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VASARAS MIEZU SKIRNES 'RUBIOLA' PARBAUDES REZULTATI

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Viena no miežu (*Hordeum vulgare* L.) audzēšanas problēmām bioloģiskajā lauksaimniecībā ir inficēšanās ar slimībām, kuru ierosinātāji saglabājas sēklas materiālā, īpaši ar putošo melnplauku (*Ustilago nuda*). Pašlaik neviena no Latvijas Augu šķirņu katalogā iekļautajām šķirnēm nav izturīga pret šo slimību. Mūsu mērķis bija piedāvāt audzētājiem izturīgu šķirni, kas būtu piemērota bioloģiskajiem audzēšanas apstākļiem. Pirmais solis, uzsākot selekciju bioloģiskās lauksaimniecības vajadzībām, bija konvencionālajā selekcijas programmā izveidotu selekcijas līniju pārbaude bioloģiskos apstākļos. Selekcijas līnija PR-2797 ('Rubiola') izveidota no krustojuma kombinācijas, kurā viens no vecākaugiem ir ar izturības gēnu Un8 pret putošo melnplauku. Rakstā apkopoti rezultāti par 'Rubiolas' pārbaudes rezultātiem konvencionālos apstākļos (5 gadi) un bioloģiskos apstākļos (3 gadi). Salīdzināšanai izmantotas Latvijā selekcionētas miežu šķirnes 'Abava', 'Idumeja', 'Ansis' un 'Rūja'. Konvencionālos apstākļos 'Rubiolas' raža pārspēja ekstensīva tipa šķirnes, taču tā atpalika no intensīvā tipa šķirnes 'Ansis'. 'Rubiolas' vidējā raža bioloģiskos apstākļos būtiski neatšķīrās no standartšķirņu ražas. Rezultāti rāda, ka būtisks ražas pieaugums šķirnei 'Rubiola' bioloģiskos audzēšanas apstākļos var tikt sasniegts, palielinot izsējas normu. Šķirnes izturība pret putošo melnplauku pierādīta, veicot mākslīgo inficēšanu un izmantojot molekulāros marķierus. Nozīmīgākā šķirnes 'Rubiola' priekšrocība bioloģiskajā lauksaimniecībā ir tās izturība pret putošo melnplauku; vērā ņemama ir arī relatīvi nelielā inficēšanās ar lapu slimībām, vārpu produktivitāte un augstā graudu tilpummasa. Šķirnei 'Rubiola' SĪN (saimniecisko īpašību noteikšanas) un AVS (atšķirīguma, viendabīguma un stabilitātes) pārbaudes uzsāktas no 2007.gada.

EVALUATION OF SPRING BARLEY MALTING VARIETIES FOR BREEDING PROGRAMMES

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Abstract

During the period 2005-2007 grain yield stability and the malt quality characteristics of malting spring barley varieties were investigated at the Lithuanian Institute of Agriculture. The growing conditions in 2005 and 2006 were dry and in 2007 were rather wet compared with the long-term mean. The high temperatures and drought in June of 2006 impacted low grain >2.5 mm yield and high protein content. The relationships between the lengths of spring barley growth periods and quality traits were evaluated. Using the software STABLE the stability of malting barley grain, course grain and extract yields as affected by the weather conditions during the crop year, genotype properties for varieties, as well as the interactions of variety and weather conditions were estimated. The selection of varieties promising in terms of grain yield, >2.5 mm grain yield and extract yield, was based on their ability to realize their genetic potential in various meteorological

conditions. Consequently, the highest sum of integral assessment of grain yield and grain >2.5 mm yield was identified for the varieties 'Tocada', 'Justina', 'Cruiser', 'Scarlett' and 'Annabell'. The varieties which exhibited high grain yield stability and were distinguished by high grain quality, disease resistance and other agronomic traits were involved in further breeding programmes.

Key words: *Hordeum vulgare*, L., disease resistance, yield stability, malting quality traits

Introduction

The agromorphological and grain quality traits of barley are commonly influenced by environmental factors and growing conditions and therefore are of limited use for assessing the levels of variability. The genotypic peculiarities of a variety and the climatic conditions over a growing period are the key factors influencing grain yield and quality (Tamm, 2003; Paynter and Young, 2004; Lazauskas *et al*., 2005). The evaluation of the genetic diversity of initial material and the matching of individuals with suitable traits for the malting barley breeding programmes are of primary importance (Bail and Meynard, 2003). The coarse grain output (grain on 2.5 x 20 mm sieve) is a specific requirement for malting barley. According to the present brewing requirements it must be not less than 90.0 %. The weather humidity and temperature over the grain filling period affect it (Paynter and Young, 2004; Passarella *et al*., 2005). Low grain protein content positively correlates with good malt quality (Eagles *et al.*, 1995; Molina-Cano *et al*., 1997; Leach *et al*., 2002; Zhang *et al*., 2006). A strong correlation exists between grain protein content and extract content. Spring barley varieties differ among themselves according to their reaction to the growing conditions. Therefore the variation of yield and grain quality traits is wide in range (Mašauskienė *et al*., 2001; Costa and Bollero, 2001). In Lithuania, temperatures noticeably vary during the summer months and every second or third summer is much colder or much hotter than the long-term mean (Galvonaitė *et al*., 2007). Therefore the weather conditions during the growing period are among the factors of primary importance which impact malting barley yield and especially grain and malt quality.

Even though the yield components of cereals are partly determined in the vegetative stage, the actual process of grain formation and filling takes place between the heading and physiological maturity stages. Distinctly shorter grain filling periods of barley were observed under drought stress (Long *et al*., 1998). Low yields of barley have often been observed when grain filling was shortened as a consequence of high temperatures and/or insufficient water supply (Savin *et al*., 1997a). Besides yield reductions, significant negative effects on malting quality have been observed as a consequence of stress situations during grain filling. Increased protein concentrations in the grain have been found in association with elevated temperatures and/or drought stress (Savin and Nicolas, 1996). A smaller average grain size has been related to stress factors.

Grain yields over a wide range were relatively independent from the total precipitation in the time span from January 1 to yellow ripeness. High temperatures also tended to reduce grading percentages and to a smaller extent increase protein concentrations. Precipitation amounts within certain periods are not as decisive as the occurrence of drought stress (Schelling *et al*., 2003).

However, moist weather also favours rapid development of fungal pathogens. Net blotch infection suppresses plant height and reduces 1000-grain weight (Robinson, 2000). Khan (1987) established a statistically significant relationship between yield loss and net blotch infection under Australian conditions using values for mean foliar damage on the top three leaves.

In Lithuania the sufficiently humid (normal monthly amount of precipitation in June and July is 69-79 mm) climate and warm summers enable barley to perform well. Therefore the investigation of varieties and their snitability for malting barley breeding programmes is of great relevance. The main objectives of this study is to evaluate phenological traits as well as grain, coarse grain and the extract yield stability of spring barley genetic resources and to select the most suitable varieties for malting barley breeding.

Materials and Methods

During the period 2005-2007, malting spring barley varieties were studied for yield, disease resistance and malt quality characteristics at the Lithuanian Institute of Agriculture. The genotypes tested were Lithuania-registered varieties, varieties from genetic resources collections, and new

varieties for initial breeding. The experimental plot for each cultivar was 20 m^2. The plots were arranged in a random design with four replications. The soil of the experimental site was sod gleyic (*Endocalcari-Endohypogleyic Cambisol* (CMg-n-w-can) light loam, with a clay content of 240-270 g kg^{-1}, pH_{KCl} 6.0-7.0. The organic matter by Tyurin in the plough layer was 25-27 g kg^{-1}; content of available P – 83-109 and K – 166-216 mg kg^{-1} by Egner-Riehm-Domingo. Fertilizers at a rate of $N_{90}P_{60}$ K_{60} were applied annually before seeding.

The period 2005-2007 was rather favourable for spring barley versatile evaluation because of the variable weather conditions. The conditions for seed germination and initial growth were favourable, but the growth period from booting till maturity in 2005 was warm and dry, in 2006 it was hot and dry and in 2007 - warm and wetter than the long-term mean.

In the trials we evaluated grain yield (t ha^{-1}), 1000 kernel weight (TKW) (g), hectolitre weight (HLW) (g l^{-1}) and grain grading >2.5 mm (%). Malt extract content (%), protein content (g kg^{-1}) and starch content (g kg^{-1}) were calculated in dry matter. Protein content was measured by the Kjeldahl method, starch content by hydrochloric acid dissolution. Malt extract content was determined on the basis of EBC (Analytica-EBC, 1987). Coarse (>2.5 mm) grain and malt extract yields per hectare were calculated. During the growth period earliness was defined as the number of days from germination (BBCH 10) to heading (BBCH 58) (pre-anthesis period) and the post-anthesis period was marked as the number of days from heading to maturity (BBCH 89).

Resistance to diseases was estimated. Powdery mildew (*Blumeria graminis* DC) and net blotch (*Pyrenophora teres*) were assessed once at the plant early–medium milk development stage (BBCH 73-75). The severity of the diseases were measured in scores, using the scale 1-9, where 1 meant full resistance, and 9 - complete susceptibility.

The level of statistical significance of data was calculated by the analysis of variance using the software package STATISTICS. The coefficients of linear correlation, trait mean $\bar{x}$, $\boxed{\text{Sx}}$ and the least significant difference $LSD_{0.05}$ was introduced. The stability of traits was evaluated by the mathematical model STABLE (Kang, Magari, 1995) adapted at LIA by P. Tarakanovas (2004) and used for the analysis of varietal grain yield stability.

Results and Discussion

Grain yield, 1000 kernel weight, course grain, extract and the starch percentage of malting barley varieties were significantly and negatively impacted by the length of the growing period from germination to heading (Table 1).

Table 1. Phenotypic correlation coefficients between the length of growth stages, resistance to diseases and spring barley grain yield and quality, Dotnuva, 2005-2007.

Trait	Grain yield, t ha^{-1}	Grain grading, % (>2.5 mm)	Extract content, %	1000 kernel weight, g	Hectoliter weight, g l^{-1}	Protein content, g kg^{-1}	Starch content, g kg^{-1}
Germination – heading, days	-0.267*	-0.493**	-0.254*	-0.392**	-0.194	0.186	-0.254*
Heading – maturity, days	-0.438**	0.565**	0.638**	0.345**	0.156	-0.847**	0.472**
Resistance to powdery mildew, scores	-0.121	0.311*	0.086	0.271*	0.227	-0.196	0.086
Resistance to net blotch, scores	-0.431**	0.034	0.485**	-0.159	0.076	-0.649**	0.485**

Significant at *P<0.05; **P<0.01

However, the influence of the post-anthesis period was much more substantial on these indices than that of pre-antheis period. The resistance to powdery mildew impacted grain grading and 1000 kernel weight. The higher grain yield matured and a higher protein content was accumulated for resistant to net blotch varieties, but the extract percentage in that case was lower. It led to the

explanation that the number of grain per spike for resistant varieties might have been too high and therefore the smaller-sized grain maturedcompared with the varieties affected by the net blotch. The correlation between the length of the growing periods and resistance to disease was insignificant.
Varieties of Lithuania origin 'Alsa', 'Aura DS', 'Aidas' had the highest protein content and the varieties 'Ūla', 'Luokė' were characterized by lower protein content (Table 2).

Table 2. The characteristics of grain quality and disease resistance of spring barley varieties, Dotnuva, 2005-2007.

Variety	Country of origin*	Duration in days		Resistance to diseases in scores**		Grain quality traits		
		BBCH 10 – BBCH 58	BBCH 10 – BBCH 89	Powdery mildew	Net blotch	1000-kernel weight, g	Protein, g kg^{-1}	Starch g kg^{-1}
Auksiniai 3	LT	41.7	80.7	4.7	2.7	44.7	129	608
Aidas	LT	43.7	83.0	4.3	2.0	47.1	135	585
Luokė	LT	40.7	80.3	5.3	2.3	49.7	127	564
Ūla	LT	40.7	80.3	5.3	2.7	51.2	131	587
Aura DS	LT	43.3	81.0	5.0	2.3	48.6	134	575
Alsa	LT	43.7	82.3	4.0	2.7	46.4	136	590
Henni	DE	42.3	80.7	4.3	2.7	44.8	127	600
Annabell	DE	42.7	79.3	3.7	2.3	43.4	132	605
Scarlett	DE	43.3	79.3	2.3	5.3	41.9	124	586
Pongo	SE	42.7	80.7	1.3	3.7	46.9	124	585
Jersey	NL	43.0	82.0	4.0	2.3	47.3	133	577
Tolar	NL	41.0	80.3	1.3	4.0	48.5	128	588
Prestige	FR	41.0	78.7	1.3	3.0	45.8	127	596
Breamer	UK	41.7	79.7	1.3	4.0	48.0	131	607
Barke	DE	41.7	79.7	1.7	3.3	46.4	124	587
Justina	DE	42.0	79.3	4.0	2.7	44.2	123	618
Sebastian	DK	42.7	81.3	3.0	3.7	47.3	128	593
Tocada	DE	43.7	81.7	2.7	3.3	45.8	127	598
Class	FR	42.3	80.0	1.0	6.7	46.5	126	591
Cruiser	DE	42.7	80.0	1.0	3.7	44.7	128	598
Power	UK	41.0	79.0	2.3	3.3	44.1	125	601
$\bar{x}$		42.25	80.44	3.05	3.27	46.35	128.4	592.3
$LSD_{0.05}$		1.492	1.726	1.875	1.326	3.071	11.82	22.04

* DE – Germany, DK – Denmark, FR – France, LT – Lithuania, NL – the Netherlands, SE – Sweden, UK – United Kingdom.
** 1 - full resistance, 9 - complete susceptibility.

The low protein content could be an inherent property of both these varieties. However, their resistance to powdery mildew was low. According to the protein percentage almost every registered foreign malting variety could be used as a donor for the development of the malting barley lines. However, their resistance to net blotch should be taken into account because of their negative relationship with grain yield. The varieties 'Annabell' and 'Tocada' demonstrated satisfactory resistance to both diseases. Net blotch infection was most severe in 2007. Therefore, although the weather conditions were conducive to grain formation, all the varieties investigated formed better grain >2.5 mm yield in 2005, except for 'Annabell' and 'Tolar'. They yielded better in 2007. Disease infection in 2006 (powdery mildew, net blotch and leaf spots) were low because of the high temperatures and drought. But this did not have any impact on yield as lack of

precipitation was the main limiting factor. The resistance to net blotch positively correlated with the extract and starch content and negatively with the protein content.

Table 3. Mean-square of the analysis of variance of spring barley grain, grain >2.5 mm and extract yields, Dotnuva 2005-2007.

Source of variability	DF	Mean square of the yield (MS)		
		grain t ha^{-1}	grain >2.5 mm t ha^{-1}	extract t ha^{-1}
Varieties (V)	21	2.501**	1.498	2.465**
Year (Y)	3	3,237.368**	1,812.767**	485.574**
Interaction (VxY)	62	63.849**	23.908**	12.9005**
Heterogeneity	20	0.211	0.789	0.186
Standard error	180	0.007	0.026	0.019

Significant at *P<0.05; **P<0.01

According to grain yield an especially high assessment was given for the 'Tocada', 'Justina', 'Cruiser', 'Annabel', 'Power', 'Tolar' and 'Henni' (Table 4). These varieties combined high yield with a low variance of stability. They were developed in countries that have warm and wet weather conditions. Therefore there is some uncertainty about their properties in relation with climate warming.

Table 4. Assessment of spring barley varieties according to yield, grain >2.5 mm and extract yield and stability, Dotnuva, 2005-2007.

Variety	Grain yield, t ha^{-1}		Grain>2.5 mm yield, t ha^{-1}		Extract yield, t ha^{-1}	
	Means	YS(i)*	Means	YS(i)*	Means	YS(i)*
Auksiniai 3	3.644	-8	3.071	-4	2.869	-6
Aidas	3.324	-10	2.448	-2	2.514	-6
Luokė	3.904	1	3.229	7+	2.954	4
Ūla	3.671	-7	3.167	4	2.762	-9
Aura DS	3.898	0	3.163	3	2.999	1
Alsa	3.763	-4	2.988	-6	2.878	-5
Henni	4.092	10+	3.177	5	3.188	8+
Annabell	4.306	13+	3.308	14+	3.364	18+
Scarlett	3.921	2	2.578	-9	3.148	7+
Pongo	3.584	-9	3.389	11+	2.830	-7
Jersey	3.944	4+	3.416	12+	3.110	4
Tolar	4.254	11+	3.130	5	3.358	11+
Prestige	3.695	-6	3.147	8+	2.906	-4
Breamer	3.742	-5	3.281	8+	2.932	5
Barke	3.773	5+	3.443	14+	2.980	8+
Justina	4.429	15+	3.142	-1	3.397	15+
Sebastian	3.924	3	3.581	24+	3.112	5
Tocada	4.525	16+	3.214	6+	3.553	24+
Class	3.986	7+	3.136	-2	3.122	10+
Cruiser	4.311	14+	3.507	23+	3.382	17+
Power	4.256	12+	2.834	-8	3.387	14+
$LSD_{0.05}$	0.068		0.130		0.129	

*- The varieties that surpassed the average integral evaluation YS(i) of the trial are indicated by (+)

The lowest assessment for grain yield stability was obtained for the Lithuanian varieties. However over the experimental period the grain yield and yield stability for the modern varieties 'Luokė' and 'Aura DS' was higher than that for 'Pongo', 'Prestige' and 'Breamer'.

Grain grading is an important parameter both for food and malt barley. A high integral assessment for this parameter was given to the varieties 'Sebastian', 'Cruiser', 'Barke', 'Annabell', 'Jersey',

'Pongo'. The integral assessment of course grain output per hectare for 'Luokė' was the highest among Lithuania-bread varieties. For the extract yield varieties 'Tocada', 'Annabell', 'Cruiser', 'Justina', 'Power' and 'Tolar' did well.

Over the experimental period the crop-year weather conditions varied considerably. Despite the fact that according to the averaged three years data the growth period of spring barley varieties varied between 79-83 days, the length of that period among varieties in some years was greater.

As a result, the impact of length of specific growth periods on yield and grain qualities was noted. The influence of the post-anthesis period was much more substantial on these indices than that of the pre-anthesis. In Lithuania's weather conditions the long post-anthesis period is frequently related to wet and cloudy weather which is favourable for starch and unfavourable for protein synthesis, therefore the long post-anthesis period positively affected the traits which are important for spring barley malting qualities. In several studies low barley grain yield has been related to the short duration of the heading-maturity period (Savin *et al*., 1997a; Savin *et al*., 1997b, Schelling *et al*., 2003). According to the climate classification Lithuania belongs to the southwestern sub area of the Atlantics wood continental area. Only the Lithuanian coast of the Baltic Sea from the point of climate is similar to Western Europe and can be linked to the separate South Baltic sub area (Galvonaite *et al*., 2007). However, the climate is influenced by the global warming phenomena. Our study showed that the influence of the weather conditions on spring barley yield and malting qualities is much more considerable than that of genotype properties. As a result, the genotypes with shorter pre- and post-anthesis and simultaneously low protein content like 'Scarlett', 'Cruiser' or 'Justina' will have priority. The Lithuanian varieties were more often characterized by longer growth and post-anthesis periods than the other investigated ones, but the grain yield and malting qualities were lower. The varieties 'Annabell' and 'Tocada' demonstrated satisfactory resistance to powdery mildew and net blotch. The selection of varieties promising for malting barley breeding programmes in terms of grain yield, >2.5 mm grain yield and extract yield stability was based on their ability to realize the genetic potential in various growing conditions. Consequently, the highest sum of integral assessment of grain yield and grain >2.5 mm yield was identified for the varieties 'Tocada', 'Justina', 'Cruiser', 'Scarlett' and 'Annabell' and therefore these genotypes are acceptable for the breeding of varieties intended for Lithuanian weather conditions.

Conclusions

The genotypes with shorter pre- and post-anthesis and simultaneously low protein content will have priority in breeding programmes for growing in the south-west sub area of the Atlantic continental forest area. The influence of the length of the post-anthesis period on grain yield and malting qualities was more pronounced than that of the pre-anthesis.

The impact of varietal resistance to net blotch on grain yield, protein, starch, extract content was greater than that of their resistance to powdery mildew.

According to their ability to realize their genetic potential in various weather conditions in terms of grain yield, >2.5 mm grain yield and extract yield stability the varieties 'Tocada', 'Justina', 'Cruiser', 'Scarlett' and 'Annabell' are best for breeding programmes in Lithuanian meteorological conditions.

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VASARAS MIEŽU ALUS ŠĶIRŅU IZVĒRTĒJUMS SELEKCIJAS PROGRAMMU VAJADZĪBĀM

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Laika periodā no 2005. līdz 2007. gadam Lietuvas Zemkopības institūtā tika pētīta vasaras alus miežu šķirņu graudu ražas stabilitāte un iesala kvalitātes pazīmes. Augšanas apstākļi 2005. un 2006. gadā bija sausi, bet 2007. gadā tie bija samērā lietaini, salīdzinot ar ilglaicīgi novērotajiem vidējiem rādītājiem. Augstās temperatūras un sausuma ietekmē 2006. gadā veidojās zema graudu frakcijas >2.5 mm raža un augsts proteīna saturs. Tika novērtētas sakarības starp vasaras miežu veģetācijas perioda garumu un kvalitātes pazīmēm. Izmantojot datorprogrammu STABLE, tika noteikta alus miežu graudu, rupjās graudu frakcijas un ekstraktvielu ražas stabilitāte audzēšanas gadu meteoroloģisko apstākļu, šķirņu genotipisko īpašību, kā arī šķirņu un meteoroloģisko apstākļu mijiedarbības ietekmē. Tika veikta daudzsološāko šķirņu atlase pēc graudu, graudu frakcijas >2.5 mm un ekstraktvielu ražas, pamatojoties uz šķirņu spēju realizēt ģenētisko potenciālu dažādos meteoroloģiskos apstākļos. Rezultātā augstākā integrālā novērtējuma summa graudu ražai un graudu frakcijas >2.5 mm ražai tika konstatēta šķirnēm 'Tocada', 'Justina', 'Cruiser', 'Scarlett' un 'Annabell'. Šķirnes ar augstu graudu ražas stabilitāti, izturību pret slimībām un citām agronomiskām īpašībām tika tālāk izmantotas selekcijas programmās.