniferous stands, where deciduous trees take up 20–50% of the wood volume;
- aspen forest (habitat code – B2; 596.4 ha or 5.2%) - naturally regenerated stands, followed by the succession of deciduous trees after natural or anthropogenic disturbances and the wood volume of aspen takes up at least 50%;
- wet pine and birch forest (habitat code C3; 559.0 ha or 4.9%),
- biologically valuable places for beavers (habitat code E2; 405.6 ha or 4.6%).

The distribution of birch NWH and PNWH in other habitat groups is more uniform – their areas range from 0.9 to 161.7 ha.

The indicator species and habitat specialists in the birch NWH and PNWH

The following species are most often found in birch natural woodland habitats: lichens *Graphis scripta* (4137.1 ha or 18.4% of birch NWH un PNWH area), *Lecanactis abietina* (1970.9 ha or 8.8%), *Lobaria pulmanaria* (1419.8 ha or 6.3%); mosses *Homalia trichomanoides* (4842.3 ha or 21.6%), *Jamesoniella autumnalis* (1332.0 ha or 5.9%), and *Neckera complanata* (1290.5 ha or 5.7%). The habitat specialists – *Cerychus chysomelinus* living in wet decays and *Saperda perforata* living in older birch trees – are most often species of insects in birch NWH and PNWH. The indicator species *Peltis grossa* lives in snags and decays, and *Necydalis*

major lives in hard dead wood (Ek, 2001; Plīse, Bičevskis, 2001).

The diversity and occurrence of indicator species and habitat specialists related to different tree species in the birch NWH and PNWH are the result of a mixed structure of forests.

Conclusions

1. The total area of birch stands in Latvia is 573338.1 ha; the biggest areas of birch stands are in following regions: Liepāja (9.4% of total area), Limbaži (8.9%), Madona (8.7%), Aizkraukle (7.9%), Jēkabpils (7.8%), and Cēsis region (7.1%). The biggest proportion of birch NWH and PNWH area is in Gulbene (2.7%), Daugavpils (2.5%), Dobele (1.9%), Jelgava (1.8%), and Ogre regions (1.5%). The proportion of birch NWH and PNWH area to birch stands in Latvia is 20%.

2. The distribution of birch stands by age structure is irregular and shows that birch stands are much more restored than harvested. The birch NWH and PNWH dominate at the age of 81–100 years though birch NWH and PNWH areas are at the age up to 10 years, which is explained by the presence of old trees in young forest stands, important for biodiversity – the existence of IS and HS. The analysis of birch NWH and PNWH proportion shows that the most important birch stands for maintaining the biodiversity are from the age of 100 years and older.

3. The birch stands are in all types of forest growing conditions: the biggest proportion of birch stands is in dry forests (41.0%). The biggest proportion of the birch NWH and PNWH is in Dryopteriosa (5.01%), Aegopodiosa (4.75%), Filipendulosa (4.07%), Callunoso-sphagnosa (3.53%), and Dryopterioso-caricosa (3.11%), which is explained by the lack of economical management of wet forests. The important areas of birch NWH and PNWH in such types of forest conditions as Mercuraliosa mel. and Oxalidosa turf.mel. show the significance of birch in maintaining the biodiversity in the anthropogenic reformed forest ecosystems.

4. The birch NWH and PNWH areas dominate in the following habitat groups: other deciduous forest (5691.1 ha or 49.6%), wet black alder forest (2332.9 ha or 20.3%), mixed coniferous–deciduous forest (691.4 ha or 6.0%), aspen forest (596.4 ha or 5.2%), wet pine and birch forest (559.0 ha or 4.9%), and biologically valuable places for beavers (405.6 ha or 4.6%).

5. The occurrence of indicator species and habitat specialists in the birch NWH and PNWH is related to birch and other tree species as well as different structural elements located in the area.

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DISTINGUISHING BETWEEN THE EFFECT OF SEED MATERIAL AND FOREST TYPE ON SCOTS PINE STAND PRODUCTIVITY

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Abstract

Due to large diversity of site conditions suitable for Scots pine growth in Latvia, it is important to evaluate their influence on growth and survival of particular Scots pine families. To do so, open pollinated progenies from phenotypically selected plus trees of 35 at the age of 32 years have been evaluated in 2 forest types (*Cladinoso-callunosa* and *Hylocomyosa*).

Investigation revealed that forest type and family influence had a great significance to height, diameter at breast height, and diameter of thickest branch up to 2 meters' height ($\alpha < 0.001$). Forest type had highly significant influence on tree survival ($\alpha < 0.001$), but clone influence had lower significance ($\alpha = 0.008$). Proportion of influence to height growth caused by tree family was 70% at the age of 6 years and 17% at the age of 32 years. Proportion of influence on survival caused by tree family was 57% and 44% respectively. The corresponding influence of forest type was 12% and 28% to height, 15% and 39% to survival. Diameter at breast height at the age of 32 years was equally influenced by forest type and family (~11%).

Equal breeding effect – but not with the same families – can be reached both in fertile and poor soils. In group (20%) selection this effect was ~8% for height, 11% for diameter, and 30% for survival; in individual selection ~10% for height, and ~17% for diameter.
Key words: scots pine, family x environment interaction, growth, survival, breeding effect.

Introduction

Numerous trials have been made to evaluate Scots pine performance in different ecological conditions both in international arena (provenance trials – reviewed by Giertych, 1991) and countrywide (e.g. Sabor, 1994; Baumanis et al., 2001). In these trials, pine provenances with site specific and general adaptability have been found (Shutyaev, Giertych, 1997). Most of these trials evaluate both site quality (forest type) and climate influence on Scots pine performance. In some cases, equal site type is used to evaluate only climatic influence (e.g., Ståhl, 1988; Jansons, Baumanis, 2005,). However, there are only several trials that evaluate separately soil effect on growth and survival of Scots pine (Pedersen, 1994; Pliūra, Gabrilavičius, 1994).

In Latvia, totally 23 forest types are distinguished. Those types differ in soil richness, structure and humidity, and the differences are indicated by dominate ground vegetation plant community. Pine is considered as optimal dominant tree species in 15 forest types and is planted in 10 (Bušs, 1976). That's why in Latvian conditions it is important to evaluate influence of site conditions on survival and growth of Scots pine families.

Already in 1973 it was clarified that Norway spruce families have different height ranks in different forest types, but there is still lack of such evaluation for Scots pine.

Average performance of particular tree species in one or another site conditions is well known. If a lot of trees are planted, in thinnings made during rotation period the best growing trees (the most appropriate for particular site type) are selected and they make the final stand. The same thing happens during natural stand thinning. However, the trend is to plant less and less trees per ha in order to decrease costs (Bušs, 1971; Mangalis, 2004). At the same time, stand productivity should be maintained or even increased. It is possible only with seed material selected via breeding process. However, tree breeding requires long-term investments.

In order to secure payback, it is important to know performance of a particular family in a particular forest type. It means evaluation – is there some general trend and/or differences, and do the same families perform best in all site conditions or not. Partially it can answer also in which forest type the Scots pine breeding trials should be allocated.

Estimation of possible breeding benefits (in individual or group selection) in different forest types can give answer – is it meaningful to allocate breeding efforts to all forest types or only to rich (poor) ones.

Since the tree family material comes from all largest pine regions in Latvia, it is suitable to assess the following: is there a general trend that pine families from one region grow better in one or another forest type.

The trees used in the trial have reached age of 32 years (1/3 of Scots pine rotation period in Latvia) and can give credible answers to the issues mentioned above.

Methods

To establish the experiment in Kalsnava, open pollinated progenies from phenotypically selected plus-trees from all largest pine regions in Latvia were used (Fig. 1). The planting site was chosen with a most continental climate in Latvia: frost-free period – 130 days, snow cover – ~120 days, sum of active temperatures – (>10 °C) 1900 degree days, precipitation on average 450 mm/year (Kļaviņš et al, 1992).

The experiment was established in spring, 1972, with 2 years old containerized seedlings in two different forest types – *Cladinoso-callunosa* and *Hylocomyosa*. According to Latvian forest typology (Bušs, 1976) *Cladinoso-*

callunosa (further in text Sl) is a forest type growing on poor, sandy soils with maximum pine full density stand yield at age 100 years 284 m³ ha⁻¹. *Hylocomyosa* (further in text Dm) is a forest type on average rich sandy-clay soils with normal humidity and maximum pine full density stand yield at age 100 years 538 m³ ha⁻¹.

The experiment design – randomized blocks, 4 replicates in each forest type, in total 60 plants from each family in each forest type. Size of parcel – 15 trees (5 trees in 3 rows), distance between rows 2m, distance between trees 1 m (i.e. initial spacing 5000 trees ha⁻¹).

At age 6 years, tree survival and height had been measured. Height assessments had been made also for age 3, 4 and 5 years (according to the height of corresponding whorl).

At age 32 years, tree height, diameter at breast height (1.3 m) (further in text – diameter) and diameter of the thickest branch up to 2 meters height had been measured for each living tree.

For calculations, only dominant trees (20% of the highest from initially planted trees, i.e. 12 trees from each family in each forest type) were used. It corresponded approximately with the density recommended as optimal in a particular age in pine stand (1000 trees ha⁻¹) (Anonymous, 2000). For calculations SPSS (Table 1) and Microsoft Excel (all other cases) computer programs were used. Deta were processed with ANOVA and Turkey's test. The proportion of influence was calculated according to method described by Liepa (1974):

$$\eta_A = (SS_A / SS_{Total}^{-1}) \times 100, \qquad (1)$$

where

η_A – proportion of influence of factor A, %;
SS_A – sum of squares for factor A;
SS_{Total} – total sum of squares.

Factor having the strongest influence to measured trait had the highest η.

Results

Stand structure in both forest types

The actual situation in both forest types (Sl and Dm) is presented in Figure 2. In more fertile soils, total number of trees is lower (766 in Dm contrary to 1236 in Sl). Most of the trees in fertile soils are taller (height 16–17m in Dm compared to 13–14 m in Sl) and thicker (10–20 cm in Dm compared to 6–16 in Sl; data not shown). However, the differences in diameter distribution are not so visible. The average diameter of all live trees at age 32 years in Sl is 11.7 cm, average height – 12.7 m. In Dm, the corresponding numbers are 14.8 cm and 15.5 m. In Sl and Dm all trees are within 16 m interval of height and 23 cm interval of diameter.

The distribution of trees in different diameter and height classes is in accordance with well-known trend – most of the trees in plot are close to the value of arithmetical average (Eitigen, 1951). If initial spacing is the same, trees in fertile soils close their crowns earlier because of faster growth (Bērziņš, 1974). Therefore, the competition among them starts earlier and the natural mortality is higher (Nesterov, 1954). Eitigen (1951) concluded that natural mortality caused by competition for Scots pine is the highest between age 15 and 30 years. In the end of this period, in poor soils there can be almost twice as much trees as in fertile soils – it is in accordance with presented data. The some trend has been observed in Latvia also previously (Sarma, Princis, 1947, Bušs, 1971).

It is well known that in better soils trees are growing faster (Sarma, Princis, 1947) because of the resources available. But recently (Vanninen, 2004) it has been concluded that increased competition (as it is in fertile soils) increase tree growth allocation to stem.
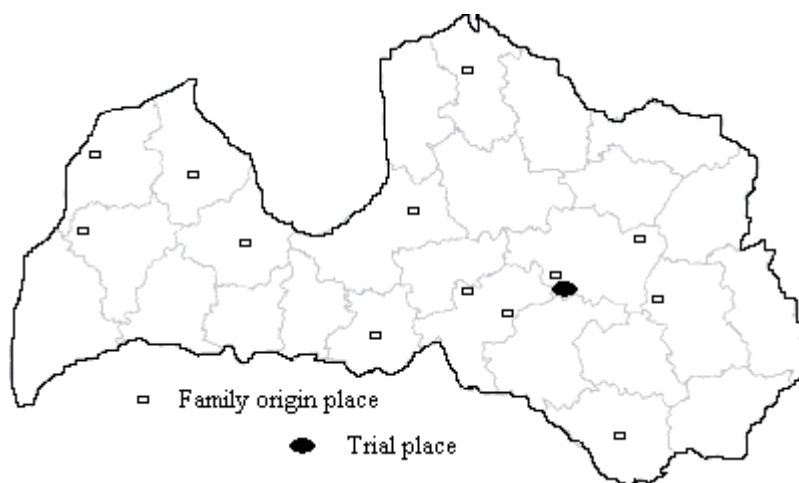
Fig. 1. Distribution of places from where plus tree families originated and trial place (Kalsnava). Figure drawn by author.
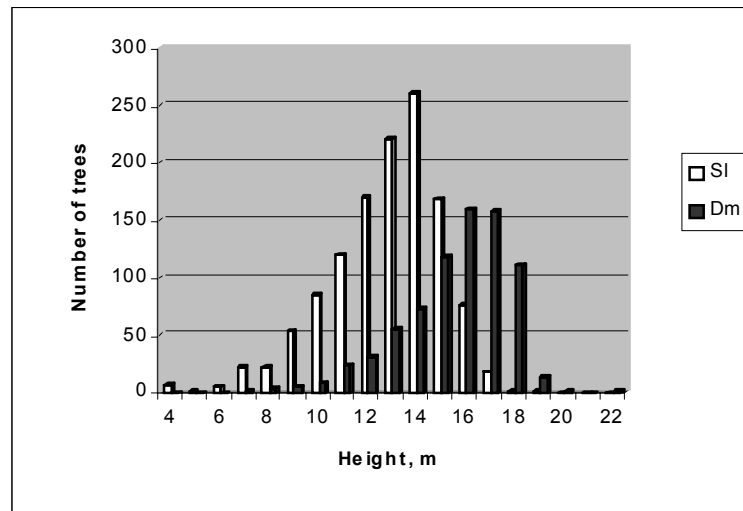
Fig. 2. Distribution of all living trees in age 32 years in different height classes
Sl – *Cladinoso-callunosa* forest type; Dm – *Hylocomyosa* forest type

Factors that influence pine growth

The influence of seed material (particular family) and forest type are shown in Table 1. At age 32 years, forest type and family has highly significant effect to height, diameter at breast height and branch diameter (α<0.001). Height (η=28%) and branch diameter (η=24%) is influenced more by forest type than by tree family (family influence 17% and 9% respectively). Soil and planting material (tree family) have almost equal influence on tree diameter, but these influences are quite low, while background effect (unexplained influence) is high (72%). For tree height, family influence is the highest and background effect is the lowest.

Table 1

Results of ANOVA and proportion of influence of different factors

Dependent Variable: Height						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Proportion of influence, %
Forest type	709	1	708.9	398	< 0.001	28
Family	435	34	12.8	7	< 0.001	17
Forest type x Family	96	34	2.8	2	0.020	4
Error	1280	718	1.8			50
Total	2570	787				
Dependent Variable: Diameter at breast height						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Proportion of influence, %
Forest type	1040	1	1039.8	107	< 0.001	11
Family	1165	34	34.3	4	< 0.001	12
Forest type x Family	440	34	12.9	1	0.099	5
Error	6957	718	9.7			71
Total	9762	787				
Dependent Variable: Branch diameter						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Proportion of influence, %
Forest type	46	1	45.7	260	< 0.001	24
Family	17	34	0.5	3	< 0.001	9
Forest type x Family	3	34	0.1	1	0.991	2
Error	126	718	0.2			65
Total	195	787				

Table 2

ANOVA of survival and average height and proportion of influence of different factors

Height							Survival						
Age 6 years							**Age 6 years**						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*η %*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*η %*
Forest type	0.2	1	0.19	22	< 0.001	12	Forest type	506	1	506	17	< 0.001	15
Family	1.1	32	0.03	4	< 0.001	70	Family	1946	31	63	2	0.023	57
Error	0.3	32	0.01			18	Error	938	31	30			28
Total	1.6	65					Total	3390	63				
Age 32 years							**Age 32 years**						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*η %*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*η %*
Forest type	61.9	1	61.86	214	< 0.001	59	Forest type	1475	1	1475	68	< 0.001	38
Family	33.9	32	1.06	4	< 0.001	32	Family	1667	32	52	2	0.008	43
Error	9.2	32	0.29			9	Error	692	32	22			18
Total	104.9	65					Total	3834	65				

η % - proportion of influence, %.

If only average height of dominant trees is considered, soil and planting material influence to tree height increases almost twice (53% and 38% respectively), but the unexplained variance decreases to 9% (35 tree families considered, data not shown).

33 tree families measured at age 6 and 32 years are analyzed in table 2. Most interestingly, the juvenile height growth (at age 6 years) is much more influenced by tree family (70%) than by soil conditions (18%) The influence of soil conditions and family in both ages are highly significant ($\alpha < 0.001$) (Table 2).

Pliūra and Gabrilavičius (1994) analyzed Lithuanian pine populations at age 10 years and also concluded that both site and population effect to height and diameter growth are highly significant ($\alpha < 0.001$). Also site x population interaction was significant, but in lower level. These results confirm trends observed in Latvia.

In Lithuanian experiment, most of the variance had been explained by site influence (75% for height, 80% for diameter). The population influence to variation was lower (7% for height, 4% for diameter).

Juodvalkis (1994) revealed, that 60–70% of total variation in tree height increment can be explained by genetic properties of trees and only the rest by ecological and coenotic factors. It is in agreement with results in Latvia at juvenile age (6 years).

The relatively high influence of forest type to branchiness is in agreement with results in Sweden, where soil and site conditions had been found as significant predictors of pine branchiness (Tegelmark, 1999).

Scots pine as wind pollinated species has high levels of gene flow (Govindaraju, 1988). Since the experiment had been established from open-pollinated progenies, there were genetic differences among them. The paternal effect to tree height growth (Baumanis, Birģelis, 1993) and survival (Baumanis et al., 2002) is considerable. Most likely these differences make the major part of the unexplained variance ("Error" in ANOVA). Part of "Error", especially for branchiness and diameter, can be differences in survival and with that related differences in growth area for individual tree (Mäkinen, 1996; Nummi, 1999).

Factors that influence pine survival

The family influence on early survival (at age 6 years) is 57% ($\alpha = 0.05$), and it is a bit lower as at age 32 years (44%; $\alpha = 0.01$). Forest type influence has increased rapidly (15% at age 6 years and 39% at age 32 years), and it is highly significant ($\alpha < 0.001$) (Table 2). Also, Dreimanis and Šmite (1975) have reported significant differences between Scots pine families in early survival (up to age 3 years).

The survival for progenies from particular clone at age 32 years on infertile soil (Sl) varies from 18 to 68% and on fertile soil (Dm) varies from 8 to 48% of initially planted trees. The average survival in Sl is: at age 6 years – 67%, at age 32 years – 42%; in Dm, those numbers are 77% and 27% respectively. The average survival at age 32 years is in accordance with survival reported by Mangalis (2004) in middle-fertile site (in soil conditions between Sl and Dm) (31%).

Correlative relationships

Survival in the same forest type for particular family correlates between ages 6 and 32 years – in Dm, r = 0.43, $\alpha = 0.05$, and in Sl, r = 0.78, $\alpha = 0.01$. Correlation in Sl is approximately the same as obtained by Olsson (2001) – r = 0.8. Not so tight correlation in Dm can be related to heavy competition – in such circumstances, survival of

particular family in small parcel (30 m²) can be influenced from survival and height growth of neighboring families.

The average tree height at age 32 years correlates with early survival (at age 6 years) in the same forest type (r = 0.36, α = 0.05 in Dm, r = 0.62, α = 0.01 in Sl), as well as with survival at age 32 years (r = 0.64 and r = 0.71 with α = 0.01 respectively). It is in agreement with findings by Olsson (2001) – genetic correlation between survival and height can vary between 0.03 and 0.65.

For the same family at age 32 years in Sl and Dm, height, branch diameter and diameter at breast height correlate well (r = 0.58, α = 0.01; r = 0.71, α = 0.01 and r = 0.42, α = 0.05 respectively). That indicates stability of average performance of Latvian Scots pine in different forest types.

Table 3

Average values and breeding difference of different traits for Scots pine clones in age 32 years

Forest type																	
Cladinoso-callunosa									*Hylocomiosa*								
Families	H		DBH		BD		N		Families	H		DBH		BD		N	
	Av	S%	Av	S%	Av	S%	Av	S%		Av	S%	Av	S%	Av	S%	Av	S%
Als10	14	-1	13	-12	1	-3	16	-38	Als10	15	-8	15	-12	2	-3	11	-32
Als11	13	-7	14	-5	1	1	24	-6	Als11	15	-5	17	1	2	1	14	-14
Als13	12	-15	13	-9	1	-19	11	-57	Als13	15	-5	13	-25	1	-26	12	-26
Als19	14	1	15	2	1	3	28	9	Als19	15	-4	15	-11	2	9	13	-20
Als21	15	3	15	5	1	3	29	13	Als21	17	5	19	11	2	5	14	-14
Als23	14	2	14	-4	1	-8	27	5	Als23	17	6	18	9	2	-1	22	36
Als9	12	-14	12	-18	1	-14	16	-38	Als9	15	-7	17	-2	2	6	11	-32
Ba15	15	3	15	0	1	-3	29	13	Ba15	18	10	20	18	2	-1	21	30
Ba29	15	5	16	11	1	10	30	17	Ba29	17	5	18	9	2	-3	22	36
Da10	14	2	15	6	1	2	26	2	Da10	16	-3	18	6	2	8	16	-1
Et1	13	-11	12	-16	1	4	21	-18	Et1	14	-11	13	-23	1	-10	6	-63
In13	13	-5	15	1	1	5	18	-30	In13	15	-5	17	1	1	-6	14	-14
In5	14	-1	14	-1	1	5	34	33	In5	17	3	18	8	2	15	11	-32
Ja30	16	10	17	17	1	7	28	9	Ja30	17	4	17	3	1	-7	15	-7
Ja8	14	0	15	6	1	6	22	-14	Ja8	16	0	19	13	2	8	20	23
Ka10	14	-1	15	1	1	-5	29	13	Ka10	15	-4	14	-17	1	-16	12	-26
Ka14	15	8	16	10	1	-1	36	41	Ka14	18	8	19	14	2	9	19	17
Ka23	16	12	16	9	1	-3	41	60	Ka23	17	4	18	6	1	-4	21	30
Ko13	15	4	15	5	1	-2	20	-22	Ko13	15	-10	15	-10	1	-14	10	-38
Ko2	14	-4	12	-15	1	-17	27	5	Ko2	17	5	18	6	2	-3	20	23
Lub19	13	-7	12	-16	1	-10	24	-6	Lub19	15	-6	16	-7	2	7	15	-7
Ma13	14	1	15	1	2	49	38	48	Ma13	17	6	18	8	2	34	22	36
Ma15	14	-4	14	-5	1	3	22	-14	Ma15	16	-3	15	-11	2	8	11	-32
Ma16	15	8	16	9	1	14	35	37	Ma16	17	2	18	6	2	10	21	30
Ma6	15	2	15	0	1	-6	27	5	Ma6	17	3	17	4	2	14	11	-32
Ta1	14	-2	15	1	1	-5	18	-30	Ta1	16	1	16	-4	1	-11	13	-20
Ta16	14	-2	14	-2	1	-16	18	-30	Ta16	16	-2	17	0	1	-15	5	-69
Ta17	14	1	14	-2	1	-11	23	-10	Ta17	16	-1	15	-11	1	-16	14	-14
Tu16	14	0	14	-7	1	-19	19	-26	Tu16	17	5	17	3	1	-17	29	79
Va1	14	1	14	0	1	-4	23	-10	Va1	16	1	17	2	2	-1	20	23
Va2	15	5	16	8	1	15	29	13	Va2	17	3	17	3	2	11	21	30
Va3	13	-5	14	-6	1	-3	24	-6	Va3	15	-5	16	-6	1	-4	18	11
Ve25	14	1	16	9	1	11	24	-6	Ve25	16	1	18	9	2	10	20	23
Ve27	15	6	15	2	1	4	28	9	Ve27	18	9	17	1	2	10	18	11
Ve28	14	1	16	7	1	23	33	29	Ve28	16	-4	16	-2	2	16	21	30

Av – average value; S% – breeding difference, % from average value of trait in particular forest type; H – height, m; DBH – diameter at breast height (1.3 m), cm; BD – diameter of thickest branch up to 2 m height, cm; Number of trees.

The average tree height in Sl at age 4, 5 and 6 years as well as at age 32 years is approximately 10% lover as in Dm. However, the difference in absolute numbers is increasing (10, 10, 12 cm and 2 m respectively). This is the average influence of site type that is a basis for most of yield tables (e.g. Sarma, Princis, 1947).

Correlation between average height at age 3 years and dominant height at age 32 years in Dm is 0.34, between height at 6 and 32 years – 0.53. The some trend has been observed in Sl.

Possible breeding effect

Final evaluation of the experiment is presented in Table 3. In group selection, almost 20% (6 from 35) best families are chosen (marked with grey). These clones in particular site conditions were among the best ones in 3 positions (height, diameter, survival (number of trees left). Only 2 families (Ba29 and Ka14) were among the best in both forest types.

Group selection in Sl gives the following additional (above average) growth: 8% in height, 11% in diameter and 30% in survival. In Dm, the corresponding numbers are almost the same: 7%, 11% and 30%. The best family in Sl (Ja 30) was 10% higher and 17% thicker than average, in Dm (Ba15) – 9% higher and 18% thicker than average. It indicates that equal breeding effect can be reached both in poor and fertile soils, but not within the some families. This conclusion is also supported by ranking of families according to average height – only in 2 cases (from 35) the rank for particular family is the same in Sl and Dm. Similar tendency is observed for populations in Lithuania (Pliūra, Gabrilavičius, 1994). Pedersen (1994) summarizes results from numerous Scots pine trials in Denmark and also concludes that general adapted provenances are merely absent. The tested Scots pine provenances have demonstrated strong site dependency.

If experiment would be made only in fertile soil (Dm) and results (best 6 clones) would be used in Sl, the breeding difference in Sl would be only 3% for height, 1% for diameter and 22% for survival. If the 6 best families selected in Sl would be used in Dm, breeding difference would be 5% for height, 7% for diameter and 22% for survival. Results show that benefits from breeding would be considerably lower, and this is one more evidence for site-specific adaptation of families. However, families with superior growth and survival in poor sites demonstrated high phenotypic plasticity and well growth in rich sites, but not vice versa. If the best families selected in Dm are used in Sl, average height is reduced per 0.8 m and diameter per 1.5 cm compared to best families selected in Sl. In vice versa, the losses in absolute numbers are lower – 0.3 m and 0.6 cm.

Conclusion – if the seed material is planned for use in different site conditions, the best test site would be in poor soil, but the maximum benefits can be achieved only by site-specific breeding. The trial should be allocated in the same site type in which seed material use is planned.

It should be considered that in present situation tree breeding efforts in Latvia are allocated to highly productive forest types and use of natural regeneration in poorer ones.

The families from one region in Latvia can demonstrate considerably different growth results – e.g., different families from Als (Alsunga – western coastal region of Latvia) in Sl can have average height from 12.1m to 14.6 m and diameter from 11.9 cm to 15.1 cm. It indicates that family influence to growth is considerable. The same conclusion has been drawn from geographical Scots pine provenance trial – at age 28 years, influence of particular provenance to height growth was much larger than the influence of origin region (represented with several provenances) (Jansons, Baumanis, 2005).

Families from origin regions in Alsunga (Als), Koknese (Ko), Inčukalns (In) and Talsi (Ta) show results below average in height growth (negative difference) in both forest types. At the same time, family Als 23 is among the best ones in Dm. It confirms the conclusion mentioned above and indicates that the division of pine regions according to their average performance can lead to losses of particular families with superior growth, and therefore, related benefits in further breeding process.

According to Tukeys test, on average in both experiments family K14 has significantly ($\alpha=0.05$) superior height and diameter growth. In the next group (significantly better than all the other groups but not so good as K14) both in height and diameter is Ba 29, Ka 23, Ja 30, Ma16 and Als 21. These families (especially K14 and Ba 29) demonstrate high general adaptability, and they can be recommended for use in next generation seed orchards.

Conclusions

1. At age 32 years, in *Hylocomiosa* forest type Scots pine survival is almost twice as lower than in *Cladinoso-callunosa* forest type, but the average height and diameter of all living trees is higher (15.5 m, 14.8 cm and 12.7 m, 11.7 cm respectively).

2. At age 32 years, forest type and family has highly significant influence to height, diameter at breast height and diameter of thickest branch up to 2 meters height ($\alpha < 0.001$). Forest type has highly significant influence on survival ($\alpha < 0.001$), but tree family influence is not so significant ($\alpha = 0.008$).

3. The proportion of influence caused by tree family to height growth at age 6 years is 70%, at age 32 years it is 17%; the proportion of influence caused by tree family to survival is 57% and 44% respectively. The corresponding influence caused by forest type was 12% and 28% to height, and 15% and 39% to survival. Diameter at breast height at age 32 years was equally influenced by forest type and seed material (tree family) (~11%).

4. The unexplained variance (background effect) for analyzed traits makes up to 70%; it is not very surprising because open-pollinated progenies were used.

5. Equal breeding effect – but not with the same families – can be reached both in fertile and poor soils. In group

(20%) selection the breeding effect is ~8% for height, 11% for diameter and 30% for survival; in individual selection, it is ~10% for height and ~17% for diameter.

6. If the seed material is planned for use in different site conditions, the best test site would be in poor soil – families with superior growth and survival in poor forest type (*Cladinoso-callunosa*) have demonstrated high phenotypic plasticity and good growth in rich soil (*Hylo-comiosa*), but not vice versa.

7. The maximum benefits can be achieved only by site-specific breeding – the trial should be allocated in site type in which seed material use is planned.

8. Families with superior growth, survival and high general adaptability (especially K14 and Ba 29) are recommended for use in next generation seed orchards.

9. Open pollinated progenies of phenotypically selected trees from one region in Latvia have demonstrated considerably different growth and survival. This is true in both forest types.

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AN ASSESSMENT OF A SCOTCH PINE *(PINUS SYLVESTRIS L.)* PLANTATION IN THE HIGH MOUNTAIN FOREST REGION IN ARTVIN, TURKEY

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Abstract

Turkey is a mountainous country with many high mountains. Recent estimations show that there are approximately 20.7 million ha of forested area in Turkey, covering 25.8% of the total land area. However, little over half of this forested area is classified as unproductive (51.7%). Artvin is located in the North Eastern Blacksea part of Turkey and is the home of a very rich biological diversity. Forests in Artvin region are in different climatic zones – from temperate climate to continental climate zone - and there are several vegetation zones in the region which ranges from sea level to the altitude of 3500 m.

A scotch pine (*Pinus sylvestris* L.) plantation, planted in 1996 in the alpine zone in Artvin-Ardanuc region, was investigated. The size of study area was 40 ha and this research was done on 12 sample plots. There were 50 scotch pine seedlings on each sample plot. Height and root collar diameter of the seedlings were measured. The mean slope was the same (60%) on the sample plots, and the effects of exposure and altitude of plots on the seedling growth were determined. The exposure and altitude significantly affected the height and root collar diameter growth of the seedlings (P<0.05). It was determined that increased altitude is associated with decreased height growth and root collar diameter of the seedlings.

Key words: *Pinus sylvestris* L., plantation, alpine zone, seedling growth.

Introduction

In general, Turkey is a mountainous country with many high mountains. Recent estimations show that there is approximately 20.7 million ha of forested area in Turkey, covering 25.8% of the total land area. However, little over half of this forested area is classified as unproductive (51.7%) (Konukçu, 2001). Also, mostly it is not possible to see real forestline in the mountain forests. The forestlines in Turkey have been lowered to lower altitudes due to the overgrazing and antropogen effects. The forests adjacent to this artificial forestline have changed to degraded forests and also transition zone and treeline have disappeared. Afforestation and rehabilitation works in these areas have an importance to protect settlement areas and agricultural lands against avalanche, rolling rocks and flood and to prevent soils against erosion (Ürgenç, 1985 and 1998).

Mountain regions cover 24% of the earth's land surface and contain 28% of the world's closed forests. Fifty-five percent of these mountain forests occur below altitudes of 1000 m above sea level. While only one in 10 people live in mountain regions affects many more people living in the lowlands. For example, deforestation in mountain forests may have an impact on the climate and contribute to flooding in lower regions. Mountain forests are therefore globally important (Schönenberger and Brang, 2004). High mountain forests have a different ecosystem that clearly separates them from lower forests. Special silvicultural techniques are needed in these forests because of the extreme site conditions and some natural risks (Çolak and Pitterle, 1999).

There is much more radiation in alpine zones compared to lower altitudes. Thus, temperature is high in areas like these during the day. Contrary to this, the temperature decreases quickly at nights due to less atmosphere stratum, steam and high heat loose. This situation limits the seedling growth. In addition, when the altitude increases, vegetation period decreases rapidly. Even if the most suitable plantation techniques are carried out in afforestation efforts in high regions, the success of plantation can not be high, contrary to afforestation in lower altitudes (Ürgenç, 1998).

High mountainous regions have also extreme climatic conditions. Towards forestline and treeline, strong and unsuitable environmental effects for forests are in question. And also, air current, exposure, shape of slope and the other physiographic and edaphic factors affect negatively the structure and living of forests. Even climatic characteristics in small areas in high mountainous regions show strong differences from each other (Çolak and Pitterle, 1999).

Afforestation efforts usually have many risks because their establishment is artificial. Life conditions for plants in high mountains are always hard and for that reason it is too difficult to obtain successful plantation efforts. Long-term studies of the ecology of subalpine afforestation have shown that the young trees tend to be threatened over decades by fungal diseases, adverse climatic conditions and snow movements (Schönenberger, 2001; Üçler et al., 2002). Natural forests in high mountainous regions have steep slopes and variable conditions. Afforestation efforts in areas like these show three different situations. One of them is degraded forests due to of antropogen effects. The other is unpruductive areas where degradation appears due to natural reasons, and another is on soils forming during recent years (Çolak and Pitterle, 1999).

It is difficult to carry out forestry activities in mountainous regions in view of economics. For that reason, it is necessary to apply the most suitable silvicultural systems for the definite conditions (Schönenberger and Brang, 2001). Tending and replacement plantings also are very important in high mountain afforestation efforts. The replacement plantings should be done at the right time (Ürgenç, 1998).

According to Ürgenc and Boydak (1985), about 10 mil-

lion ha needs reforestation in Turkey. Only in the Artvin region there is about 154000 ha of degraded forested area. Thus, there is an urgent need afforestation and erosion control efforts in these areas (Göktürk et al., 2004).

Scotch pine is a kind of softwood which is in northern region of Asia and Europe. It has a very large natural distribution area approximately 3700 km in width (37°–70° N) and 14700 km in length (7°–137° E) in Europe and Asia (Saatçioğlu, 1976). It shows natural distribution between 38° 34′ – 41° 48′ North latitude (Pınarbası-Ayancık line) and 28° 50′ – 43° 05′ (Orhaneli-Kağızman line) East longitude in Turkey (Saatçioğlu, 1976). S pine makes 3.6% of the total forest area (738000 ha) of Turkey (Ata, 1995), and is located in Borçka-Otingo district, at the altitude of 200 m where is its lowest distribution area, the highest is 2700 m in Sarıkamış-Ziyarettepe region (Atay, 1987). Scotch pine is mostly distributed between the altitude of 1000 and 2500 m in Turkey (Saatçioğlu, 1976).

Scotch pine stands are found both in steep slopes in mountainous regions and in flat places in subalpine and alpine zones in Turkey (Anonymous, 1994). Some of the tree species which grow in the alpine and sub-alpine zone in Turkey are scotch pine (*Pinus silvestris*), spruce (*Picea orientalis*), fir (*Abies nordmanniana* subsp. *nordmanniana* ve *Abies cilicica*), beech (*Fagus orientalis*), trembling poplar (*Populus tremula*), birch (*Betula pendula*), crimean pine (*Pinus nigra*), junipers (*Juniperus* ssp.), and lebanon cedar (*Cedrus libani*) (Saatçioğlu, 1976; Ürgenç, 1985).

The objective of this study is to determine growth of scotch pine seedlings planted in the alpine zone, in Artvin region of Turkey.

Material and Methods

The afforestation area is located in Artvin, Ardanuç (latitude: 41° 04′ N, longitude: 42°13′ E, h: 2100–2250 m), in the northeastern part of Turkey. The size of the study area planted in 1996 is 40 ha and adjacent to the alpine zone. It covers two different hillsides. Measurements were carried out on 12 different sample plots (6 of them are on eastern slope and 6 of them are on western slope). There were 50 seedlings on each sample plot.

The seedlings planted for fill-in planting as 2-year old and potted in 1998 by General Directorate of Afforestation were used. Height, root collar diameter and shoot growth of the last year of the seedlings were measured. The average inclination of each sample plot on the study area is about 60%.

Data analyses (ANOVA and Duncan Test) were conducted using SPSS 9.0 and Statgraphics Plus. All differences were deemed significant at $\alpha=0.05$.

Results and Discussion

The afforestation area was established in 1996 using 2-year old, bare rooted scotch pine seedlings originated from Artvin-Yusufeli. But, due to the fact that most of these seedlings died, fill-in plantings were carried out in 1998 using 2-year old and potted seedlings. It was observed that all of these replanteds were alive in the area. The research area was between the altitude of 2100 and 2250 m and was located in the western and eastern exposures.

As a result of observation on the environment near and upper side (2325 m) the study area it was defined 5 scotch pine trees about 180-200-aged as remainder. In addition, according to the forest management plan and the stand map belong to the study area (Anonymous, 1985), it was defined that there has been scotch pine-oriental spruce mixed forests close to the afforestation area. These findings indicate that the study area was a forest in the past and was changed to meadow because of different destructions in the course of time.

According to statistical analysis, growth of the seedlings was in the western exposure highest than in the eastern exposure on the sample plots. The average height of the seedling and root collar diameter was determined 162.1 cm and 49.1 mm in the western exposure and 148.5 cm and 46.5 mm in the eastern exposure, respectively. But there is no difference between exposure and shoot growth

Table 1

ANOVA and Duncan test results showing the relationship of the parameters belong sample plots with exposures (Means in column with the same letter are not significantly different from each other, p<0.05)

Exposure	Number of sample (N)	Mean height of the seedlings (cm)	F-ratio	Homogeneous groups
East	300	148.5	20.980*	a
West	300	162.1		b
Exposure	Number of sample (N)	Mean root collar diameter (mm)	F-ratio	Homogeneous groups
East	300	46.5	5.910*	a
West	300	49.1		b
Exposure	Number of sample (N)	Mean height growth of the last year (cm)	F-ratio	Homogeneous groups
East	300	36.2	5.910[NS]	a
West	300	37.1		a

Table 2

ANOVA and Duncan test results showing the relationship of the parameters belong sample plots with altitudes (Means in column with the same letter are not significantly different from each other, p<0.05)

Altitude steps	Number of sample (N)	Mean height of the seedlings (cm)	F-ratio	Homogeneous groups
2200-2250	100	128.9	44.720*	a
2150-2200	250	158.8		b
2100-2150	250	161.4		b
Altitude Steps	Number of sample (N)	Mean root collar diameter (mm)	F-ratio	Homogeneous groups
2200-2250	100	41.6	18.950*	a
2100-2150	250	48.9		b
2150-2200	250	49.1		b
Altitude steps	Number of sample (N)	Mean shoot growth of the last year (cm)	F-ratio	Homogeneous groups
2200-2250	100	31.7	24.990*	a
2100-2150	250	36.7		b
2150-2200	250	38.8		b

NS: Not significant *: significant at 95% significance level.

of the last year of the seedlings at the confidence level of 95% (Table 1).

According to Duncan test, two different homogeneous groups were detemined for relationship between altitudes and growth of the seedlings. The highest mean height of the seedling (161.4 cm) was obtained between the altitudes of 2100 and 2150 m. The least mean height was 128.9 cm between the altitudes of 2200 and 2250 m (Table 2).

When the relationship between the mean root collar diameter and the shoot growth of the last year of seedlings and the altitudes was considered, the best mean root collar diameter (49.1%) and the shoot growth of the last year of seedlings (38.8 cm) were obtained in the 2150–2200 m altitude step. Also 2100–2150 m and 2150–2200 m altitude steps are the same statistically (P<0.05) in view of the each two variables (Table 2).

When the relationship between altitude and growth of the seedlings was considered, the maximum growth of the seedlings was obtained at 2100–2150 meters (Table 2). In general, while altitude increases, height of plant decreases. And also both soil depth and plant nutrient elements were higher in lower parts of slopes than in upper parts (Çepel, 1995).

Conclusion

1. At present there are few economic activities in the Artvin-Ardanuç region of Turkey, which do not rely on the natural environment; forestry, livestock and bee-keeping are the mainstay of the local economy. The livelihood activities in each village are the same. The economy is predominantly subsistence-based, with a few livestock and honey.

2. The current livelihood system in the region is believed to be well within sustainable limits. There is little economic incentive to protect the environment: wildlife causes damage to crops, livestock and beehives; fuelwood

is the only realistic energy source for cooking and heating, and much agricultural production occurs on steep slopes.

3. Natural forestline and treeline have been lowered towards lower altitudes in the region because of negative antropogen effects going on for centuries. Forests in the region have been degraded with biotic, abiotic and antropogen effects, and as a result of this, real alpine and subalpine zones disappeared, as reported for the other regions of Turkey.

4. When this afforestation effort in the alpine zone is evaluated according to the findings, it can be said that the western exposure has more positive effects on the growth of the seedlings compared to eastern exposure for each three variables.

5. In general, researcher aimed at solving problems of extreme high mountainous regions are being continued at present. A high afforestation success in these regions should not be expected even if suitable methods are applied.

6. Suitable species, origins and type of seedlings will be planted in alpine or subalpine zones should be defined and also they should be grown in good quality in nurseries before they are planted in the areas. Instead of bare rooted seedlings, usage of potted and good quality seedlings can be suggested. While species are suitable to region are defined indicator plants on the regions should be taken into consideration.

7. There are many degraded forest areas, subalpine and alpine zones in Artvin region of Turkey. This plantation effort can be an example for the plantation studies which will be done in the future.

Acknowledgements

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EDUCATIONAL SCIENCES

COMPETENCE IN HIGHER EDUCATION IN MULTI-DIMENSIONAL ASPECT

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Abstract

The term "competence" has not been clearly defined in the literature. Two meanings of the term have been identified. One refers to the outputs or results of education (training), but other – to the inputs or underlying attributes needed for a person to demonstrate competent performance. Each meaning has been used to describe both individual and organizational competences. A classification of the meanings of competence is given to show that the term has several meanings depending on the purpose for which it is used.

Although competence is an important concept in education, it is unclear what competence is. Constructivism is a way out of the competence confusion – we don't search for one absolute true definition, but do use the competence concept for our own purposes.

At the end of Article a description (definition) of competence is given. This definition is appropriate to define inputs for undergraduate programmes and to improve student's lifelong and lifewide learning competences while studying undergraduate study programmes.

Key words: competence, competences, constructivist's approach, boundary approach.

Introduction

The term "competence" is multi-faceted and has been defined in the literature from several different points of view. It was originally used in the field of education to describe trainee teacher behaviors (Bowden and Masters, 1993). However, the term "competence" has not settled down in any particular area or branch. In fact, a variety of users (psychologists, management theorists, human resource managers, educationalists, etc.) were involved in using the term and each with their own agendas (Burgoyne, 1993):

- psychologists are measuring the ability (Sternberg and Kolligian, 1990) on the base of observable performance of a person;
- human resource managers use the concept as a technical tool for strategic decisions, such as training, assessment, personnel planning, etc. (Burgoyne, 1993);
- educationists relate the idea of work preparation and professional recognition with that of a broad education (Bowden and Masters, 1993).

This lack of clarity of the term has produced confusion among competence. It is not surprising then to find that there seems to be little agreement in the literature. The term "competence" has no widely accepted single definition (Strebler et al., 1997; Jubb and Robotham, 1997). Stakeholders have evolved several meanings that serve as a focus for their efforts to implement the competence approach to their work. This has produced a multi-faceted concept called competences. Many researchers argue that the rationale of the use of competences will determine the definition given to the term.

Discrete meanings and new labels for the term have recently evolved through common usage. Specialists in the UK, for example, Strebler et al. (1997) suggest that two different meanings of the term "competence" have been developed. Competences may be "expressed as behaviours that an individual needs to demonstrate", or they may be "expressed as minimum standards of ... performance" (Strebler et al., 1997). The term "competence" has been used to refer to the meaning expressed as behaviours, while the term „competences" – to refer to the meaning expressed as standards.

A review of the literature showed three main positions taken toward a definition of the term. Competences were defined as either:

- underlying attributes of a person (Boyatzis,1982; Sternberg and Kolligian, 1990);
- observable performance (Boam and Sparrow, 1992; Bowden and Masters, 1993) or
- standard or quality of the outcome of the person's performance (Hager et al., 1994).

For use in higher education area, appropriate position is related with focusing on underlying attributes of a person. A focus on the underlying attributes begins with a need to design the content of educational (training) programmes to achieve competent performance. The need to determine the inputs may be based on the uncertainty of the precise outputs required. For simpler jobs it is easier to describe outputs as performances. The requirements expected of a turner, a brick-layer or a janitor, are more easily to define in terms of specific performances and standards of output than, for example, of a middle level manager. Where jobs are more complex, the task of describing outputs is much more difficult. First, this is because a wide range of results seems to be appropriate to name demonstrated performance as competent; secondly, some of the tasks are very complex and, thirdly, relationship between knowing how to do the job and actually doing it well is uncertain.

The job of a middle level manager may require a set

of underlying attributes rather than a number of prescribed performances. For competent performance a manager needs not only knowledge and skills of marketing, but also abilities as a manager of people. The task to develop competences may be easier when looking at specific inputs for educational (training) programmes rather than at uncertain outputs in more complex jobs. Where to start the process depends on how the problem is presented and therefore how the term "competence" will be defined (Hoffmann, 1999).

Because different authors use the term "competence" to mean different things, there is reason for concern over the usefulness of the term. For educators, trainers and other stakeholders using the competence approach, it may be better to choose how to use the term for their own purposes rather than search for the „true" meaning of the term. The meaning of competence shifts according to the context of its use and the requirements of the user. Acknowledging this may help to focus user's efforts in using the competence approach to the own needs.

The **aim of the research** is to determine aspects on which definition of the competence depends, to point out the meaning of competence and to select one term describing the concept of competence appropriate to define inputs for didactics of an educational programme.

Methodology

The object of study is the concept of competence. The methods are study of scientific sources and interpretation of conclusions according to the aim of the research and reflection of personal experience.

Results and discussion

Some authors focus on the individual's abilities, such as knowledge or skills, and are calling them competences. With reference to Klemp, Boyatzis (1982, p. 21) writes that competences are underlying attributes of a person resulting in effective performance. Boyatzis expands this definition and includes „a motive, trait, skill, aspect of one's self-image or social role, or a body of knowledge which he or she uses" as well (Boyatzis, 1982).

Hunt and Meech (1991) claim that „the focus is not on the task as such, but the underlying ability, the set of a person's skills, knowledge and personal characteristics". This definition ignores the observable nature of the individual's performance. As already described above, for complex jobs (and graduates of higher education programmes will work as managers), observation of persons (managers) performance doesn't give enough information about his/her competence in the observable situation.

As discussed above, the two perspectives about defining competence have different starting points. An output-based approach handles the competence as an indicator on "what an individual can do". Educational (training) programmes can be designed by using outputs of performances and standards of performance. Competences are outputs in the sense that they are performed as a conse-

quence of educational (training) programmes. The alternative – an input-based approach attempts to determine "what underlying attributes does a person need". This approach seeks to discover not "what a person can do", but "what an individual needs to know, what skills or other attributes he/she needs to have" in order to demonstrate competent performance. The focus is on the content of training and learning experiences. This information helps to build new and develop existing educational (training) programmes for students.

In the classification of the use of competence approach it is possible to describe two uses: individual and corporate. At an individual level, competences are described in order to develop educational programs. At an organisational level they describe organisational strengths or unique capabilities and the term „core competences" is used.

Stakeholders from different fields, such as education, psychology, etc., use the term "competence". The various meanings that have emerged in each of these fields will remain. The problem is therefore not to agree on a single meaning, but to select the meaning that best suits the needs of the context and the purpose for which the approach is used.

More than one meaning used in discussions about competence leads to misunderstandings and disagreement. The term "competence" must be used in a way that reflects the purpose of its application. For those, who try to introduce the competence approach, the uncertainty about the meaning of the term may be confused when confronting the literature about competence concept. With different meanings used in the various articles, it may be difficult to choose which articles are useful and relevant to their own purposes. The introduction of the approach creates other problems as well. For example, people who are unsure about the meaning and purpose of competence approach may become suspicious of the real motives for using it (Hoffmann, 1999).

Lack of a specific definition hinders the application of the concept. If the purpose of use of competence were clear and the term defined within the context of that purpose, the task of description and the sharing of understanding would be improved. Clarity of the purpose clears a focus on what is to concentrate when using the competence approach. If underlying attributes are the focus, then a different set of questions need to be answered: What is the main reason for using this approach? What will be the outcomes or results? Can the didactics of an educational (training) programme be designed with respect to underlying attributes of a person needed for competent performance?

By making a clear description of the purpose of the use of competences, it is possible to avoid mixing the typology of meaning of competence between inputs (describe the underlying attributes needed to demonstrate competent performance) and outputs (describe specific performances and standards required). This has the advantage of using the strengths of each approach. That is,

Types of meaning and purpose of the term „competence" (Hoffmann, 1999)

Approach	Individual	Corporate	Purpose
Outputs	Performance, standards	Benchmarks	Performance based objective (training)
Inputs	Underlying attributes (knowledge, skills, abilities)	Distinctive strengths	Subject matter content (education)

complex jobs may best use an input-based approach, while simpler jobs may benefit from an output-based approach. The ideal situation is to see where one starts from and choose the meaning that best suits the purpose for which the competence approach is to be used.

A table may help explain the differences between each type of approach and the purposes for each (Table 1). The input and output at the left of the table refer to the two types of uses of the term "competence". The term has been used to refer to both individual and corporate types of competence descriptions. These are labelled at the top of the table. Within the table are brief labels of the meaning of the term "competence" for each typology. To the right of the table is the purpose for using either an input or an output approach to the definition of competence.

Returning to the question what is competence, related questions arise, such as: Which competence definition is the best? Are other definitions wrong? What is competence really? Behind these questions is an objectivistic point of view. Objectivism is one of the two fundamental approaches in epistemology (Murphy, 1997). Epistemology is the branch of philosophy that studies the nature of knowledge.

Objectivists consider the world as given, meaning that there is one objective, absolute truth. This article shows that confusion about the concept of competence arises from this objectivist point of view. On the contrary, a constructivist approach, which is the other epistemological approach, releases the quest by allowing a variety of competence definitions. Here, the criterion for a competence definition is not whether the definition is true, but the extent to which the constructed definition has proven to be adequate in the context in which it is used (i.e., "viability", Von Glaserfeld, 1995).

The scope of the concept of competence is restricted. Outlining this scope offers more insight into the meaning of competence, thereby supporting people in making up their minds about competence regarding their own situation. Also, according to constructivism, competence can be defined in any possible way in the frame of the scope.

The definition of competence creates an essential problem. There is a tendency in education area to focus on the method: how to teach competence, rather than answering the question: what competences do we want our students to learn? Bowden and Marton (1998, p. 95) state: "If you do not know what the future situation will be, then teach students some fundamental skills which they can apply to any situation."

However, Everwijn (1999) has another interesting view of what should be the goal of competence based education. According to Everwijn, life in general, including work, is characterized by increasing complexity and dynamics. This means that people have to be capable of functioning in complex, dynamic environments. Competence based education should develop competences that helps people to handle problems in unfamiliar situations. The process of using competences in situations that show little resemblance with situations in which the competence was acquired, is referred to as far transfer (Butterfield and Nelson, 1989; Simons, 1990). Skills that facilitate far transfer and skills such as learning-to-learn is a solution for closing the gap between education and complex jobs.

Competence definitions are valued against their degree of viability, which increases when competence definitions are based on analyses of people, goal and context. The boundary approach of competence is used as a regu-
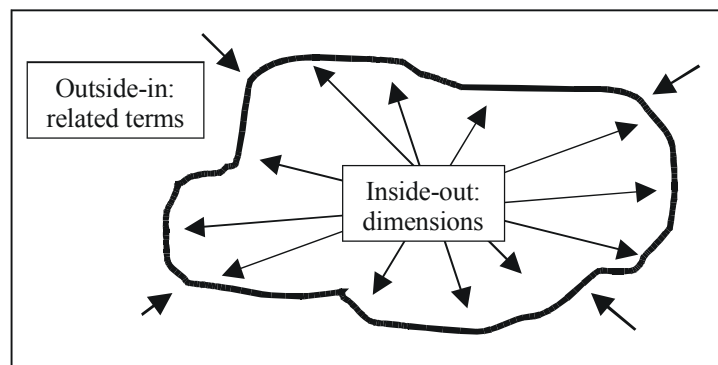

Fig. 1. Boundaries of the competence concept:
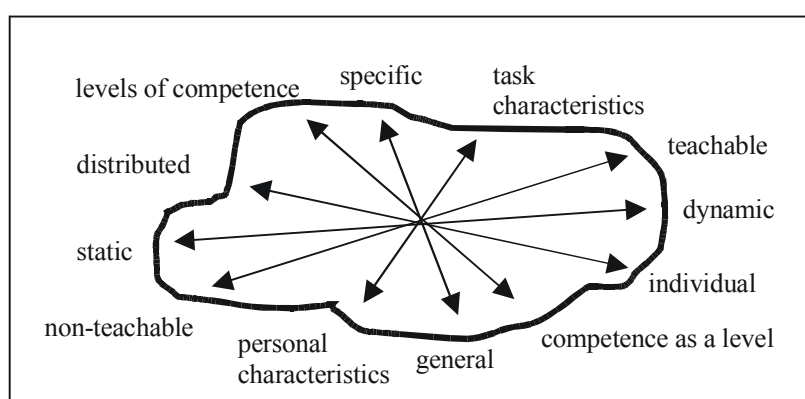what does and what doesn't belong to competence? (Stoof et al., 2000).

Figure 2. The inside-out approach of the boundary approach of competence: dimensions of competence (Stoof et al., 2000).

lative structure to map the variety of competence definitions and approaches and may support these analyses (Stoof et al., 2000).

The boundary approach of competence is a visual representation aid. It identifies what does and what does not belong to the concept of competence. There are two approaches to identify the boundary: the inside-out approach and the outside-in approach. The **inside-out approach** seeks for the boundary from inside. It focuses on dimensions of competence. A dimension is a continuum between two opposing extremes. These extremes can be viewed as points on the boundary of competence, while competence is something on the continuum between these points. On the other hand, in the **outside-in approach** the boundary is mapped from outside. This approach focuses on differences with related terms, such as performance, experience and intelligence. It identifies what competence is not. The two approaches can be visualized as two opposing forces, pushing against the boundary to broaden the scope (i.e., inside-out) and to narrow the scope (i.e., outside-in) of the concept of competence. In Figure 1, these forces are visualized as arrows. Competence definitions are placed in the middle of the figure, inside the boundary. The shape of the boundary varies with the amount in which certain dimensions or differences with related terms are stressed in competence definitions.

In the **inside-out approach,** dimensions are often used as guidelines to operationalize competence (e.g., Derous, 2000; Filius and De Zeeuw, 1999). Dimensions make the concept of competence concrete, by forcing people to think about their current or wished-for position on the continuum between two extremes. See below six dimensions that are often mentioned (Stoof et al., 2000):
- personal competence versus task characteristics;
- individual vs. distributed competence;
- specific vs. general competence;
- levels of competence vs. competence as a level;
- teachable vs. non-teachable competence;
- static vs. dynamic competence.

The boundary is dynamic. With respect to the dimensions of competence, the shape or form of the boundary varies with the emphasis that is put on the dimensions. For example, an educationalist wonders how to develop competence in students and will stress the dimension teachable vs. non-teachable more than a recruiter, who is mainly interested in assessing applicants.

Another way of identifying the boundary of competence is **outside-in approach** mapping the differences with related terms. This approach clarifies what competence is not and the nature of the relationship between competence and related terms reveals something about competence itself. The problem is how to investigate the differences and relationships between competence and its related terms.

There is an alternative, more indirect method that focuses on the comparison of terms, regardless of their definition (Blokhuis, 2000; Blokhuis and Onstenk, in press). This method is based on the assumption that although it is apparently hard to explain the meaning of abstract constructs like competence, people do have a (symbolic) representation of it. In the comparison process as proposed by Blokhuis and Onstenk, competence is repeatedly compared with one related term at the time (e.g., competence – performance, competence – qualification). Next, a decision has to be made whether the two terms are the same or not. Analyzing the decisions that are being made in the comparison process provides more insight in the meaning of the concept of competence, and also of the compared construct.

Figure 3 shows the comparison of the term "competence" with a few related terms: performance, qualification, capability, ability, and the often-mentioned cluster of knowledge, skills and attitudes.

The definitions found in literature reflect another problem about competence: the problem of terminology. Besides the struggle with the meaning of competence there is also disagreement about the term itself. The terminological problem concerns especially the use of the word
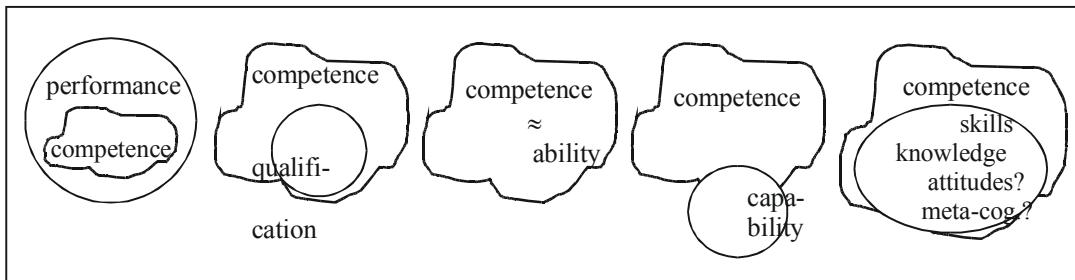
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Fig. 3. Competence and related terms (Stoof et al., 2000).

"competence" versus "competency", or in plural, "competences" versus "competencies". This article uses the term "competence" to refer to the construct in the broadest sense and the term "competences" to refer to inputs or underlying attributes of a person.

Some definitions and descriptions of competence are listed below. Briede (2004) defines competence „as a totality of knowledge, skills and reflection abilities, which is possible to prove documentary, and in action in which a person agrees to participate actively and with a sense of responsibility." It is a typical demand of employers that they need an employee with high professional knowledge and skills and at the same time ability to be flexible, able to work in a team, to be responsible, creative, ready for learning, etc. Higher school graduates should meet those demands of employers and therefore the higher schools have to guarantee a possibility to reach the appropriate level of competence. It means that the components of competence and their contents should be defined.

Kobus (1983, cited from Conlon, 2004) suggests, that global competences incorporate necessary information, skills and attitudes about the world in a „person's cognitive repertoire".

OECD (Organisation for Economic Co-operation and Development) in the DeSeCo (Definition and selection of competences) project „establishes definitional, normative, and conceptual criteria for the individually based competences required for effective participation in modern democratic societies and for coping with broad societal problems and demands. It highlights a number of competences that matter for an overall successful life and for a well-functioning society." (Definition and selection of competences, 2002). In this paper „competence is defined as the ability to meet demands or carry out a task successfully, and consists of both cognitive and non-cognitive dimensions."

Advantage of this functional approach is focusing on the personal and social demands facing individuals. „This demand-oriented definition needs to be complemented by a conceptualization of competences as internal mental structures – in the sense of abilities, capacities or dispositions embedded in the individual. Each competence is built on a combination of interrelated cognitive and practical skills, knowledge (including tacit knowledge), motivation, value orientation, attitudes, emotions, and other social and
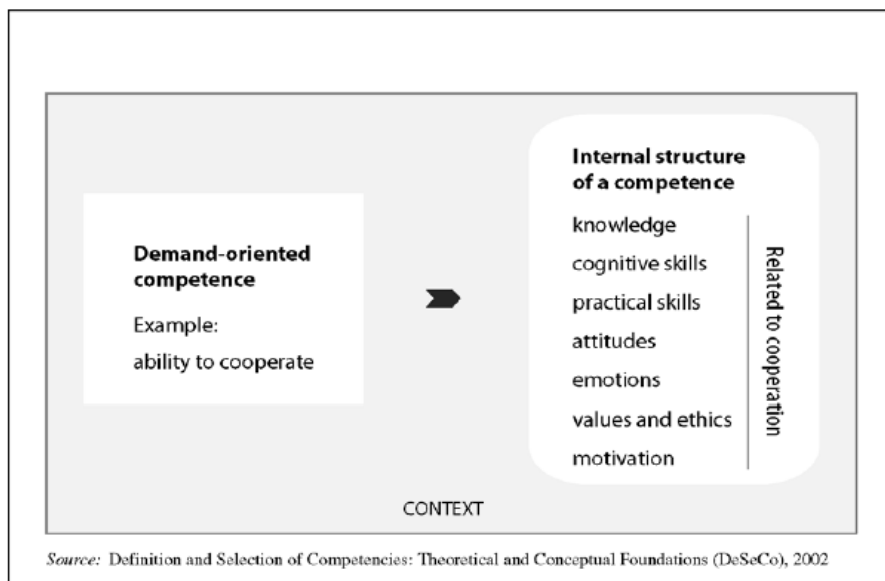
Fig. 4. The demand defines the internal structure of a competence (Definition and selection of competences, 2002).

behavioural components that together can be mobilized for effective action (see Figure 4). Although cognitive skills and the knowledge base are critical elements, it is important not to restrict attention to these components of a competence, but to include other aspects such as motivation and value orientation." (Definition and selection of competences, 2002).

It must be recognised that competences are observable only in actual actions taken by individuals in different situations. External demands, individual capacities or dispositions, and contexts are part of the complex concept of competences.

Competences are observable in the actions an individual undertakes in particular situations or contexts (i.e. both the immediate surroundings and the larger socio-economic and political environments). They don't exist internally, independent of action (which implies intentions, reasons and goals). This conceptualization is holistic in the sense that it integrates and relates such essential elements of competent performance as external demands, individual attributes (including ethics and values), and context.

Acknowledging that competences are acquired and developed throughout life and can be learned and taught in a variety of institutions and other settings, a favourable material, institutional and social environments are necessary for the development of competences. A competence is developed through action and interaction in formal and informal educational contexts. Thus, competence development does not only refer to school-related teaching and learning. Besides the education system, other institutions are also responsible for the transmission and development of the necessary competences: the family, the workplace, the mass media, religious and cultural organizations and so on.

Without resort to search for an "only true" (objectivist's approach) definition of competence, based on constuctivict's approach a description (definition) of competence appropriate to higher education area has been formulated. Acknowledging **branch** (higher education, improvement of study programmes and their components) and **purpose** (to formulate inputs towards a competence-based educational programme) **of use,** competence includes:

- "underlying characteristics of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation. Underlying characteristic means the competence is a fairly deep and enduring part of a person's personality and can predict behaviour in a wide variety of situations and job tasks. Causally related means that a competence actually causes or predicts behaviour and performance. Criterion referenced means that the competence actually predicts who does something well or poorly…" (Spencer and Spencer, 1993, p. 9);
- "… knowledge, skills, abilities, or characteristics associated with high performance on a job, such as problem solving, analytical thinking, or leadership. Some definitions of a competence include motives, beliefs and values." (Mirabile, 1997, p. 75);
- the ability to handle a (familiar and unfamiliar, foreseen and unforeseen) situation (Keen, 1992, p. 115);
- "… a compound, made up of different parts just like the fingers of a hand [i.e., skills, knowledge, experience, contacts, values, and additionally coordination which is located in the palm, and supervision, symbolized by the nervous system]." (Keen, 1992, p. 112).

Conclusions

1. Definition of the competence depends on:
- branch, purposes and context of use (education, training, human resources management, psychology, etc.);
- complexity of the job or situation;
- base for measuring competences (observable performance, standard or quality of the outcome or underlying attributes of a person).

2. The use of the competence approach will determine the starting point taken towards the definition. Where competence means the underlying attributes of individuals, then the rationale is to determine the syllabus or content of learning that will lead to competent performance. This approach allows defining the term competence and helps to define inputs for didactics of an educational programme.

3. On the base of approaches and definitions described, appropriate to branch and purpose of use, is term "competences".

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ELEMENTS OF DISTANCE EDUCATION AND E-STUDIES CONTENT IN HIGHER EDUCATIONAL ESTABLISHMENTS

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Abstract

Nowadays the industrial society changes over to the information society. The introduction of elements from distance education and e-studies is an effective means in updating traditional education system in higher educational establishments of Latvia. Due to the decrease of the amount of contact classes and increase of the share of independent work, the version of studies of a mixed-mode type (the introduction of separate elements from the distance education and e-studies in traditional subjects of studies) is the most appropriate types of education in higher educational establishments of Latvia. Hence new study materials elaborated exactly to cover the needs of independent active studies with feedback are required. The techniques type of study materials has to be acceptable for students of different age groups. The aims and tasks are to be clearly defined in the study materials for distance education and e-studies. Tests and examinations are carried out to state whether the aims and tasks are fulfilled. The objective of tests and exams is not a severe evaluation of student knowledge but the analysis of made mistakes. With the introduction of the elements of distance education and e-studies in the process of teaching and learning of subjects in higher educational establishments, the students from towns and country will have greater possibilities to acquire knowledge at the speed, time and place most suitable for them.
Key words: distance education, e-studies, study materials, feedback, tests and examinations.

Introduction

Presently all over the world the society experiences transition from the industrial society to the information society. It can also be observed in education and science. The distance education and e-studies are an effective means in updating the traditional education system in higher educational establishments.

The present society evidences such an important feature as fast change of technologies and rapid outdating of knowledge. Therefore more and more young employees and those of older age having special requirements enter the market of education. With the introduction of the elements of distance education and e-studies - special teaching/learning strategy, special study materials elaborated directly for independent active studies with feedback, study support system with advisers, consultations, which are carried out individually and in groups, special system of examinations, different electronic technologies in the process of teaching and learning of subjects in higher educational establishments - every student (both townsman and countryman) will have greater possibilities to acquire knowledge at the speed, time and place most suitable for them.

The introduction of modern technologies in education of teachers is of special importance, also in education of future teachers at the Latvia University of Agriculture (LLU). Consequently, these technologies would be rapidly applied at rural schools and town schools, and the use of technologies accessible at schools would be more efficient.

Research methods

Studies of professional literature.
Observations.

Discussion, results

The distance learning is a type of education, where a lecturer lacks continuous and direct contact with students.

Every student can study at the speed, time and place most suitable for him or her.

Independent studies form the basis for distance education. Yet it is not self-education, since it is specially planned and organized system of independent studies supported by consultants.

Distance education is mainly envisaged for adults, who are sufficiently motivated and able to organize themselves for active studies (Deķe and author collective, 2000).

The distance education is suitable for part-time studies. It is oriented chiefly for adults and it is characteristic for a specially organized study process with specially systematized and structured study materials and use of different technologies and means of electronic technologies (telephone, TV, radio, press), as well as with individual learning speed and particular evaluation type and order of acquired knowledge testing and achieved education level. The most important precondition of the successful implementation of distance education process is the mutual responsible teaching/learning collaborate of both the participants of this process – the students and the teacher – with the careful self–control and control, supplemented by the teacher's proposals for the further teaching/learning process. Distance education is student's independent study process. Seminars, consultations and other types of direct contact are also used in the distance education, however there are only elements that support study system. The distance education differs from self-education with study support system, that includes study centres, advisers, consultants, consultations individually and in groups, mentors, tests and exams, study camps (Pedagoģijas …, 2000).

E-studies is learning done by means of electronic technologies – telecommunication and computers, internet and intranet, radio and TV, audio, video tape, interactive TV and multimedia CD–ROM. The opinion of the author of this

paper is that information and telecommunication technologies, audio and video techniques can ensure new ways of studies. The special organized virtual studies environment with characteristic techniques, interaction study materials to self-education and self-estimation are an essential sign of e-studies (Lawler, 1997).

The process of distance education and e-studies is presented below in Fig.1.

The survey of above-mentioned definitions and structure scheme of distance education and e-studies suggests that the elements of distance education and e-studies can be included both in full-time and part-time studies.

The distance education can be implemented in compliance with different organizational models:

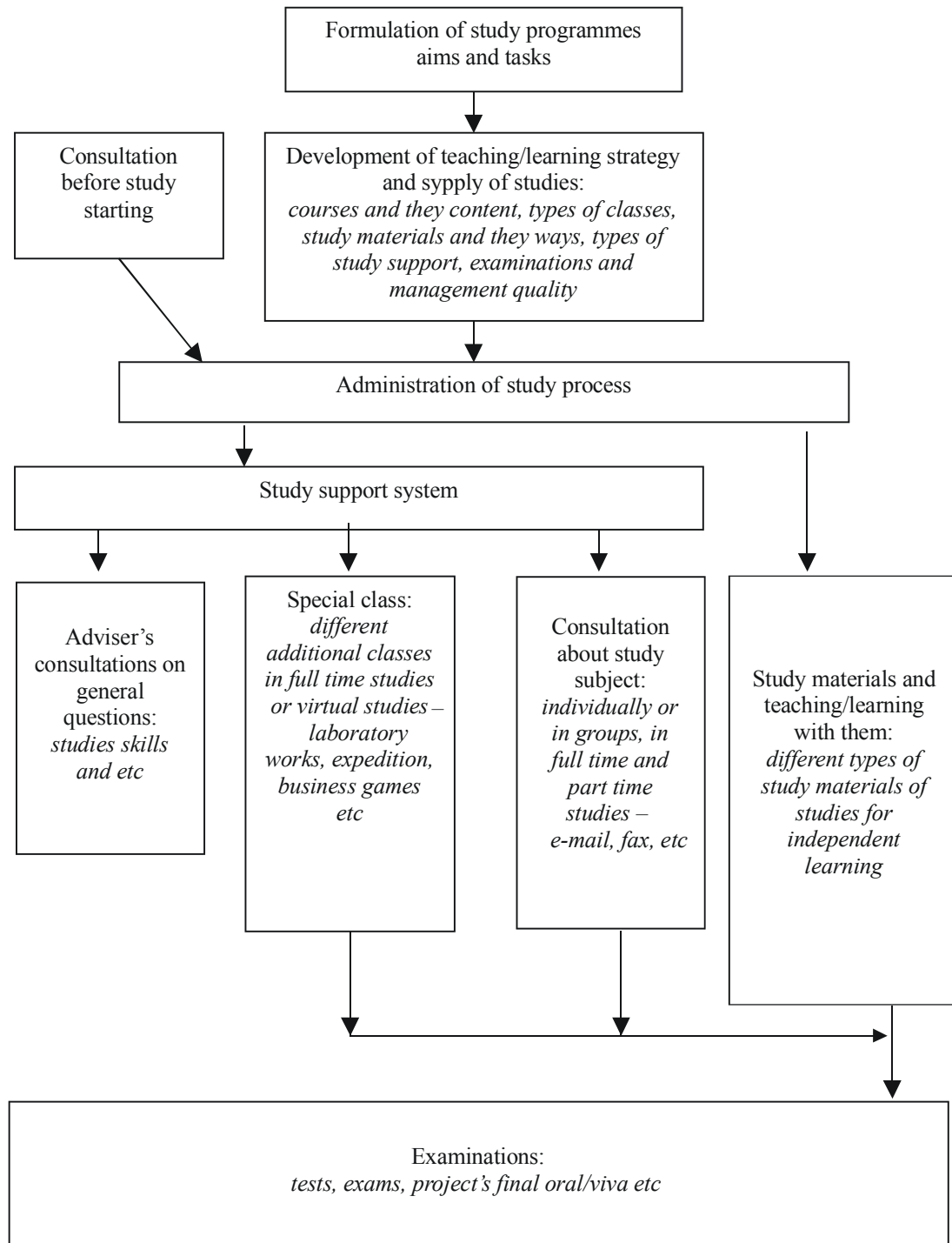- one-mode – education is carried out only by means of distance learning;

Fig. 1. Distance education and e–studies process structure scheme.

- dual-mode – distance learning is carried out parallel to traditional education;
- mixed-mode – mixed types of studies in traditional education.

Qualitative education being offered by open universities, which do only one-mode distance education, requires big investments and is very expensive. Also dual-mode distance education offering full study courses in certain subjects is expensive (Tālmācība Latvijas augstskolās, 2003). The mixed–mode distance education is the most suitable in higher educational establishments of Latvia. It means, that separate courses of one of the study programmes can be implemented both in traditional way and in distance education form also for full-time students. It allows make the study process more flexible, effective and increases the quality of educations. For example, teaching in the form of distance education for full-time first year students, part-time studies has begun in the course of commercial business at the Electronic and Telecommunication faculty of Riga Technical University in the 2002 /2003 study year. The e-studies courses in the traditional study programme were commenced at the University of Latvia in the 2002 /2003 study year (Slaidiņš, 2003).

According to the author, due to the decrease of the number of contact classes and increase of the share of independent work, the version of studies of mixed-mode type (introduction of separate elements from distance education and e-studies in traditional subjects of studies) is the most appropriate type of education in higher educational establishments of Latvia. For example already nowadays LLU lecturers frequently use modern technologies (multimedia CD–ROM) and e-mail as an addition to traditional classes forms.

The number of contact classes in full-time studies may be reduced by the introduction of elements of distance education and e-studies in traditional subjects of studies:

1. Formulation aims and tasks of study subject.

2. Development of teaching/learning process strategy and studies supply.

3. Study materials elaborated directly for independent active studies with feedback elements.

4. Study support system:
- consultations on general questions and about study subject, which are carried out individually and in groups, in full-time and part-time studies;
- usage of diverse electronic technologies (computers, audio, video tape, multimedia CD–ROM), telecommunication technologies (telephone, e-mail, fax);
- special classes: laboratory work, business games, excursion, discussions, analysis of mistakes made in the tests etc.

5. Examination.

Formulation aims and tasks of study subject: the aims and tasks of the particular study course are formulated in accordance with the students' study needs.

Development of teaching/learning process strategy and studies supply: it means that the teaching/learning strategy corresponds to the set aims and tasks. When choosing teaching/learning strategy, the students' possibilities and needs are taken into account. The teaching/learning strategy means that the course content, duration is formulated, the types of classes are chosen, the type of study materials is adapted, the study support system and examination are developed. In order to ensure teaching/learning process it is necessary to procure and prepare this study materials, necessary room and technical equipment before the start of the study course.

Study materials of the studies are developed as an alternative to traditional full-time lectures, during which a lecturer sets forth the material and answers to students questions. Different types of study materials of studies for independent learning – printed materials, interactive multimedia materials CD-ROM or placed in virtual environment. The study materials are specially structured and divided in to several parts. The aims and tasks need to be clearly defined in the materials of distance education and e-learning – stating what kind of knowledge and skills need to be acquired at the end of the course. The directions and advices on the study methods need to be included there. Each part starts with the aim and task and questions for self-control and exercises are included into each section. Questions for self-control, tasks and exercises ensuring interactivity and motivation are included in these materials. Each part of the course usually ends with a summary, a list of literature and a test to be submitted for correction and provision of feedback. The glossary of terms, right answers to the questions for self-control and exercises are also to be included in these materials. Scientific writings, monographs, standards, sets of laws and different other materials are recommended for additional studies and more profound acknowledgement of the subject. Sometimes copies are already attached to the materials. Fig. 2. illustrates the study materials structure scheme.

The technologies type of study materials should be acceptable for students of different age groups. The "tutorial in print" materials are recommended for older students who do not work on a computer or have no access to computers. Where as young students are more eager to work with study materials prepared by means of modern technologies.

The study materials regardless of technology are developed to stimulate **active studies.** It might be achieved by: doing exercises, reflecting on the studied material, answering self-control questions, fulfilling tests, applying obtained knowledge and skills in practice. The principle of "learning by doing" works in the active studies. To implement this principle, exercises on all important themes of the study course are included in the study materials. The content of exercises should promote the acquiring of the necessary knowledge and skills.

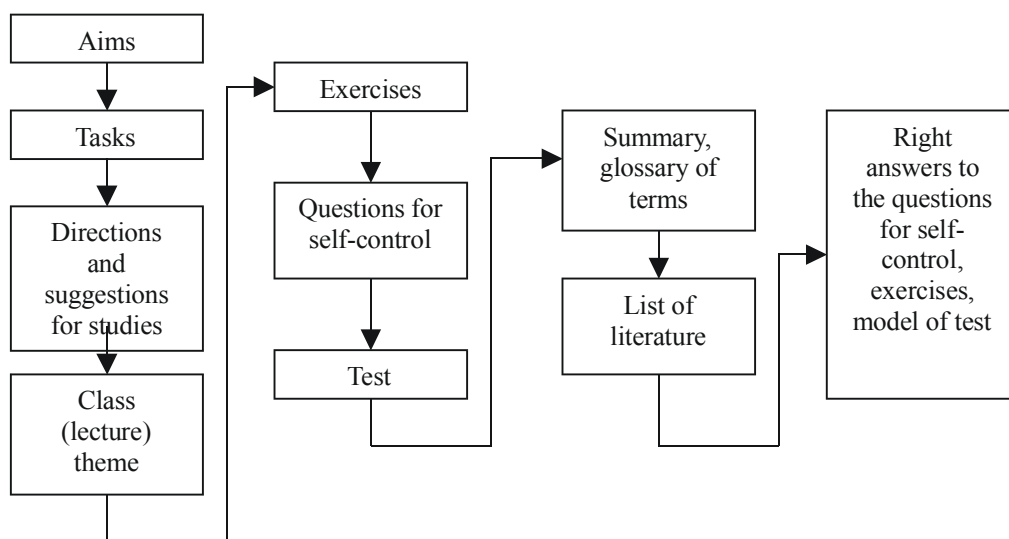**Study support system:** the basic principle, used

Fig. 2. Structure scheme of study materials.

in the study support system, is a **feedback.** The study support is implemented by the member of teaching staff as a consultant (tutor). The study support form is individually and groups consultation through tutorials and correspondence (e-mail, fax, etc), discussions, laboratory works, excursions and so on.

The teaching/learning methodology of distance education and e-studies should insure strengthen feedback. The contacts are made to achieve the feedback. Every student may assess his or her achieved results, if:

- the right answers or samples of answers and possible variants to the set questions and tasks are given, so a student at once can ascertain the comprehension of the material;
- during consultations and seminars students exchange their knowledge;
- the lecturer's comments, notes and directions are listened to;
- the results of tests and exams with notes and comments are received;
- the knowledge and skills are applied in practice.

The lecturer in turn can evaluate the quality of study materials and quality of the job performed according to the questions asked during consultations and in electronic technologies (telephone, e-mail, fax), from characteristic mistakes made at tests and exams.

Examination: to state whether the aims and tasks are carried out, the knowledge of students is tested by means of tests, exams, a report or an essay, a project or a dissertation, modelling of situation and analysis or training work. To avoid monotonousness in the study process, it is recommended to change the forms of tests during the course of teaching process. Small but regular tests are advised in the study process to ensure a continuous feedback.

The main methodological principals, then developing examinations:

- first of all easy questions and exercises should be given;
- questions and exercises should be formulated precisely and clearly; they should help to find out, whether the aims and tasks of the course are achieved;
- students should be prepared for such type of examination.

What should be considered, when preparing of examination:

- there should be only one correct answer to each question;
- how the partly correct answers would be assessment;
- whether all the basic knowledge and skills are checked that had to be acquired within the course.

Examination task is not a severe evaluation but the analysis of mistakes made to adjust the study process to let the students feel satisfied with their achievements and promote their wish to proceed with even more intensive studies.

Conclusions

1. The mixed–mode distance education is the most suitable in higher educational establishments of Latvia. It means, that separate courses of one of the study programmes can be implemented both in traditional way and in distance education form also for full-time students. It allows to make the study process more flexible, effective and increases the quality of education. Then every student (both townsman and countryman) will have greater possibilities to acquire knowledge at the speed, time and place most suitable for him/her.

2. When the number of contact classes decreases and the share of independent works increases, the version of

studies of mixed-mode type introduction of separate elements from the distance education and e-studies in traditional subjects of studies is the most appropriate type of education in higher educational establishments of Latvia.

3. The number of contact classes in full-time studies may be reduced by the introduction of elements of distance education and e-learning in traditional subjects of studies: special studies materials elaborated directly for independent active studies with feedback, special system of examination, consultations, discussions, laboratory works, analysis of mistakes, made at tests, carried out individually and in groups in full-time and part-time studies, diverse electronic technologies (computers, audio, video tape, multimedia CD–ROM), and telecommunication technologies (telephone, e-mail, fax).

4. Study materials are to be developed for independent active studies to ensure provision of feedback.

5. The technologies type of study materials has to be acceptable for students of different age groups.

6. The task of examinations is to analyse the study process, stimulate students for more intensive studies, and ensure feedback.

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STUDY COURSE "RURAL TOURISM" IN HIGHER EDUCATIONAL ESTABLISHMENTS

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Abstract

Rural tourism is becoming more and more important in Latvia and Europe, where rural environment changes began already more than a couple of decennaries ago. Current trends in development of tourism are favourable for lasting development of rural tourism in the whole European Union. Rural tourism in Latvia is extremely popular, because it includes both recreational and cognitive elements of tourism, and takes place in countryside. It gives people a chance to become acquainted with a country lifestyle, the process of production and be in touch with nature, be able to obtain strength and take emotional pleasure in the energy of nature. The study course "Rural tourism" is lectured both in Latvia's, and foreign higher educational establishments. This course usually is the free choice study object. The aim of the work is to observe study course "Rural tourism" aims and describe the content of this study course in higher educational establishments in Baltic states and North Europe.

Key words: study course, rural tourism, credits, content, aim.

Introduction

Rural tourism has become a perspective, because it gives an opportunity to create new working places, limit outflow of rural population to city, conserve country environment, and further the development of Latvian national economy. Latvian countryside and its tidy environment help set off Latvian traditions and values, which are not found elsewhere in the world. Rural tourism is one of those areas that helps popularize these values. Today, historical, national and exotic values are worldwide respected, and traditional Latvian culture is original and with deep roots. In recent years, the demand has increased for rural tourism and trips over the areas in Latvia and for recreation in slightly modified nature environment.

The study course "Rural tourism" is analyzed in concordance with Education Law and Higher Educational Establishment Law of the Republic of Latvia. The concept of the study program and study content in the Higher Educational Establishment Law is described. The course of the study content determines:

- requirements to preliminary education;
- the aims and tasks of program realization;
- the content of education;
- the program acquirement time division;
- acquired knowledge estimation criterions and control forms etc. (Higher Educational Establishment Law, paragraph 55, 1995).

In the regulations of Education Law, the course program is determined as an educational program component. It contains:

- the aims and tasks of study course;
- content of the study course;
- the plan of content acquirement;
- knowledge estimation criterions;
- the methods of learning (Education Law, paragraph 1, point 13, 1999).

The study course is a part of study subject (lectures, practical work, self-dependent studies, etc.) within the term.

Next, the study course "Rural tourism" will be described and following parameters and criteria of the study course will be featured:

- Volume (number of credits)
- The aim of the course
- The content of the course
- Obligatory and commendatory literature volume.

The main comparing criteria is the aim of study course "Rural tourism". There are many higher educational establishments where tourism studies are represented, but we observed only the study courses "Rural tourism" with above-mentioned parameters. We compared the aims and the content of study course "Rural Tourism" to determine the field of study course in different higher educational establishments.

Methodology

The following methods were used to carry out the research: theoretical research, survey (normative documents and scientific sources).

Text of report

Latvia University of Agriculture. The study course "Rural tourism" is realized at the faculty of Agriculture at LLU. It is an optional course that is made as a huge block of study subjects with 10 credits. The aim of this course is to give knowledge about the importance of tourism, tourism development, contribute to appreciation of the values of fatherland's culture, history and nature.

The authors of the course anticipate that it could rouse the interest of students in self-dependent studies, independently do research on Latvian cultural and historical heritage. The structure of the content of this course is made as follows:

1) space and environment,
2) basics of tourism,
3) culture studies (ethnotourism),
4) business activities in rural tourism,
5) interface in tourism,

6) agroenvironment,

7) service of tourism,

8) tourism in Latvia and in the world.

The educational materials are directly connected with rural tourism in three chapters of the course: in the chapter „Basics of tourism" (1 credit) students are acquainted with the concept of rural tourism, its characterization and development prospects in Latvia. Students are given lectures about safety regulations, statutes and normative acts in rural tourism. The recent study literature is included in bibliography (8 titles).

In the chapter „Culture studies" („Ethnotourism") – 1.5 credits. The aim of ethnotourism is to return to the native place (for example, parents home, place of childhood, relatives). This kind of tourism is called nostalgia tourism. Latvian rural tourism in "Culture studies" is offered as a potential of Latvian culture, history, and nature. The concept of culture and culture environment are interpreted in the culture block. Students are acquainted with Latvia's politics of culture and the national programme „Culture". Ideas about Latvian identity and perspectives of integration are created in this chapter. Students obtain information about cultural archetypes, mythic culture and ethnoculture. Lectures are delivered on how Latvia's culture, history and nature are disclosed on television, radio, and the Internet. Students research cultural monuments in Latvia. Educational materials about historical places in Latvia, history of areas, and also cultural and historical differences in districts are described in the „History" block. Students are acquainted with folklore, orthography in Latvia, and activities of the museums. Materials about folkdances and national costumes, national craft are included in the course. Students are acquainted with the aesthetic potential of landscape, peculiarities of the territory of country parks in the „Nature" block. Characteristics of adventure tourism and active tourism in the countryside are given. Students get the notion about health recreation tourism in country and theatre performances outdoors. Students have to plan tourism itinerary in the country and they have to write a paper about utilization of Latvian cultural, historical or nature resources in practical part. Both recent and past (of the year 1937) literature are included in the bibliography (4 titles).

In the chapter „Tourism in Latvia and in the world" – 1.5 credits - students are acquainted with tourism resources, „Latvian Tourism Law", literature about tourism, and activities of the Rural tourism association. A University lecturer expounds the material about active tourism and recreation in countryside. The task of practical part is to plan an itinerary of an excursion or a trip. The recent literature is included in the list of obligatory and commendatory literature (8 titles).

The School of Business Administration "Turiba". The study course „Rural tourism" is included in Tourism and Hospitality Management study course. It is a free choice course and its volume conforms to 2 credits. The aim of the course is to give students necessary knowledge and skills of how to establish and direct rural tourism enterprise; teach them to understand and evaluate resources and development possibilities of rural tourism; and introduce the products of rural tourism.

The content of the course.

1. Rural tourism importance, its resources, influence and possibilities of development.

Rural tourism concepts and definitions.

2. The types of rural tourism enterprise.

The products of rural tourism.

The marketing of rural tourism.

3. The offer and strategy of development of Latvian rural tourism. Supports of the state and local authority, collaboration of the entrepreneurs.

Bibliography includes published materials „Lauku ceļotājs" and the recent literature in English (in total 6 titles).

Vidzeme University College. The study course „Rural tourism" is a free choice course (part B) and its volume conforms to 2 credits.

The aim of the course is to create an understanding among students about rural tourism, give knowledge about trends of its development in Europe and Latvia, give students practical knowledge of how to adjust a country estate to the needs of tourism, how to furnish living-houses and bath-houses, give basics of how to organize feeding and leisure time spending for tourists, to give knowledge of how to chair recreational and sporting events.

The themes of term-papers are connected with the design of rural tourism infrastructure and development of tourism in countryside. Students must be able to organize and manage a rural tourism business after acquisition of this course. Practical part contains preparation of a report that has to be publicly presented and practical works.

The content of the course.

1. Terminology, rural tourism importance, its resources and products.

2. Rural tourism in Europe, the source of rural tourism development, situation of the rural tourism market in Europe, international associations (EIROGITS etc.)

3. Rural tourism in Latvia, history of its development, situation of rural tourism market in Latvia, the strategy of its development, marketing of a rural tourism product.

4. Demand and supply in rural tourism, projection and headship.

5. The inception of activities of rural tourism establishment (habilitation):

people and environment, quality standards of establishments (habitations), contract signing, preparing to receive visitors, information for visitors, basic principles of room arrangement.

6. Tourism activities in countryside: recreation near the water, ecotourism, observing birds and animals, hunting and fishing, velotourism, celebration and festivity.

Bibliography contains literature only in English (4 titles).

Students also have an opportunity to become ac-

quainted with celebration of Latvian festivals. The course "History of culture and tourism" is included in the obligatory part of tourism organization and management study programs. One of the aims is to introduce students with heritage and traditions of culture and history in Latvia`s regions. The emphasis in the course "Geography of tourism" is put on charisma of Latvia and the region of Vidzeme from the view of tourism. An understanding about how tourism is of benefit to the state, region, rural municipality and country estate is created among students in the course "Introduction into tourism". The free choice part includes the course "Introduction to human geography", where an understanding is created among students about landscape construction and the role of human in it. Students have practice in different tourism agencies, "Lauku ceļotājs", Vidzeme tourism association, local lore museums of the area of Valmiera, and farms that are involved in tourism business. Students work on diploma papers and choose interesting themes about tourism: "Culture tourism in Kurzeme", "Nature paths in Latvia", "Resources and possibilities of culture tourism in Vidzeme", etc.

Liepaja Academy of Pedagogy. The study course "Rural tourism" is the professional specialization course of the sector and its volume conforms to 1 credit. The aim of the course is to acquire the basics of rural tourism business.

The content of the course.

1. The place of rural tourism in tourism industry.

2. Rural tourism as alternative trend of agriculture.

3. Accommodation of rural establishments to needs of tourism.

4. Europe standards in creation of campsites.

5. Agrotourism, the place of biodynamic agriculture enterprises in rural tourism.

6. The certification of establishments (habitations) utilized in rural tourism, the "Green certificate", association "Lauku ceļotājs".

The recent literature is included in bibliography (7 titles).

Rural tourism is studied as an alternative specialization of agriculture in the Liepaja Academy of Pedagogy. The course "Nature sciences" is offered to students in the professional study programme "Tourism management", students enrich their knowledge by researching native land folklore and native land literature. If one studies geography and biota of Latvia, he/she will acquire a lot of useful knowledge. Students study the resources of Latvia's nature and its possibilities in development of tourism. Students are told about the Baltic Sea, glacial hollows (coulees), braes and waterfalls as favorite tourism objects. Much attention is paid to Latvia's lakes, fountains and curatives and their cultural and historical importance. Students become acquainted with biodiversity of Latvia and learn environment science. Lecturers also read courses "Landscape science" and "Ecotourism". Students have ecotourism practice: they must know how to evaluate territory landscape. The aim of the

course "Tourism management" is to prepare specialists of tourism, paying particular attention to the region of Kurzeme. Professional specialization courses of the programme sector contain courses: "Tourism and environment" and "Geography of Latvian tourism", where students research cultural and historical tourism resources become acquainted with the Baltic Sea as a significant factor of Latvian tourism development, with inland waters as a favorite tourism object, ecotourism, rural and urban tourism. The course "History of culture" gives an opportunity to acquire basic problems of culture logics of today and reveals the variety of cultural theories. Students use theoretical knowledge to look into the history of concrete areas and towns, they get to know the role of the study of local lore in the research of Latvia's history in the course "History of Latvia and tourism". Free choice courses are: "Native land folklore", "Peculiarities of native land language", and "Tourism objects of Latvian nature". Students become acquainted with the types and genres of Latvian folklore, they are given knowledge about Latvian mythology and interrelation between mythology and folklore with the emphasis on specific features of the regions in the course "Native land folklore". Lecturers tell about calendar customs, celebration traditions of people, folksongs and narrative folklore. Folklore in the context of today's culture and specificity of folklore in the regions of Latvia are also studied. The best cultural workers of the native land are studied in the course "Native land literature". Students become acquainted with the native land literature as an original reflector of Latvian intellectual life and aspirations. Lecturers tell about a portrayal of color of native lands and centuries-old processes in Latvian literature – landscape, traditions, sights of everyday life, and cultural processes. In this course, Latvian regions are characterized in cultural and historical aspects and portrayal of regions in Latvian literature is studied – description of landscape, revelation of traditions, processes of cultural and economic life in the works of Latvian authors. Students are taught about the peculiarities of the native land language, of the regions of Zemgale and Vidzeme – a place where many distinguished persons lived and worked. The attention is paid to the aspect of study of local lore of the literary process. The course "Peculiarities of native land language" gives knowledge about the link between the historical and cultural regions of Latvia and dialects of Latvian language and its areas. Students become acquainted with a reflection of the peculiarities of native land language in Latvian folksongs and works of Latvian writers. The course "Tourism Objects of Latvian Nature" also is a free choice course, its aim is to study natural resources of Latvia – landscape, big stones, big trees, cult stones, rock drawings, etc. natural sites, and to rouse the interest of students in the studies and protection of natural sites. Natural sites are investigated as the elements of landscape and as the content of Latvian landscape. This course gives information about nature symbols in the stones, rock drawings as a discovery of unique petroglyphs. Students are acquainted with cul-

tural and historical objects of the native town in the courses „History of Liepaja" and „ History of Liepaja architecture".

So, the course „Rural tourism" at the Liepaja Academy of Pedagogy has practical direction, although the other courses of the programme give opportunity to students to enrich knowledge in several areas and infer from self-dependent work in the research of the native land.

There are specializations „Tourism and Hotel Management" and „Tourism Business" in the programme „Economics" at Rezekne Higher Educational Institution. Rural tourism is mentioned only in the course „Service bookkeeping", where students learn the peculiarities of organization and accountancy of rural tourism bookkeeping. Currently, the theme of scientific work "Possibilities of tourism development in the region of Latgale" is researched. None of research papers is about tourism or rural tourism. Thus, economic approach is observed in the studies of tourism objects. The department carried out training for tourism businessmen of Latgale, in which students were also involved. This higher education establishment provides interesting career opportunities for students of tourism specialization: travel agents, tour operators of various levels, and tour consultants in corporative level. An interesting approach is carried out there. After acquiring a definite part of the programme, a qualification paper is awarded to students.

Lithuania. There are tourism programmes also at Lithuania's higher education establishments: "Tourism and sport management" and "Recreation and tourism management". It is possible to obtain a qualification of a rural tourism organizer and a qualification of a recreation and tourism manager in higher education establishments of Lithuania. It is possible to study a free choice course "Tourism and Recreational resources" (3 credits) in the programme "Recreation and tourism" of the Faculty of social sciences at Klaipeda University. The aim of the course is to introduce students to development of the Recreation and Tourim system in Lithuania, Finland, and other Baltic states. The course "Rural geography of Lithuania" (1.5 credits), where students become acquainted with Lihuanian natural resources, perspectives of rural development, and rural tourism as an alternative to labour of rural population is included in this programme. Besides, students attend the following courses: "Culture Heritage", "History of Lithuanian culture", and "Lithuanian Ethnoculture". This programme contains the course "Rural tourism" (chapter B). The content of the course "Rural tourism" is not available. The list of the rest of higher educational establishments of Lithuania is not available in English, only in the Lithuanian language.

Estonia. Students can study tourism speciality in Estonia higher education establishments. Only the list of programmes is available at the Faculty of Economics of Estonian Agricultural University. There is a tourism speciality at the Faculty of Economics and Business Administration at the University of Tartu. The programme "Tourism and transportation" contains the courses "Geography of Esto-

nian tourism", "Tourism projection", and other courses related to economics. In Estonia, students can study at the College of Tourism and Hotel Management. The Tallinn Pedagogical University offers the course "Tourism Management", but information about the content of the course is not available. Available materials are only in Estonian language. There are no courses related to tourism at the Estonian business school.

Finland. Laurea Polytechnic Tuusulanjarvi Institute offers programme "Tourism" (140 credits). This programme contains courses "Introduction to tourism", "Tourist geography", "Cultural tourism", and "Rural tourism" (5 credits). An important role in this course is granted to culture studies and language lessons. A specialist of tourism sector must know 3 languages. **Lahti Polytechnic Institute** offers study programme "Tourism management" that contains course "Rural tourism" (2 credits). The aim of the course is to introduce students to concept of rural tourism development and the share of rural tourism in tourism industry, give students knowledge about the resources and perspectives of rural tourism, learn to organize the enterprises of rural tourism.

The content of the course.
1. Rural tourism in Finland and Europe
2. Entrepreneurship in rural tourism
3. Rural policy programmes in Finland
4. Projects and the EU (European Union)
5. Visiting a rural tourism operator.

Business School Ikaalinen offers study programme "Business Administration and Tourism". The programme contains study course "Nature tourism" (2 credits). The aim of the course is to familiarize students with the conditions of rural tourism, give knowledge about tourist attraction factors, and familiarize with supply of rural tourism in Finland as well as the forms and activities of rural tourism during the study unit.

The content of the course.
1. Concepts of rural tourism
2. Products and activities of rural tourism
3. Building the operational environment of rural tourism
4. Environmental effects of tourism
5. Finnish nature as tourist attraction
6. Globally significant rural tourist attractions.

Following teaching and learning strategies, this course applies: lectures, group work, and study trips.

There are many interesting courses like "Ecological modernization and agricultural extension" at the Faculty of Agriculture and Forestry of the University of Helsinki. However, the course "Rural tourism" is not included there.

The University of Joensuu offers different tourism studies, for example "Tourism as an economic activity", "Introduction to tourism entrepreneurship", "Economy of tourism and the economical impacts of tourism", "Culture and tourism", "Tourism, tourist and culture", "E-business in tourism", "Tourism and arts", "Finnish culture and tourism", etc. The

University of Joensuu offers a free choice study course "Rural tourism", but the content of the course is not available.

Scotland. The Scottish Agricultural College offers study programme "Rural recreation and tourism management". The aim of the course is to equip students with the necessary management skills of rural based recreation, familiarize students with tourism activities in rural areas, teach students to use nature resources. Management theory is applied during practical works in rural areas. Students can select also "Culture studies". The content of this course: 1) Rural tourism and countryside recreation, 2) Culture studies, 3) Environmental awareness, 4) Rural tourism management, 5) Planning horse-riding itineraries (practical horse-riding can also be elected), 6) Information technologies in rural tourism, 7) Managing an event. Studies take place not just in the lecture-halls. Students travel along Scotland, write reports and papers, and learn business activities in rural tourism by practice. The Scottish Agricultural College offers also the Postgraduate course "Rural tourism management" spanning 2 years. The aim of the course is to introduce students to rural development, tourism and rural business, culture studies, and environmental awareness.

The content of the course.
1. Research and information management
2. Tourism and integrated rural development
3. Rural business management and diversification
4. Rural community and cultural identity
5. Tourism, cultural heritage and the rural environment
6. European tourism and regional development.

The University of Abertay Dundee offers study course "Tourism". The course contains following themes: the social and economic contexts of tourism, tourism management, consequence of tourism, cultural heritage management, tourism, and the environment.

Iceland. For comparison, we can view study programme "Rural tourism" at the **Holar University College** in Iceland. The aim of the programme is to make students aware of the rural tourism industry, teach them to manage small tourism enterprises, and how to develop recreation activities making use of rural nature and cultural heritage. The content of the course.
1. Principles of economics
2. History of Iceland (rural history, agriculture, literature, art and applied art, traditions and national cuisine). Students prepare a presentation about the culture of Iceland in tourism industry.
3. Hotels and Service (public relations, safety of the visitors).
4. Environmental awareness (science) (natural history and biota of Iceland, geology of Iceland, nature protection, ethics of people environment, aesthetics and technical aspects).

Great Britain. There is a study module "Rural tourism management" at the **University of Wales** in Great Britain. The aim of the study programme is to familiarize students with the theoretical and practical nature of management in rural tourism within the United Kingdom and wider European contexts. The programme "Rural tourism management" assesses the various approaches to the management of the rural tourism resource.

The content of the study programme.
1. The concept of rural tourism
2. The attraction of rural areas as tourism destinations
3. Tourism activities that take place in the rural environment
4. The management of resources for rural tourism.

Students fulfill projects and write reports on rural tourism, and access the Internet when gathering information for homework. The recent literature about rural tourism is included in the bibliography (4 titles).

The University of Newcastle offers study programme "Rural studies". The aim of the programme is to teach students to manage the use of rural resources. The study programme contains following study courses: "Rural resources", "Landscape assessment", "Cultural heritage management", and "The use of land". Students are offered the courses "Rural planning and politics" and "Countryside management", but courses related to tourism are not represented. There is also study programme "Rural resource management" at the University of Newcatsle. There are no courses related to tourism in this programme too.

Results.

The results of researching the aims and the content of study course „Rural tourism" in different higher educational establishments shows that the main field of the study course is tourism entrepreneurship; the syllabus includes issues about principles of rural economics, nature protection, culture studies. Full information about the study course „Rural tourism" field is included in the next table:

Conclusions

1. Study course „Rural tourism" is offered in many higher educational establishment in Baltic states and North Europe. There are such countries like Lithuania, Iceland, Scotland, Finland, ect.

2. Information about study course „Rural tourism" predominantly is approachable in several languages including English, sometimes only in the native language (Lithuanian, Estonian).

3. The main aim of study course „Rural tourism" is to give students knowledge about basics of rural tourism business, to teach them to manage small tourism enterprises.

4. The content of the study course „Rural tourism" includes themes about principles of rural tourism economics, nature protection, history of the native land and language, culture studies (ethnotourism), and nature attraction as tourism destination.

5. The volume of study course „Rural tourism" volume differs from 1 credit to 10 credits.

6. Students' chosen study course „Rural tourism" can also improve knowledge by free choice courses like

Table 1

The aims and the field of study course "Rural tourism" in different higher educational establishments

Higher educational establishment	The aim of the study course	Field of the study course Rural Tourism
Latvia University of Agriculture	- to give knowledge about tourism importance, - to provide knowledge about tourism development, - to contribute to appreciation of the values of fatherland's culture, history and nature.	Tourism entrepreneurship, culture studies
The School of Business Administration "Turiba"	- to give students necessary knowledge and skills of how to establish and manage rural tourism enterprise; - to teach students to understand and evaluate resources and development possibilities of rural tourism; - to introduce the products of rural tourism.	Tourism entrepreneurship, marketing strategy
Vidzeme University College	- to create an understanding among students about rural tourism; - to give knowledge about trends of its development in Europe and Latvia; - to familiarize students with practical knowledge of how to adjust a country estate to needs of tourism; - to acquaint students with how to furnish living-houses and bath-houses; - to give basics how to organize feeding and leisure time spending for tourists; - to offer knowledge about how to chair recreational and sporting events.	Tourism entrepreneurship, recreation management, culture studies
Liepaja Academy of Pedagogy	- to acquire the basics of rural tourism business	Tourism entrepreneurship, culture studies
Laurea Polytechnic Tuusulanjarvi Institute (Finland)	- to introduce students to concept of rural tourism development and the share of rural tourism in tourism industry; - to offer students knowledge about the resources and perspectives of rural tourism; - to acquaint students with how to organize the enterprises of rural tourism	Tourism entrepreneurship, culture studies
Business School Ikaalinen (Finland)	- to familiarize students with the conditions of rural tourism; - to teach students tourist attraction factors; - to acquaint with supply of rural tourism in Finland as well as the forms and activities of rural tourism during the study unit	Tourism entrepreneurship, nature protection
The Scottish Agricultural College (Scotland)	- to equip students with the necessary management skills of rural based recreation; - to familiarize students with tourism activities in rural areas; - to teach use of nature resources	Tourism management, culture studies, nature protection
Holar University College (Iceland)	- to make students aware of the rural tourism industry; - to teach students to manage small tourism enterprises; - to teach how to develop recreation activities making use of rural nature and cultural heritage.	Tourism entrepreneurship, culture studies, environment
University of Wales (Great Britain)	- to familiarize students with the theoretical and practical nature of management in rural tourism within the United Kingdom and wider European contexts	Tourism entrepreneurship

„Nature science", „Landscape science", „Ecotourism", „Tourism and environment", and „Tourism objects of native land".

7. In addition, higher educational establishments offer study courses connected with native land culture: „History of culture and tourism", „Native land folklore", „Ethnotourism", and „Peculiarities of native land language".

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ARTS EDUCATION AS PEDAGOGICAL PROBLEM

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Abstract

The purpose of Arts Education at University is to create students' attitude to five forms of Art – literature, drama, dance, music, and visual arts. As a study subject, the Art is an integral part of Education and perception of Art is the result of cognition of the surrounding environment. A.Dauge (1868–937) and J.A.Students (1898–1964) observed that Arts Education is finding out the question of integrity the logically rational and the emotionally experienced in the system of counterbalancing mind and feelings. At the beginning of the XXI century, as the paradigm of Education is changing, the opinion also changed about what makes a knowledgeable and socially valuable person. In order to promote the development of one's personality self-fulfillment pedagogues are called for introducing certain changes which are contributing to the opening - up of their students. University students are going through the process of evaluation of an interpretation of opera as recorded performance on a videotape and in live performance on the opera house stage. It makes their opinion based on well – grounded argumentation and personally valuable self - evaluation. The last is functioning as the regulating mechanism for learning the properties of Arts in the context of developing the human personality. The opera performance on the stage is the live communication with a different culture heritage and people are going to performances to be immersed in Art values. Usually the repertoire is hosen for visiting the opera house as an interesting and enjoyable entertainment for students. Such masterpieces as "The Magic Flute" of W.A.Mozart, "Flying Dutchman" by R.Wagner, "Aida" and "La Traviata" by G.Verdi are actually stimulated the students discovery of the artwork. Understanding of opera art increases the students' knowledge, emotional experience, interest and positive attitude to high art values. Arts Educating as intelligent cultural assessment is the dominating purpose of the teaching - learning process.

Key words: arts education, opera performance, personally valuable self-evaluation.

Introduction

There is an important parallel here between high culture and Arts Education. Pedagogues have debated the value of high art: what exactly do we learn and teach through the study of the five forms of art – literature, drama, dance, music, and visual art? Are we simply memorizing dates and facts, compositions and techniques or some other kind of knowledges involved there?

Art as a study subject at University in my approach includes three distinct kinds:

1) knowledge "that" or informative level;

2) knowledge "how" or skilled level;

3) knowledge "what" or valuation level.

In reverse order these correspond to the three inputs into a rational mind: the ends, the means, and the facts. University studies are orientated to educate the well-balanced humane personality who knows not only what to do as a matter of right evaluation but also involves feeling. This means feeling what the Art situation requires: the emotion towards the right object on the right occasion and in the adequate degree. Arts Education has just such knowledge as its goal – it is an Education of the Emotions.

By teaching-learning process students are extending the repertoire of emotions. Feeling does not exist in and of itself, in some purely subjective medium. Feeling exists only when it finds an objective form as the opera performance in live for example. Such kind of feeling involves a picture of the cultural world and it is predicated on understanding through self-evaluation. Through reading literature, listening music or looker-on dancing we are restored. This is the importance of Arts Education and it continues to provide the aesthetic vision that all forms of Art are made so easily available.

Students began to dispute over the difference between recorded opera performance on a videotape and in live performance on the stage. At this point they might object to the direction of personal juxtaposition. Some of the greatest examples of opera art in XVIII and XIX centuries are attempts like "The Magic Flute" of W.A.Mozart, "Flying Dutchman" of R.Wagner, "Aida" and "La Traviata" of G. Verdi to discover an inward and imagined world in live performance on the opera stage.

In modern pedagogy, upbringing of a human personality is the main goal of Education and it is aimed at cultivation as unity of students mind, feelings, and will. Scientific research findings in medicine on the brain's functional asymmetry point out the fact that a spoken word is perceived by one side of the brain, while music and word together is perceived with both cerebral hemispheres. Exploitation of opera art performances as one of teaching-learning methods is accepted, in my opinion, as the productive way to distinguish the difference between good art and bad one. It is possible by using synthesis of art forms in opera performance to construct curricula whose sole contents are the masterpieces of literary, musical or artistic tradition. The aim of the case study is to discover the pedagogical conditions furthering the student's understanding of Art values as being significant for themselves.

Methods

The research is based on the data received from the analysis of the situation in practice. During the five academic years (2001–2005), an experiment with opera art
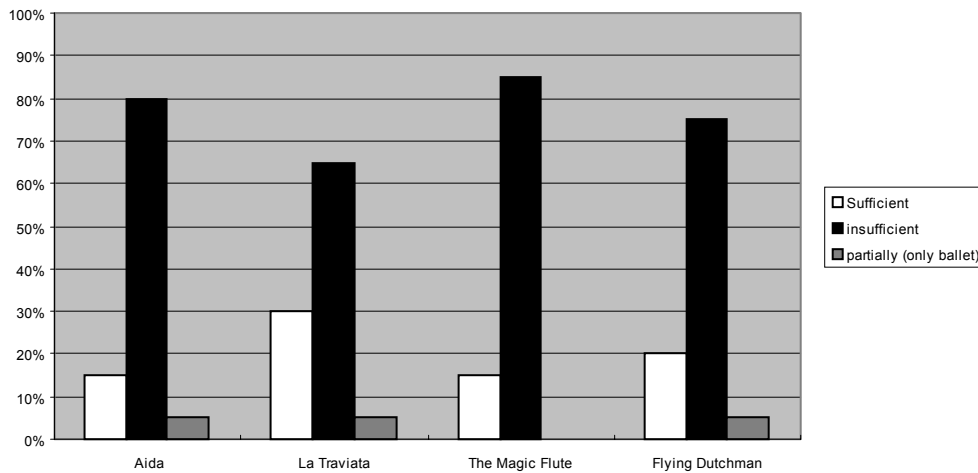
Fig. 1 The levels of information before student's visit.

perception was held. Students examined four different opera performances and their emotional experience was carried out in 2 stages:

1) audio – visual opera film presentation in the auditorium;

2) performance in live in the Opera House in Riga.

The possibility of didactic audio – visual opera presentation has such significantly factor as easy access to the teaching-learning material (opera film recordings). It helps students concentrate to a large extent on teaching knowledge about art values.

Four different opera performances were chosen for examination:

1) "Aida" by G. Verdi in 2001;

2) "La Traviata" by G.Verdi in 2002 and 2005 (twice);

3) "The Magic Flute" by W.A.Mozart in 2003;

4) "Flying Dutchman" by R.Wagner in 2004.

The pedagogical study examined 3 distinct kinds or 3 levels of student's knowledge: information, skills, and values. The efficacy of the Arts Education was perceived to depend upon the students' practical activity and personal satisfaction they gained from discovering literary sources of the opera masterpiece.

Students were asked to complete a questionnaire that was constructed in three parts. The first of them was about the visiting Latvia National Opera house in Riga listening to a live opera performance on stage. The second part of the questionnaire was about the student's perception of the main idea of the opera content after visiting Latvia National Opera. The third part was about the importance of opera art for their opera listening activity as a value being significant for themselves. In the case study, the author observed the students during and after the opera performance in Latvia National Opera house.

Results

The outcomes attributable to the Arts Education confirmed large differences between the quality of student's art experiences. The effects of the Arts Education are increasing to stimulate the initiative and innovation in the field of study subject. The major group of students displayed a weak perception in at least one of the five forms of art. Another significant discovery was the limited impact of the Arts Education on the majority of students at the University. To this extent and with varied degrees of relevance to all the artforms, the rhetoric of the "arts as accessible to all" was not always carried out in reality.
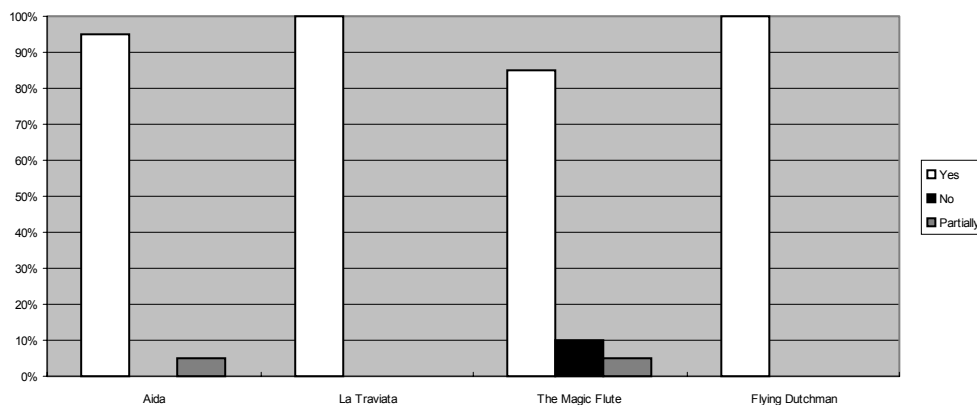

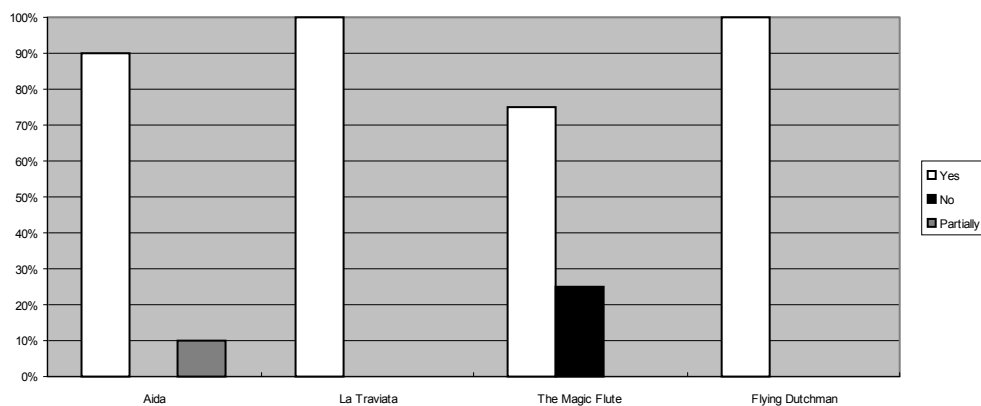Fig. 2. Perception of the main idea of the opera content.

Fig. 3. Importance of opera values for students.

The Arts achieved a wide variety of important effects and was the most likely to be perceived as having an impact. Finally, the Arts were seen by the students to have the most considerable effect on the whole University ethos, mainly encouraging a positive cohesive atmosphere through enchanting enjoyment, student's self-esteem and overall achievement.

The students were asked to fill in the first part of the questionnaire before visiting LNO. The results of the first part showed that most of students had never been in LNO house before (the level of information). Among them are students who had never listened music of Mozart's "The Magic Flute", Verdi's "Aida", and Wagner's "Flying Dutchman". It means that the Art as a study subject and integral part of general academic education in the Latvia University of Agriculture is been desirable there.

The second part of the questionnaire after visiting LNO explained results about understanding the main idea of the opera content (the level of skills). Analyzing the results of this investigation we can see that most of all students had mastered the main idea of the content of these famous European opera art treasures. Some of the respondents mentioned incomprehension of performance in live in LNO in Riga. These students had been absent from lectures including practical video demonstration of chosen opera masterpiece before visiting them Latvia National Opera.

The third part of the questionnaire explained students' thoughts about the high Art values as being personally important for themselves (the level of values). The results of this investigation show that students are changing their attitude after visiting performance in live in the Latvia National Opera. The respondents mentioned such specific additional aspects of further visiting LNO as going together with girlfriend/boyfriend, together with family and together with children.

Discussion

The terms "classic" and "romantic" were being used to contrast XVIII and XIX centuries art and the distinction was acknowledged as fundamental to the understanding of in-

terpretation of the opera performance today. Especially romantic opera has defined itself as the exaltation of the subjective over theobjective and the inner yearning over the outward form. The greatest of the romantics – Wagner and Verdi – thought of themselves as reacting to the good taste and decorum of their predecessor – W.A.Mozart, who was a master of the Enlightenment.

These are the reasons to make the choice for University students to practicing art learning in live opera performance which is more or less connected with comprehension of the values of Arts Education. One of the way of solving this pedagogical problem of understanding high art is creating a content of study subject to be based on the nexhaustible riches of the values common for opera art. Within this audio-visual method in the content of Arts Education not only the specific for music ideas are to be stressed. Encouraging students to perceive, feel, grow in emotional experience and comprehend the main idea of an opera performance the preventing isolation among five forms of art is overcoming.

Such Latvian leading theorists in the History of Pedagogics of Art as A.Dauge (1868–1937) and J.A.Students (1898 –1964) in the 1920s and 1930s observed that the Arts Education is cultivating the unity of development of a person's mind, will, and feelings. They found out importance of arts in educational process. Dauge wrote that school pays a little attention to counterbalancing mind and feelings, but Students stressed the role of the Arts Education traditions as the integration of the logically rational and the aesthetically emotional in the system of general education.

According to Dauge and Students, school is the single institution in the society to be obliged to introduce the system of values and views. That, in its turn, would encourage students who do not possess outspoken artistic abilities to see the general experience of the Art and to create a link with the real life in understanding the high art values.

In the period of Romanticism, music became the most appreciated value and opera art was used to point out the

mutual interaction of the kinds of art. This epoch (XIX century) recognized the Art as a united entirely. The analysis of the musical literature makes it possible to conclude that the West European music has always possessed a serious attention to opera art, especially in the classical and romantic periods.

Study of the effects and effectiveness of the Arts Education at the Latvia University of Agriculture set out to investigate the range of outcomes. Attributable to the Arts Education there is in particular the opinion that engagement in the Arts can boost general academic education. The method of using audiovideo presentation of opera performance in the didactics of the Arts Education has been the key factor in teaching students more.

Owing to the use of opera performance in video, the lecturer has a possibility to prepare an interesting lecture that is full of content and include practical demonstration and presentation of complicated art effects with using sounds of music of chosen masterpiece. The aim of such kind of activities is to increase students' interest about opera as the synthesis of arts.

In emotional experience of the video demonstration, sense of eyesight has decisive meaning. Great deal of external impulses are picked up through hearing. For this reason, to obtain the best results in the Arts Education, it is necessary to use illustrations (video opera film) discussed and commented by the lecturer. Sight is the most important human sense. Through this sense we absorb the greatest quantity of information.

Conclusions

1. The results of the research approve that the main pedagogical problem of the Arts Education is students self-evaluation: the inability to evaluate the role of art and the values of West European opera masterpieces as a value being significant for themselves.

2. The three distinct kinds of knowledge in the Arts Education are important to raise student's initiative in the learning process: knowledge "that", knowledge "how", knowledge "what".

3. Positive attitude to an increasing degree for acquisition of opera performances is created in University students by means of audio-visual method.

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