ražošanas izmaksas un nav pieņemama bioloģiskajā lauksaimniecībā. Miežiem piemīt dabiskā izturība pret miltrasu, ko nosaka vairāki genoma rajoni, no kuriem svarīgākie ir *Mlo* un *Mla* lokusi. Dabiskas vai inducētas recesīvas mutācijas *Mlo* lokusā nodrošina plaša spektra izturību pret gandrīz visiem zināmajiem miltrasas patotipiem. *Mlo* gēns ir klonēts un vairākas mutācijas gēna DNS sekvencē, kas piešķir slimību izturību, ir zināmas. Mēs raksturojām jaunu *mlo* allēli mutantā, kas iegūts no šķirnes Maja, kurā notikusi aminoskābes Gly nomaiņa par Arg 318 pozīcijā. Lai raksturotu *mlo* miltrasas izturību Eiropas miežu šķirnēs, kā arī Latvijas un ārzemju selekcijas līnijās, tika izmantoti CAPS marķieri *mlo-5*, *mlo-9* un *mlo-11* allēlēm. Iegūtie rezultāti apstiprina molekulāro marķieru pielietojuma perspektīvu pret miltrasu izturīgu miežu hibrīdu selekcijā.

A COMPARISION OF THE YIELD AND QUALITY TRAITS OF WINTER AND SPRING WHEAT

Koppel, R., Ingver, A.
Jõgeva Plant Breeding Institute, Aamisepa 1, Jõgeva alevik, Estonia, 48 309, phone +372 77 66 901, e-mail: reine@jpbi.ee

Abstract
Traditionally winter wheat is known by its higher yield potential and spring wheat by better baking quality. In this investigation we studied how yield and quality traits of spring and winter wheat differed at the Jõgeva PBI trials during 2004-2007. Yield and 1000 kernel weight of winter wheat exceeded spring wheat every year. Spring wheat had higher protein and gluten content and volume weight. There was no clear trend for the falling number and gluten index.
According to variance analyses, the value of yield and 1000 kernel weight were determined by the wheat type (spring or winter) but other characteristics were more affected by the weather conditions of a particular year. The effect of the weather conditions for the year was greater for yield, 1000 kernel weight, protein and gluten content, bread loaf volume and dough stability for the both types of wheat. For falling number the influence of the year was greater than that of the variety of spring wheat and the influence was revesed for winter wheat. Volume weight depended more on the weather for spring wheat and on the variety for winter wheat.

Key words: spring wheat, winter wheat, quality, yield

Introduction
The climatic conditions in Estonia are suitable for cultivation of the both wheat types – spring and winter wheat. The acreage of wheat cultivation has enlarged from 78 to 102 thousand ha during the last 4 years (2004-2007). The acreage share of winter wheat is 1/3 smaller than that of spring wheat (but has a tendency to increase). Traditionally winter wheat is known for its higher yield potential and spring wheat for its better baking quality (Swenson, 2006; Baker and Townley-Smith, 1986). Yield and quality potential is largely determined by the variety, but the extent to which this potential is achieved depends upon factors such as seasonal weather conditions. Higher grain yields are usually associated with lower protein concentration (Terman *et al*., 1969, Blackman and Payne, 1987). The protein is a primary quality component of cereal grains. The protein concentration is influenced by both environmental and genotypic factors that are difficult to separate (Fowler *et al*, 1990)**.** The protein content of wheat grains can vary from 6% up to as much as 25%, depending upon the growing conditions (Blackman and Payne, 1987). Terman *et al.* (1969) noted that protein content varied more widely among locations than among varieties at the growing location. Differences among cultivars tended to be greatest under optimum growth conditions (Terman, 1979). Protein content and protein quality have been also shown to be significant for baking quality (Johanson and Svensson, 1998). Fredericson *et al*. (1997, 1998) found that protein content was positively correlated with wet gluten content, farinogram dough stability and bread loaf volume.
The great majority of wheat products are adversely affected by alfa-amylase. The activity of alfa-amylase can be described by the falling number test. High levels of alfa-amylase activity in the

grain may be due to naturally high endogenous levels of the enzyme, or to premature germination causing alfa-amylase to be synthesized de novo (Blackman and Payne, 1987).
Kernel weight, usually expressed in grams per 1000 kernels, is a function of kernel size and kernel density. Big wheat kernels usually have a higher ratio of endosperm to nonendosperm components. 1000 kernel weight can be used as a reliable guide to predict flour yield.
One of the most used criteria of wheat quality is volume weight. Volume weight is a good indication of the density and soundness of the wheat. Very low volume weight is normally associated, not with cultivar characteristics, but with sub-optimum growing and harvest conditions that cause shrinkage and shrivelling and subsequent loss of grade (Tipples, 1986).
The goal of this work was the comparison of yield and quality characteristics and variation the of these traits in spring and winter wheat; the comparison of the influence of wheat type and environment (growing year) on these traits; the comparison of the influence of genotype and environment separately on spring and winter wheat characteristics; to find out correlations between the various characteristics.

Materials and Methods

Fifteen wheat varieties from the Estonian Variety List and the Jõgeva PBI collection trial of winter wheat (WW) and fourteen varieties of spring wheat (SW) were tested. The WW varieties were Ada, Bill, Ballad, Bjorke, Compliment, Gunbo, Korweta, Lars, Portal, Ramiro, Residence, Sani, Širvinta 1, Tarso and Urho and SW varieties Baldus, Helle, Mahti, Manu, Meri, Mooni, Munk, Satu, SW Estrad, Zebra, Tjalve, Trappe, Triso, Vinjett. Varieties were grown on 9 m² plots with three replications. The level of fertilizer was N 90 kg ha^{-1}. Yield (Y), 1000 kernel weight (TKW) and volume weight (VW) was calculated as an average of three replications. Protein and gluten content the gluten index and falling number, dough stability time and bread volume was tested in one replication per variety by each year. Data about dough stability time and bread loaf volume were obtained from the years 2004-2006, other data from 2004-2007.
Protein content (PC) was determined by the Kjeldahl method. Wet gluten content (WGC) and gluten index (GI) were determined by the ICC standard method 137, 155 and 158 using the Glutomatic 2200 instrument. The falling number (FN) was determined by the ICC standard method 107/1. The farinogram test was conducted using the ICC standard method 115. By farinogram farinograph dough stability time (DST) was measured. Baking tests on 250g of flour according to the long fermentation process were carried out by the method of the Finnish State Granary (Suomen Valtion Viljavarasto Koeleivontamenetelmä, 1996). Bread volume was analysed by measuring the displacement of canola seeds.
Statistical analyses were performed using the Agrobase 4 software package. Data were analysed by the analyses of variance and for correlations the Spearman Rank Correlation was used. The analyses of variance and the estimates of the components of variance (determination coefficient) due to wheat type (spring and winter) R_T^2, environment (growing year) R_E^2 and genotype R_G^2 were calculated and was expressed as % of the total variance. The least significant differences ($LSD_{0,05}$) among mean values were calculated. Stability analyses of genotypes and quality parameters were based on a coefficient of variation (CV).

Results and Discussion

The grain yield of WW was higher compared to SW every year. The four years average was more than 2 t ha^{-1} higher (Table 1). The variations of yield were similar. The highest yielding among SW and WW were respectively the varieties Trappe (5,601 kg ha^{-1}) and Ballad (7,242 kg ha^{-1}) (data not shown here). Y was more influenced by the wheat type than the growing year – the variation of this factor was 43.4 % from the total variation of yield (Table 2). The yield potential of autumn-sown cereal crops is considerably higher than that of spring-sown crops. A crop stand already established in spring is able to respond immediately to rising temperatures and increased of solar radiation; by contrast, since a spring crop cannot be sown until there are suitable soil conditions, part of the growing season is lost (Hay and Porter, 2004). Concerning the types; the Y of both types was significantly influenced by the climatic conditions of the year (Tables 3 and 4). The influence on the variety was bigger for SW, the effect of GxE for WW. The grain yield of a cereal crop can be split into three major components: ear population density, ear size and individual grain weight (measured as TKW). The four years average TKW of WW was 9.4 g bigger than that of SW. The variation of kernel size was higher for SW. The biggest kernels among the SW varieties belonged to Triso, Zebra and Munk (35.4 g) and WW variety Širvinta 1(48.6 g). The mean grain weight is determined primarily by the quantity of assimilates available for transport to the ear between anthesis and maturity. This depends upon the green leaf area duration after anthesis and the photosynthetic activity of the ear. The period from anthesis to maturity was 37-56 days for WW and 41-49 days for SW during 2004-2007. The TKW of WW was bigger than that of SW even in the year when the grain filling period was shorter. Similarly to factors influencing Y, the wheat type had a bigger effect than the year also on kernel size - the variation of this factor was 49.5% from the total variation of TKW. For the kernel size of SW the influence of the year was more important (R_E^2 = 70.6) than for WW where the effect of the two factors was distributed more equally (R_E^2 = 43.2 R_G^2 = 35.4). The TKW of both types was positively correlated with VW (SW: r=0.78***; WW: r=0.22**; data of correlations are not shown in the tables).

Table 1. Average data of winter wheat and spring wheat varieties from 2004-2007

	Y, kg ha^{-1}	TKW, g	VW, g l^{-1}	PC, g kg^{-1}	WGC, g kg^{-1}	GI, %	FN, sec	LV[a], cm^3	DST[a], min
SW	4,438	32.7	775	146	329	66	281	1,342	8.8
CV[b] (%)	20.2	15.1	4.9	12.9	17.1	29.3	34.7	8.2	63.0
WW	6,523	42.1	761	116	252	62	283	1,320	4.7
CV (%)	21.4	10.9	3.5	20.1	31	31.9	27.3	12.2	87.7
$LSD_{0,05}$	167.8	0.55	3.9	2.7	0.94	4.6	18.7	30.8	1.2

WW – winter wheat, SW – spring wheat,, Y – yield, TKW – thousand kernel weight, VW – volume weight, PC – protein content, WGC – wet gluten content, GI – gluten index, FN – falling number, LV – bread loaf volume, DST – dough stability time; [a] data of 2004-2006; [b] CV=coefficient of variation

Table 2. Analyses of traits variance. Components of variation due to environment -year (R_E^2), wheat type (R_T^2), type by year (R_{TxE}^2) and residuals in percentage of the total sum of square

Source of variation	Y	TKW	VW	PC	WGC	GI	FN	LV[a]	DST[a]
Environ.	6.1***	25.4***	20.2***	43.5***	42.1***	22.2***	36.8***	39.3***	46.0***
Type	43.4***	49.5***	4.5***	32.5***	24.4***	0.8ns	0.1ns	0.7ns	15.5***
Type by environ.	13.9***	3.4***	32.0***	13.0***	19.0***	20.3***	15.8***	24.8***	0.0
Residual	36.6	21.7	43.4	11.0	14.5	56.7	47.0	35.2	38.9
R^2	0.63	0.78	0.57	0.89	0.86	0.43	0.53	0.65	0.61

ns=non-significant; ***,**,* significant at *P* < 0.001; 0.01 and 0.05 respectively.
WW – winter wheat, SW – spring wheat, Y – yield, TKW – thousand kernel weight, VW – volume weight, PC – protein content, WGC – wet gluten content, GI – gluten index, FN – falling number, LV – bread loaf volume, DST – dough stability time; [a] data of 2004-2006.

Table 3. Analyses of variance traits in spring wheat. Components of variation due to environment - year (R_E^2), genotype (R_G^2), genotype x year (R_{GxE}^2) and residual in percentage of the total sum of square.

Source of variation	Y	TKW	VW	PC	WGC	GI	FN	LV[b]	DST[b]
Environ.	36.6***	70.6***	77.8***	74.7***	66.8***	41.9***	61.9***	40.4***	53.8***
Genotype	24.4***	21.2***	8.6***	20.6***	26.9***	45.6***	20.1**	24.7ns	24.0ns
Genotype by env.	14.1*	5.3***	7.9***	NA	NA	NA	NA	NA	NA
Residual	24.9	2.9	5.7	4.6	6.3	12.5	18.0	34.9	22.2
R^2	0.75	0.97	0,94	0.95	0.94	0.87	0.82	0.65	0.78

ns=non-significant; ***,**,* significant at $P < 0.001$; 0.01 and 0.05 respectively.
NA – data not available, Y – yield, TKW – thousand kernel weight, VW – volume weight, PC – protein content, WGC – wet gluten content, GI – gluten index, FN – falling number, LV – bread loaf volume, DST – dough stability time; [a] data of 2004-2006;

Table 4. Analyses of variance traits in winter wheat. Components of variation due to environment - year (R_E^2), genotype (R_G^2), genotype x year (R_{GxE}^2) and residual in percentage of the total sum of square.

Source of variation	Y	TKW	VW	PC	WGC	GI	FN	LV	DST
Environ.	34.9***	43.2***	13.6***	88.7***	87.2***	43.6***	39.6***	74.0***	54.1***
Genotype	6.2**	35.4***	58.7***	5.4**	6.7**	27.5**	40.4***	18.2***	24.8ns
Genotype by env.	37.9***	16.4***	15.0***	NA	NA	NA	NA	NA	NA
Residual	21.0	5.0	12.7	5.9	6.1	28.9	20.1	7.1	21.1
R^2	0.79	0.95	0.87	0.94	0.94	0.71	0.80	0.93	0.79

ns=non-significant; ***,**,* significant at $P < 0.001$; 0.01 and 0.05 respectively.
NA – data not available, Y – yield, TKW – thousand kernel weight, VW – volume weight, PC – protein content, WGC – wet gluten content, GI – gluten index, FN – falling number, LV – bread loaf volume, DST – dough stability time; [a] data of 2004-2006

According to Chung (2003) there was no significant difference between the mean VW for WW and SW when these were cultivated under the same environmental conditions without effect of different. According to Monsalve-Conzales and Pomeranz, (1993) over-wintering increased the test weight when the tested wheat was facultative wheat which was sown in the winter and in the spring after verbalization. The average VW of SW was 14 g l^{-1} higher in our study. The CV was higher for SW. The highest average VW were found in the SW varieties Satu (795 g l^{-1}) and the WW variety Ada (801 g l^{-1}). The wheat type factor explained only 4.5 % from total sum of square. The effect of genotype was low for SW (R_G^2 =8.6***) but highest than any other factor for WW (R_G^2 = 58.7***).

The average amylolytic activity, which was measured as FN for both wheat types was similar (SW: 281 sec, WW: 283 sec). More variable were the SW varieties. The variation was greater in the year with a lower average FN (data not shown). The higher FN had SW variety Mooni (408 sec) and WW Tarso (401 sec). The effect of the climatic conditions was stronger than the influence of type. The effect of the climatic conditions on SW was larger. For WW the effect of year and genotype were similar.

Research has demonstrated that there is a strong positive correlation between protein content and bread volume, and that the baking quality of spring wheat is directly related to protein content and wet gluten (Hanell, 2004). In this investigation the average PC of SW was 30 g kg^{-1} higher than WW. The highest protein content was found in the early SW variety Manu by 161 g kg^{-1} and WW Ada by 126 g kg^{-1}. The PC is positively correlated with WGC (Fredericson *et al*, 1997; 1998), which is strongly influenced by the growing environment (Grausgruber *et al*, 2000). The correlation between protein and gluten content was positive for both types of wheat and stronger for SW (SW: r =0.96***; WW: r =0.97***) in our investigation. The four years average WGC of SW was 329 and 252 g kg^{-1} for WW. The variety Helle (SW) produced the highest average gluten content in the period of 2004-2007 (378 g kg^{-1}) compared to the best from among the WW, the variety Širvinta 1 by 280 g kg^{-1}. The cause of this kind of big difference between the two types can be explained by two extremely unfavourable years (2005 and 2007) for the accumulation of protein for WW. In 2005 the average gluten content of WW was only 142 g kg^{-1} compared to 309 g kg^{-1} for SW. Two years later the situation was as follows - 234 for WW and 331 g kg^{-1} for SW. The most favourable year for protein and gluten concentration was 2006, when WW ranged between 281-380 g kg^{-1} and SW 351-479 g kg^{-1}. According to Johannson and Svensson (1988) the influence of the mean temperature and rainfall on protein content is clearer for spring wheat. In our investigation the influence of the environment was greater for WW -variation of PC and WGC was higher for WW varieties. For both protein and gluten content, the main influence was the climatic effect (PC:

R_E^2 = 43.5***; WGC: R_E^2 =42.1***) and of secondary importance was the influence of the wheat type. The effect of climatic conditions was greater than the genotypic impact for both types. The influence of genotype was especially low for WW.

PC and Y were inversely related. This trend is in accordance with other research (Grant *et al.*, 1985; Peltonen, 1992; Bly and Woodard, 2003). The r according to the Spearman Rank Correlation was –0.41*** for WW and –0.54*** for SW. The inverse relationship between yield and protein may be partly due to the effect of the dilution of N. As grain yield increases, a limited amount of protein is diluted within the greater mass of grain.

One measurement to express protein and gluten quality character is GI. Protein quality is much less affected by the environment and is mainly genetically controlled (Blackman and Payne, 1987). There was no significant difference of the average GI between WW and SW. The variation of this trait was also similar for two wheat types. There was no significant influence of wheat type. For SW the effect of the environment and genotype were similar (R_E^2 =41.9*** R_G^2 =45.9***) but for WW the influence of the envioronment was greater than genotype (R_E^2 =43.6***; R_G^2 =27.5**).

There wasn't a significant difference between the LV of WW and SW. From the WW varieties Compliment had the highest average LV (1460 cm^3) of all the tested varieties. The second highest was the LV of the SW variety Meri (1440 cm^3). The CV was higher for WW. Over the years type interaction had a significant influence on the LV but no influence of type. The main factor influencing the LV of WW the years (R_E^2 =74.7 ***). For SW the influence of the year was lower and the effect of the genotype even of no significant. Johansson and Svensson (1998) found that the correlation between PC and LV is not significant in SW material with large differences in protein quality. Other researches have demonstrated that there is a strong positive correlation between PC and bread volume, and that the baking quality of SW is directly related to PC and WGC (Hanell, 2004). Variations in LV resulted mainly from the quantitative effects of gluten proteins (Chung *et al.*, 2003). According to Peterson *et al.* (1998) for many baking parameters, variation attributed to environmental effects was of greater magnitude than for the genotype of WW and correlations of protein components with baking parameters were generally low. According to Wieser and Kieffer (1999) bread volume was influenced more by the amount of gluten proteins than by the total amount of protein. In our investigation WW had strong positive correlation of LV with PC (r=0.74***) and WGC (r=and 0.72***). Surprisingly there was no correlation between the LV and protein and gluten characteristics of SW.

Four years the average DST of SW was higher than that of WW (SW: 8.8 min, WW: 4.7 min). The variation of this trait was high (CV 63-88%). The influence of the year was greater than the influence of type for DST (R_E^2 =46.0***; R_T^2 =15.5***), but also the residual part was quite high. For WW and SW the effect of the genotype wasn't significant, the effect of the year was R_E^2 =53.8*** and R_E^2 =54.1*** respectively. There were positive relationships between DST- PC and DST-WGC for both types of wheat (SW: r=0.75***, r=0.66*** respectively; WW r=0.90***, r=0.82*** respectively). A strong positive correlation between LV and DST was found only for WW (r=0.69***).

Conclusion

The results, based on the data of the 15 WW and 14 SW varieties during 2004-2007 indicated, that WW had higher yield potential and bigger kernels under Estonian conditions. Quality data were better for SW: higher volume weight, protein and gluten content. But there were not found significant differences between the gluten index and the falling number between the two wheat types. Although the bred loaf volume was bigger for SW, the difference wasn't significant. Dough stability was better for SW.

The value of the yield and 1000 kernel weight were determined by the wheat type but other characteristics were more affected by the environment (year). If the two wheat types are compared separately, yield and kernel size were determined by the environment for both types of wheat. Volume weight was influenced by the genotype for WW and by the year for SW. The influence of the year was greater for the bread loaf volume and dough stability of WW. The most important measuremont of bread quality may be considered to be the final loaf volume. It was predictable better by the protein and gluten content and gluten index of WW there wasn't a correlation of SW between these traits. But there were positive and strong correlations between dough stability and protein and gluten content for both types of wheat.

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ZIEMAS UN VASARAS KVIEŠU RAŽAS UN KVALITĀTES PAZĪMJU SALĪDZINĀJUMS

Koppel, R., Ingver, A.

Ziemas kvieši tradicionāli ir pazīstami ar augstāku ražas potenciālu un vasaras kvieši – ar labākām maizes cepamīpašībām. Šajā pētījumā tika pārbaudīts, kā atšķīrās ziemas un vasaras kviešu ražas

un kvalitātes pazīmes Jogevas Augu Selekcijas institūta izmēģinājumos laikā no 2004. līdz 2007. gadam. Ziemas kviešu raža un 1000 graudu masa pārsniedza vasaras kviešu rādītājus katru gadu. Vasaras kviešiem bija augstāks proteīna saturs un tilpummasa. Graudu raža un 1000 graudu masa bija atkarīgas no kviešu sezonālā tipa, bet citas pazīmes vairāk ietekmēja attiecīgo gadu meteoroloģiskie apstākļi. Gada ietekme abiem kviešu tipiem bija lielāka uz ražu, 1000 graudu masu, proteīna un lipekļa saturu, maizes kukuļa apjomu un mīklas stabilitāti. Gada ietekme uz krišanas skaitli vasaras kviešiem bija lielāka nekā šķirnes ietekme, bet ziemas kviešiem – otrādi. Tilpummasa vasaras kviešiem bija vairāk atkarīga no gada, bet ziemas kviešiem - no šķirnes.

SELECTION CRITERIA IN TRITICALE BREEDING FOR ORGANIC FARMING

Kronberga A.
State Priekuli Plant Breeding Institute, Zinatnes str. 1a, Priekuli, Cesis distr., Latvia, LV-4126, phone +371 4130162, e-mail: artakron@navigator.lv

Abstract

For creating varieties suitable for organic farming a special breeding programme has been started in Priekuli Plant Breeding Institute. The evaluation of triticale genotypes in organic farming was done in Priekuli during 2005 - 2007. The aims of research are:

Estimating possibility for selecting genotypes desirable for organic farming in conventional fields.

To find desired traits for the organic triticale varieties breeding programme.

There were included 25 different winter triticale (*xTriticosecale Wittm.*) breeding lines in our trials, selected from the conventional breeding programme. The different traits were tested for each genotype. The influence of different traits on yield and grain quality was analyzed. Every year the best 25 different triticale breeding lines from the organic and conventional growing conditions were compared.

The results showed that different breeding lines reacted differently to growing conditions. It is possible to select genotypes suitable for organic conditions in the conventional field. To select genotypes with better stability of the traits (especially in the years with unfavorable weather conditions) and suitability for organic farming, selected breeding lines must be tested in organic growing conditions.

For organic farming only genotypes with good winterhardiness and resistance to snow mould should be selected.

Triticale genotypes with different plant height, growth habit, leaf size would be suitable for organic growing conditions.

Key words: triticale, organic breeding, trait

Introduction

For the further development of organic agriculture, more attention is being focused on the creation of better adapted varieties. As organic conditions are less controllable and more variable, breeding should be aimed on improved yield stability and product quality by being adapted to organic soil fertility, sustainable weed, pest and disease management (Lammerts van Bueren., 2002; Lammerts van Bueren *et al.*, 2007). Therefore the traits required for the varieties in organic and conventional farming differ. Some breeding programmes were started in the last years with aim to evaluate genotypes adaptation to organic agriculture for characteristic traits required in organic farming systems and to elaborate the selection criteria that facilitate the breeding of proper varieties for organic agriculture (Schneider *et al.*, 2007; Legzdina and Skrabule, 2005).

The main objectives in the breeding programmes for small grains cultivars for organic farming are: to improve the nutrient efficiency, weed suppression ability (new ideotype of plant), as well as the resistance to leaf, spike and soil born diseases, the efficient use of manure, reducing risk of diseases (long stem, ear high above flag leaf, ear not too compact, last leaves green for the longest time possible), reducing risks at harvest, higher stress tolerance to abiotic causes (Ittu *et al.*, 2007, Legzdina and Skrabule, 2005; Lammerts van Bueren, 2002; Kopke, 2005; Goyer *et al.*, 2005).