

COMPARISON OF POTATO CLONES DEVELOPED AND TESTED IN ORGANIC AND CONVENTIONAL GROWING CONDITIONS

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Abstract

The development of organic farming needs suitable organic growing conditions. A part of demanded conditions are included in conventional potato breeding programmes, but some of the characteristics are particularly significant for organic growing conditions. Breeding for organic agriculture could take an advantage that the expression of many traits is highly correlated between conventional agriculture and organic agriculture. In 2006 and 2007 potato clones (4th and 5th field generation) were evaluated in conventional and organic fields. The clones had been selected according to the assessment of leaf coverage, maturity, and resistance to the late blight of foliage under conventional growing conditions. The resistance to pests in field conditions, the length of the growing period, yield, starch content and others factors were evaluated and compared in both growing conditions. The breeding of new varieties for organic farming could be done in conventional conditions as part of the existing breeding programme. The differences between traits, mostly determined by genotype, were relatively similar in different growing conditions, so a genotype with an acceptable trait could be selected in a conventional breeding programme. Several assessments of traits, determined mainly by the environment, had no significant correlation. Those traits could be evaluated directly in organic growing conditions. Results of this trial prove that particular selection for organic agriculture has to be done in an organic field, as selected potentially suitable genotypes with acceptable traits in a conventional field did not fit organic conditions as expected. There has to be additional traits' assessment included in an organic breeding programme.

Key words: potato breeding, organic farming, breeding for organic farming.

Introduction

Organic farming in Europe is developing very widely. Among other crops, the potato is one of the most demanded on the market. Organic potato production depends on growing conditions, nutritional support, pest control, especially late blight. Those circumstances are partially overcome in conventional agriculture by fertilising and spraying pesticides. Flexible and robust varieties are required for such specific organic growing conditions. The evaluation of potato varieties in organic fields determined the most important traits for organic potato production. The most important trait is resistance to different pathogens (late blight, black scurf, virus diseases, rhizoctonia etc.), (Zimnoch-Guzovska, 2003; Tiemens-Hulscher *et al.*, 2003; Vogt-Kaute, 2001). The desired traits for organic potato breeding are adaptability to organic fertilization (adequate root system, rapid juvenal root and plant development, good growth vigour, efficient mineral uptake and use), the ability to produce a good yield in a short growing period (early bulking and ripening, yield stability, acceptable quality, good storability) (Tiemens-Hulscher *et al.*, 2003) and meeting market needs. A part of the above mentioned traits are included in conventional potato breeding programmes, but some of the characteristics are particularly significant for organic growing conditions. As conventional and organic growing conditions are different, requirements for varieties are different, also; (Colon *et al.*, 2003). Breeding for organic agriculture could take an advantage that the expression of many traits is highly correlated between conventional and organic agriculture (Loschenberger, 2007). One of the ways is to start breeding for organic farming in a conventional programme, using so called indirect selection, and at a defined generation evaluate potentially acceptable clones in organic conditions. Because of the expected large plant – environment – management interactions under organic conditions the most efficient way is to start selection in the organic field as early as possible (Lammerts van Bueren, 2002). The selection in the organic environment will include emphasis on rapid establishment, good ground cover, early

bulking yield potential and tolerance to changeable humidity and fertility conditions through the better root system (Bradshaw, 2007). But in some cases, for instance – onion breeding, the selection differential differed for some traits between organic and conventional selection (Thiemens-Hulscher *et al.*, 2007).

The aim of the study was to compare the evaluation and selection of selected clones from the conventional breeding programme in conventional and organic growing conditions, with a purpose to estimate the possibility of carrying out part of the breeding programme for organic farming in a conventional breeding programme, including selection in conventional growing conditions.

Materials and Methods

Nine potato clones (4th and 5th field generation) were evaluated in conventional and organic fields for two years - 2006 and 2007. The clones were selected from the existing potato breeding programme according to the assessment of leaf coverage, foliage resistance to late blight and maturity under conventional growing conditions. The variety 'Brasla' was used as a standard variety. The leaf coverage of five clones was assessed as having moderate density, but four clones – tight density. The leaf coverage of the standard variety 'Brasla' was of moderate density. Leaf coverage density is a possibly significant trait in organic field weed control – dense foliage successfully covers the ground and does not allow weed development. But at the same time wide leaf areas could possibly be a breeding ground for leaf diseases. The four selected clones and 'Brasla' have a low resistance to late blight (*Phytophthora infestans* (Mont.) de Bary). One clone's resistance was assessed as moderately low and the other four clone's resistance - as moderate.

The maturity time of selected clones was predicted taking into account their parents' maturity. Two clones were obtained from crosses of two early varieties, so it was expected that the clones could be of early maturity. Two others were obtained from medium early parent crosses, and the next two from a cross of early and medium early varieties. These clones could be early to medium early. The other two clones were obtained from medium late maturity parent varieties, so these would be medium late. One clone's parent varieties were medium late and early, the maturity of this clone would range widely. The maturity of standard variety 'Brasla' is medium late.

The soil characteristics of both environments is described in Table 1.

Table 1. Characterisation of soil in conventional and organic growing conditions

Year		2006		2007	
Growing conditions		organic	conventional	organic	conventional
Soil type		sandy loam	loamy sand	sandy loam	loamy sand
pH _{KCl}		6.5	5.3	5.9	5.7
Humus g kg ⁻¹		2.7	1.2	2.3	2.5
N mg kg ⁻¹	N mg kg ⁻¹ (in soil)	38		60.4	
	fertilised mg kg ⁻¹	-	65	-	65
	Total	38	65	60.4	65
P mg kg ⁻¹	mg kg ⁻¹ (in soil)	61	115	54	69
	fertilised mg kg ⁻¹	-	64	-	64
	Total	61	179	54	133
K mg kg ⁻¹	K ₂ O mg kg ⁻¹ (in soil)	121	168	77	111
	fertilised mg kg ⁻¹	-	75	-	75
	Total	121	242	77	186
Precrop		winter wheat	winter cereals	winter wheat	winter cereals

The soil acidity in the organic field was lower than in the conventional one. The amount of organic matter (humus) in organic field was nearly two times more than in the conventional field in 2006. The humus content in the soil of the conventional field exceeded by a slight margin the humus content of the organic field in 2007. Nitrogen content was not detected in conventional fields, so only the added nitrogen was taken into account. The estimated amount of nitrogen content in the organic field before potato planting was 1.7 times less than the conventional field on which nitrogen

was applied. The amount of nitrogen added to the potato crop was low in the organic field, but during growing period it was naturally improved due to the decomposition of the organic matter in the soil. The nitrogen supply was higher in the organic growing conditions of 2007 than in the previous year. The coverage of phosphorus and potassium was higher in conventional conditions due to better soil parameters and fertilising. The supply with nutrients determined obtaining higher yield in conventional field in both years.

The potato clones were planted in 10 m² plots in 4 replications in both environments. The seed material planted in the organic field was presprouted with the purpose to shorten the time the crop is in field conditions. Potatoes were planted in the second decade of May and harvested in the last decade of August or the 1st decade of September. In both years fungicide Tatu 550 was applied twice in the conventional field after potato flowering to limit foliage diseases.

The rainfall during the potato growing period in 2006 was very low (Figure 1.). It rained quite heavily in June: 23 – 75% of the decade's long term average data. Later in July and August rainfall varied from 0% to 26% of the normal amount, so the moisture in the soil depended only on rainfall so the potato crop suffered from drought and lack of nutrients. The crop roots could not be supplied with nutrients due to insufficient soil moisture. This was the reason for a noticeably low tuber yield in 2006. The rainfall did not differ a lot from normal amounts (Figure 1) and, consequently, soil moisture was acceptable for potato growing in 2007.

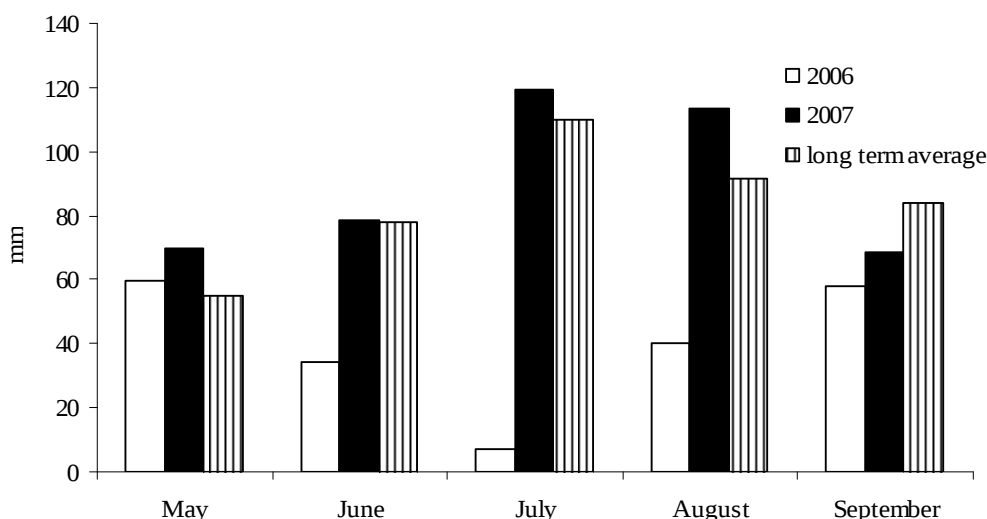


Figure 1. The rainfall during potato growing period of 2006 and 2007

The significant temperature differences during the potato growing period of both trial years was observed at the end of May and the beginning of June. During the last decade of May and the first decade of June the average day temperature was only 10.4 °C and 11.5 °C in 2006. It was 8.7 °C and 6.7 °C lower than the temperature in 2007. Owing to chilly weather, the sprouting of the potato crop was delayed in 2006. The average day temperature later in the potato growing period was not noticeably different in both trial years. In general the temperature in both years was higher than normal. The average day temperature from May to August exceeded the norm for 2.03 °C in 2006 and for 2.3 °C in 2007. The quite hot and dry weather conditions in 2006 were unfavourable for late blight (*Phytophthora infestans* (Mont.) de Bary) development and this disease was not found on potato leaves. An other disease – early blight (*Alternaria solani* Ellis and Martin) was found on potato foliage and the weather conditions were favourable for its development. The following year sufficient moisture advanced late blight development, the first damage caused by disease was observed in the first decade of August 2007. Starting in the middle of June 2007 Colorado beetles began to infest the fields. Insecticide was used in the conventional field.

The evaluation of potato clones was done during the growing period and after harvesting. Leaf resistance to pests was assessed visually (% of the damaged leaves area) during disease development in the field. The length of the growing period was determined counting days from

when 80% of the planted tubers had sprouted to the end of the vegetation period. After harvesting yield and tuber size distribution were measured. The starch content in tubers was determined indirectly via specific gravity as a percentage of the fresh weight. The boiled tuber taste was assessed by a expert panel using a 9 point scale (9 – very tasty, 1- very nasty). The results of the trait assessments in both environments were compared. The main stress was on the selection of clones suitable to the organic growing conditions.

The obtained data were analysed using descriptive statistics and the Pearson correlation coefficient. The significance of the differences between the samples was assessed using the T-test (Liepa, 1974).

Results and Discussions

Resistance to diseases. Foliage resistance to early blight was assessed in 2006 as late blight did not appear in the field. The evaluation of the damage on leaves was started on August 1st, when early blight spots covered 0-5% of the leaf area depending on the genotype. After a week damages did not exceed 10% in both environments. One potato clone had no early blight damage in both conditions. One clone's damage was only 1% of the leaf area in both environments on August 8th. For two genotypes, including the standard variety 'Brasla', the disease damage was larger in the conventional field than in the organic. But for the other two clones the damage in organic field exceeded the early blight damage experienced in the conventional field. It seems that fungicide spraying was not effective in the conventional field, perhaps due to hot and dry weather conditions, and only genotype resistance protected the crop in both environments. But a significant correlation was not found between assessments in both growing environments ($r = 0.21 < r_{0.05,10} = 0.63$). Some other circumstances – nutrition uptake, resistance to drought, foliage cover and others affected clone resistance to early blight.

The distribution of late blight on potato clone foliage was assessed only in 2007. The first spots in the organic field were observed on July 30th but only on the leaves of one clone. A week later the damage was in the range from 0 – 30% in the organic environment. The foliage was damaged almost completely for all clones in the organic field on August 13th. Late blight distribution in the conventional field started later – the first spots were observed on August 13th. After a week late blight damage reached 60 – 100% of the leaf area depending on genotype, but less than in the organic field. The application of fungicide delayed late blight development in the conventional field and saved crop vegetation for a longer time. The amount of damage in the conventional field was less than in the organic field where spraying was not used. The correlation between late blight damage assessments in both fields was not significant ($r = 0.42 < r_{0.05,10} = 0.63$). It means that genotype assessment in the conventional field which had fungicide application does not tell us about genotype resistance to late blight in organic conditions where fungicide was not applied. The evaluation to disease resistance has to be done in the organic field to get reliable data.

Growing period. The growing period was shorter in both environments during 2006 than in 2007, because of extremely dry and quite hot weather, which quickened plant development and limited nutrient availability in 2006.

The potato plants emerged 2 - 3 days earlier in organic the field than the conventional field both years due to tuber seed presprouting. But the growing period for clones in the organic field was shorter by about ten days than in the conventional field (Table 2). One reason was that presprouting quickened plant development. Another, was especially in 2007, was that late blight damaged foliage and interrupted vegetation in the organic field earlier than in the conventional field. The length of the growing period differed between genotypes according to predicted maturity time. Clones obtained from both early maturity parents and one early maturity cross with later maturity parents mostly showed faster development, as was expected. The growing period was from 57 to 63 days in 2006, from 65 to 80 days in 2007 in the organic field, and from 54 to 77 days in 2006, about 80 days in 2007 in the conventional field. The growing period of potato clones obtained from both medium late maturity parents lasted from 6 to 22 days longer in both environments. But clones expected to be more early than late maturing was (both parents medium early) had a longer growing period (59-86 days in organic and 65-97 days in conventional fields in 2006 and 2007 respectively). The difference between the average data of both environments in both years was significant (Table 3.). The correlation between the lengths of the growing period in both

environments was not significant (Figure 2). Significant relationship was not found between assessments in the organic field both years, but a correlation between the assessments of both years in the conventional field was significant. The growing period in the organic environment was more affected by weather conditions and late blight distribution than in conventional environment.

Table 2. The characteristics of the traits of potato clones in organic and conventional fields in 2006 and 2007

Traits	Organic field				Conventional field			
	2006		2007		2006		2007	
	min-max	average	min-max	average	min-max	average	min-max	average
Growing period, days from emergence to the end of vegetation	57-71	63.7	54-90	74.8	65-83	77	80-102	87.9
Tuber yield, t ha ⁻¹	10.1-28.4	16.1	17.0-35.1	24.6	4.7-41.8	23.1	33.7-65.0	44.8
Tubers > 50mm in yield, %	2-35	20	4-64	41	9-43	25	32-78	62
Starch content, %	13.9-21.4	17.2	14.9-19.4	16.2	11.5-19.1	15.0	12.2-19.3	15.6
Taste of boiled tuber, points	6-7.5	6.8	6-7.8	7.1	6.3-7.7	7.0	6.1-7.8	6.9

Yield. The potato tuber yield in 2006 was about twice as low in both environments than in 2007 (Table 2). The influence of different weather conditions, affecting soil moisture was observed during the trial. Tuber yield in organic growing conditions was lower than in conventional growing conditions during both years. The growing period in conventional growing conditions was longer and nutrition supply was better than in the organic growing conditions. This was the reason for a larger yield in the conventional field. Four potato clones significantly exceeded the yield of the standard variety 'Brasla' in the conventional environment in 2006 ($p = 0.05$), but only one of them significantly exceeded the yield of the standard variety in the organic environment. A year later the yield of three clones was significantly higher than the yield of the standard variety in the conventional field and the yield of the same clone was higher in organic field ($p = 0.05$). The length of the growing period for this clone was assessed as medium late and the resistance to late blight in 2007 was assessed as moderate in organic conditions. There were no late blight damages on the leaves of the clone in the conventional field in 2007. This clone possibly has some features better adapted to organic growing conditions, which were not tested in the trial: for example, a better root system that is more tolerant to changeable moisture and nutrient uptake. If selection was done only in the conventional field, more clones could be accepted as suitable for organic farming. But in organic conditions part of them turned out unsuitable. Comparing the average data of the potato yield in the organic and conventional field a significant difference was found in both trial years (Table 3).

Table 3. The significance level between trait assessments in organic and conventional fields (2006-2007)

Trait	t _{fact} between means in organic and conventional fields	
Growing period	2.63	3.02
Tuber yield	6.22	6.97
Tubers > 50mm in yield	1.39*	4.14
Starch content	2.88	2.72
Boiled tuber taste	0.87*	0.92*

t_{0.05} = 2.26; * - not significant

It means that genotype yield is significantly differently in different environments. The correlation between yield assessments in both environments was significant in both trial years (Figure 2.), so the relative difference between yields was similar in different environments. A significant relationship was found between tuber yields both years in the same environment. The selection of potentially high yielding potato clones for organic growing conditions could be done in the conventional breeding field, but promising clones should be tested in the organic field because predictions do not always turn out to be true.

The amount of large tubers (> 50 mm) in the yield. The genotype's ability to form bigger size tubers was assessed evaluating the percentage of large tubers (> 50 mm) in the yield. The growing conditions, probably mainly a lack of moisture in the soil, restricted large tuber formation in both environments in 2006 (Table 2). The greater amount of large tubers in the yield was obtained in the conventional field in 2007. The difference between the means of trait assessment in both environments was not significant in 2006, but there were differences in 2007 (Table 3). There was a significant correlation between the amount of large tubers in the clones' yield in the organic and conventional field in 2006. Not significant, but quite high correlation existed in 2007 (Figure 2). The correlation was not significant between trait assessments when analysing the yield in the same environment for two years. The amount of large tubers mostly depends on genotype environment a interaction in particular growing conditions.

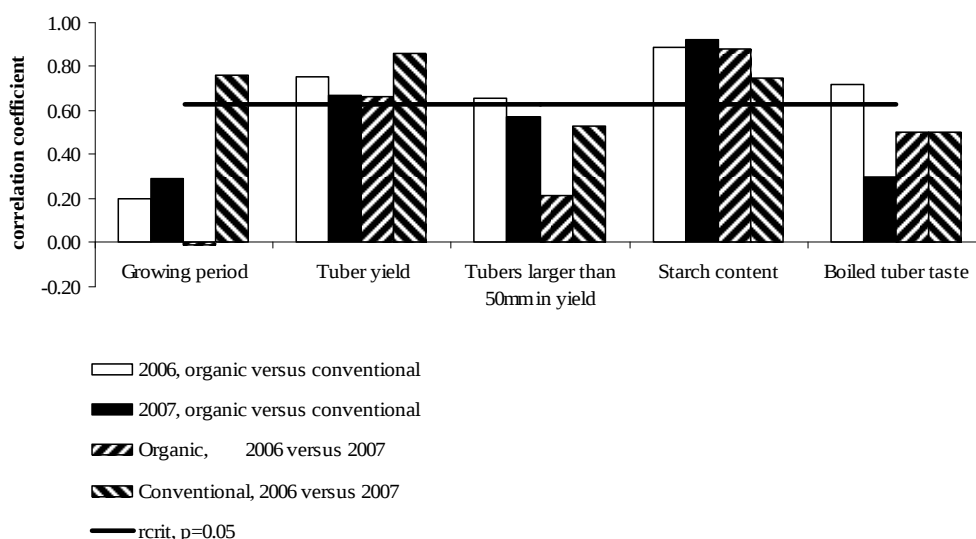


Figure 2. Correlation coefficient between trait assesment in organic and conventional growing conditions, 2006-2007

Starch content. The starch content of potato clone tubers in the organic field was higher than in the conventional field in 2006 (Table 2). Next year the starch content of the clones grown in the conventional field exceeded starch content of the clones grown in the organic field. The reason for this difference was the late blight damage which provoked the end of the growing period approximately a week earlier in the organic field than in the conventional one. This extra growing period week in the conventional field was a chance to accumulate more starch in the tubers utilising sun energy for a longer time. The starch content in tubers is mainly determined by genotype. Comparing starch content in both environments, the difference was significant in both trial years (Table 3). A significant correlation was found between the results in different environments and years (Figure 2). The genotype's ability to accumulate a comparatively higher amount of starch could be assessed in any environment because of the potato clones ability to accumulate starch in tubers was relatively similar in different growing conditions and environments.

Taste of boiled tubers. The assessment of the taste of boiled tubers did not differ much depending on the growing conditions of both years. The assessment of the clone tubers from the organic field was a little lower in 2006 and a little higher in 2007 than from the conventional field (Table 2.). There was a significant difference between the taste assessments of the clones from both

environments during the two trial years (Table 3). A significant correlation between the taste assessment of the clones grown in the organic and in the conventional field was found in 2006 (Figure 2). The next year this relationship was not significant. There was no significant correlation between two-year trait assessments in the same environment. The taste trait depends mostly on how genotypes react to different growing conditions.

Conclusions

The assessment of traits - starch content, tuber yield and partly boiled tuber taste – in the organic field significantly correlated with the assessment in the conventional field. The expression of traits in the particular environment depended on the genotype. The impact of different growing conditions on the trait expression of genotypes was similar, so differences between genotypes in each environment were relatively similar. Part of the selection for breeding potato varieties for organic farming could be done in the existing conventional breeding programme.

A significant relationship between assessments of traits like the length of the growing period and the ability to form large size tubers in both environments was not found. The traits more determined by environmental conditions preferably could be assessed and selected in particular (organic) growing conditions.

The resistance assessment of clone leaves to diseases has to be continued, the first conclusions verify that evaluation in particular growing conditions for selection would be preferable.

It is advisable to include the new trait assessments that are particularly significant for organic growing conditions in the breeding programme for organic farming. Some of these traits are the root system, plant rapid establishment and nutrient uptake. The development of specific assessment methodology is recommended for these traits.

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KARTUPEĻU KLONU VĒRTĒŠANAS SALĪDZINĀJUMS BIOĻOĢISKAJOS UN KONVENCIŅALAJOS AUGŠANAS APSTĀKĻOS

Skrabule I.

Bioloģiskās lauksaimniecības attīstība rada pieprasījumu pēc bioloģiskās audzēšanas apstākļiem piemērotām laukaugu šķirnēm. Daļa no šķirņu īpašībām, kuras būtu vēlamas šādiem audzēšanas apstākļiem, tiek izvērtētas jau pastāvošajās konvencionālajās selekcijas programmās, bet atsevišķas pazīmes ir nozīmīgas tieši bioloģiskajos laukos. Selekcija bioloģiskajai lauksaimniecībai varētu

izmantot sakarību, ka pastāv ļoti cieša korelācija starp daudzu pazīmju izpausmi bioloģiskajos un konvencionālajos audzēšanas apstākļos. Kartupeļu klonu 4. un 5. gada pavairojums 2006. un 2007. gadā tika izvērtēti bioloģiskajos un konvencionālajos augšanas apstākļos. Klonu izvēle pamatojās uz iepriekš konvencionālajos augšanas apstākļos noteiktajām pazīmēm un to iespējamās atbilstības bioloģiskajiem audzēšanas apstākļiem: aplapojuma, veģetācijas perioda ilguma, lapu izturības pret lakstu puvi. Kartupeļu klonu izturība pret lapu slimībām lauka apstākļos, veģetācijas perioda garums, raža, cietes saturs un citas pazīmes tika novērtētas un salīdzinātas abos audzēšanas apstākļos. Jaunu šķirņu selekcija bioloģiskajai lauksaimniecībai varētu tikt daļēji veikta jau esošās konvencionālās selekcijas programmas ietvaros. Izmēģinājuma rezultāti pierāda, ka bioloģiskajos laukos noteikti jāveic īpaša klonu atlase, jo konvencionālajā laukā selekcionētie labākie kloni ar bioloģiskajiem apstākļiem it kā piemērotām pazīmēm ne vienmēr izrādījās piemēroti bioloģiskajiem audzēšanas apstākļiem.

EVALUATION OF MAIN TRAITS AND THEIR RELATIONSHIPS OF SPRING WHEAT

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Abstract

Study was carried out at the State Stende Cereal Breeding Institute in 2005-2007. There were included 10 spring wheat varieties registered in Latvian Catalogue of Plant Varieties. The morphological and agronomical traits of the varieties and influence of weather conditions on yield and quality were evaluated. Yield, grain quality and correlation between traits were significantly influenced by meteorological conditions of year. On evaluation data the yield potential was on the level 5-8 t ha⁻¹, but there was a great influence on grain yield and quality traits of year. The grain yield was influenced by variety – 20.64%, but by meteorological conditions 54.02%, interaction of both factors was 16.38%. Significant positive correlation between the yield and the 1000 kernel weight was found, but the significant negative- between the 1000 kernel weight and the volume weight; the starch content and the Zeleny index; the starch content and the protein content; the protein content and the 1000 kernel weight. New variety 'Uffo' was created at State Stende Cereals Breeding institute during 1992-2004, included in the Latvian Catalogue of Plant Varieties from 2008. The variety 'Uffo' is characterizing with high yield potential (6-8 t ha⁻¹), grain quality is suitable for bread making.

Key words: spring wheat, varieties, yield, grain quality

Introduction

In Latvia spring wheat became more popular crop by the last decade of 20th Century. Growing area ranged between 50-60000 ha in each year, but there is a tendency to increase the sowing area and the production. Traditionally the spring wheat has a lower grain yield, but better grain quality (Blakman and Payne, 1987). Spring wheat is used mostly for food, less for feed or bioethanol production. The most popular spring wheat is used for conventional farming, but there are varieties suitable for organic farming too (Belederek *et al.*, 2000).

Spring wheat breeding programme was renewing in State Stende Cereals Breeding Institute in 1990, starting with renovation and evolution of the genetic resources. The main goals of breeding program were to create new varieties, characterizing with the high yield, grain quality conform with the requirements of producers, resistance to lodging and main diseases.

The aim of this study was to evaluate the main morphological and agronomical traits of spring wheat varieties and to find their relationships as well as to establish influence of weather conditions on yield and quality, and to select promising genotypes recommending for farmers.