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MORPHOLOGICAL AND AGRONOMIC CHARACTERIZATION OF SPRING BARLEY VARIETY 'AUSTRIS'

Abstract

Barley (*Hordeum vulgare* L.) variety 'Austris', bred at the State Stende Cereal Breeding Institute, is the first barley variety in Latvia created by use of biotechnology methods. Doubled haploid lines were produced by a haploproducer method, so called Bulbosum method, from breeder hybrids, with following propagation and field evolution. The spring barley variety 'Austris' was distinguished by a high yield, good lodging resistance, increased 1000 kernel and test weight, good resistance to net blotch and moderate resistance to powdery mildew. Since 2009 'Austris' is included in the Latvian National Catalogue of Plant Varieties.

Key words: *spring barley, variety, development, evaluation, DUS test.*

Introduction

Cereal breeding programs are engaged in almost all agriculturally advanced countries. Usually varieties are most able to realise they potential in the environment where varieties are bred. Latvian agro-meteorological conditions are different from other countries, as well variations can be observed in diversity of soils, rainfall intensity, duration of growing season, distribution of disease and pests etc. among distinct regions of Latvia. Local varieties in the most cases are potentially more plastic, with higher yield and with better resistance to corresponding abiotic and biotic stresses.

Requirements for the registration of a new spring barley varieties are high: the variety could be included in the National Catalogue of Plant Varieties only if it before commercialization showed positive results both from the official trials for DUS (Distinctness, Uniformity, Stability) and VCU (Value for Cultivation and Use). A new variety must be endowed with properties, which do not existing in others, the barley breeding programs have long-term priorities. The spring barley breeding program is established at the State Stende Cereals Breeding Institute (SSCBI) with the goal to create new varieties with high grain yield and quality, conforming industry requirements, as well with the resistance to lodging and main diseases.

In the case of autogamous species, such as barley (*Hordeum vulgare* L.), releasing a new variety is depending on genetic homozygosity, taking up till 10 to 14 years. Therefore the speed and efficiency become increasingly important in of spring barley breeding. Biotechnology methods are used to enhance the efficiency and accelerate spring barley breeding by rapid achieving of the homozygosity by producing doubled haploid (DH) lines either through interspecific crosses between cultivated barley and wild barley *H. bulbosum*

with subsequent chromosome elimination of wild species (Bulbosum method) or through anthers or immature pollens (microspores) cultures (Pickering & Devaux 1992). Collaboration between universities, research institutions and breeding companies has resulted in the routine use of DH technologies in practical breeding of cereals in some European cereal breeding programs (Leistrumaitė & Basiuliene 2004; Tuvešson, et al., 2007).

In the Laboratory of Plant Genetics of the Institute of Biology, University of Latvia (IBUL), the embryoculture (Bulbosum method) and anther culture methods are used for obtaining of barley DH lines (Rashal et al., 1998; Grauda, 1999) for practical purpose. Cooperation among the SSCBI and IBUL in the including barley DH lines produced from promising breeder lines in the breeding programme in addition to classical breeding material has been started since 1987. The objective of this article is to characterize the morphological and agronomic traits of barley variety 'Austris', bred at the SSCBI in collaboration with IBUL from the DH line produced by the Bulbosum method.

Materials and methods

Spring barley variety 'Austris' was created from hybrid combination of the variety 'Ansis' (Latvia) and breeding line 'WW 8208' (Sweden). Hybridization was done in the SSCBI in 1995, fifty grains were obtained. In 1996, seeds of F₂ generation were delivered to the IBUL. There 79 grains of a DH line (temporary designation G 131) were obtained from this combination by Bulbosum method and returned to the SSCBI. After multiplication field trials were carried with the line during several years (Table 1).

Table 1

Places and type of field trials of DH line G 131

Period of investigation	Trial	Place of field trial
2001-2003	Competitive trial	State Stende Cereal Breeding Institute
2004-2008	Ecological trial	State Stende Cereal Breeding Institute
2005-2008	Ecological trial	State Priekuli Crop Breeding Institute, Study and the Research Farm 'Vecauce'
2006-2008	VCU (value for cultivation and use) testing - convention and organic field trials	Plant Variety Testing Department, State Plant Protection Service, Latvia
2006-2007	DUS (distinctness, uniformity, stability)	Poland, Slupia Wielka

In the **competitive trial** 10 m² experimental plots were arranged in a random design with 6 replications. Pre-crop – potatoes. Before cultivation a complex mineral fertilizer was applied annually before sowing: N-60, P₂O₅-35, K₂O – 50, S – 42 kg ha⁻¹. The seeding rate was 400 germinated able seeds per 1 m². No fungicide was used for limitation of leaf disease development. The standard variety ‘Abava’ was used for comparison.

In the **ecological trial** 5 m² experimental plots were arranged in a random design with 4 replications. Pre-crop – potatoes. Before cultivation a complex mineral fertilizer was applied annually before sowing: N-80, P₂O₅-47, K₂O – 66, S – 56 kg ha⁻¹. The seeding rate was 400 germinated able seeds per 1 m². No fungicide was used for limitation of leaf disease development. The standard variety ‘Ansis’ was used for comparison.

In the trials grain yield (t ha⁻¹), 1000 grain weight (TGW) (g), test weight (TW) (g L⁻¹) were evaluated. Grain protein content (g kg⁻¹), starch content (g kg⁻¹) were assessed by Kjeldahl method (2001-2003) and by grain analyzer Infratech Ananalysis 1241 (2004-2008). During the growth period the number of days from germination to heading and period of vegetation were evaluated. Lodging resistance was scored in the scale 1-9, where 1 – full lodging, 9 – no lodging. Powdery mildew (*Blumeria graminis*) and net blotch (*Pyrenophora teres*) infection rate were assessed once per season at the plant early-medium milk development stage (BBCH 73-75). The severity of the diseases were scored in the scale 1-4, where 1 – full resistance, 4 – complete susceptibility. Obtained results were statistically processed using methods of descriptive statistics.

Results

Results of competitive trial in 2001 and 2003 showed that spring barley DH line G 131 (later variety ‘Austris’) provided significantly ($p < 0.05$) higher grain yield in comparison with the standard variety ‘Abava’ (+0.48 and +0.83 t ha⁻¹ respectively) (Table 2). In the years of investigation the perspective line showed better lodging resistance, higher 1000 grain weight (+4.5 g). Plant height of variety ‘Austris’ was 18.6 cm shorter than of standard variety ‘Abava’ that positively influenced lodging resistance (score 8.3, ‘Abava’ – score 7.8). ‘Austris’ characterized by increasing coefficient of productive tillering (+1.35 productive stems in comparison with the variety ‘Abava’) and better resistance to powdery mildew (score 2, ‘Abava’ – score 3) and net blotch (score 0-1, ‘Abava’ – scores 2-3).

Table 2

Characteristic of spring barley variety ‘Austris’ at the competitive trials in comparison with the standard variety ‘Abava’

Trait	‘Austris’				‘Abava’				± standard
	2001	2002	2003	Mean	2001	2002	2003	Mean	
Grain yield, t ha ⁻¹	5.11	5.52	6.72	5.47	4.19	5.49	5.41	5.03	0.44
± standard	0.92	0.03	0.83	0.44	-	-	-	-	
RS _{0.05}	0.48	0.54	0.39	-	-	-	-	-	
Lodging resistance	8	9	7.8	8.3	8	9	6.5	7.8	0.5
Period of vegetation	86	91	85	87	87	92	85	88	1
TGW, g	51.8	54.7	49.8	52.1	42.7	52.1	47.1	47.6	4.5
TW, g L ⁻¹	714.5	716.5	691.5	707.5	685.5	738.0	695.5	706.3	1.2
Crude protein, g kg ⁻¹	135	121	132	129	135	113	136	128	0.1
Plant height, cm	84.7	61.5	79.4	75.2	92.8	83.4	105.4	93.8	-18.6
Ear length, cm	4.8	5.5	7.6	6.0	5.8	6.1	9.6	7.1	-0.9
Coefficient of productive tillering	4.5	3.6	-	4.05	3.2	2.2	-	2.7	1.35
Powdery mildew	2	2	2	2	3-4	3	3	3	1
Net blotch	1	0	1	0-1	3	3	2	2-3	2

At the ecological trials in three locations (Stende, Priekuli and Vecauce) on four years average grain yield for variety ‘Austris’ ranged from 5.02 to 5.59 t ha⁻¹. Mean yield (5.34 t ha⁻¹) did not differ significantly from average yield of the standard variety ‘Ansis’ (5.44 t ha⁻¹) (Table 3).

Table 3

Grain yield spring barley variety ‘Austris’ at the ecological trials in three locations, mean of 2005-2008

Variety	Location	2005	2006	2007	2008	Mean	V%
‘Ansis’	Stende	5.75	5.49	4.82	5.87	5.48	8.6
	Priekuli	5.09	4.17	5.47	5.94	5.17	14.5
	Vecauce	6.07	4.99	6.40	5.27	5.68	11.6
	Mean	5.64	4.88	5.56	5.69	5.44	6.9
‘Austris’	Stende	5.54	5.98	4.89	5.96	5.59	9.1
	Priekuli	4.84	3.44	5.51	6.30	5.02	24.1
	Vecauce	6.76	4.72	6.05	4.29	5.46	21.0
	Mean	5.71	4.71	5.48	5.52	5.36	8.2

Barley variety ‘Austris’ is characterized by relatively good resistance to net blotch (score 0.9) and moderate resistance to powdery mildew (score 1.6) (Table 4). It is resistant also to loose smut that is major importance for organic farming conditions (date are not shown).

Table 4

Some important traits performance of spring barley variety ‘Austris’ at the ecological trials in different locations, mean of 2004 to 2008

Variety	Location	Plant height		Lodging		Powdery mildew	Net bloch
		mean	min-max	mean	min-max		
‘Ansis’, standard	Stende	65.5	61-70	7.8	4.3-9.0	0.8	1.5
	Priekuli	62.9	61-67	8.9	8.7-9.0	0.8	0.7
	Vecauce	60.0	49-69	9.0	9	-	-
	Mean	62.8	-	8.6	-	0.8	1.1
‘Austris’	Stende	76.9	64-84	8.0	6.0-9.0	1.8	1.1
	Priekuli	69.6	65-69	9.0	9	1.4	0.6
	Vecauce	62.5	47-78	8.9	8.5-9.0	-	-
	Mean	69.7	-	8.6	-	1.6	0.9

Variety ‘Austris’ is characterized with very course grains. On average 1000 kernel weight of variety was 50.2 g (‘Ansis’ - 45.5 g), while the test weight - 680.0 g L⁻¹ (‘Ansis’ - 673 g L⁻¹) (Table 5). ‘Austris’ has average crude protein content (mean value 134 g kg⁻¹) therefore belongs to the group of varieties more suitable for animal feeding.

Table 5

Grain quality of spring barley variety ‘Austris’ at the ecological trials in different locations, mean of 2004 to 2008

Variety	Location	1000 kernel weight, g		Test weight, g L ⁻¹		Crude protein, g kg ⁻¹	
		mean	min-max	mean	min-max	mean	min-max
Ansis, standard	Stende	44.5	41-47	653	629-671	122.5	113-138
	Priekuli	46.2	39-51	679	656-698	118.8	103-161
	Vecauce	45.9	43-49	688	652-713	136.8	123-168
	Mean	45.5	-	673	-	126.0	-
Austris	Stende	51.4	50-53	667	627-690	130.0	106-162
	Priekuli	49.3	42-55	685	672-704	128.8	110-166
	Vecauce	49.9	48-53	688	678-707	144.8	128-168
	Mean	50.2	-	680	-	134.5	-

DUS test for variety ‘Austris’ was successfully done in Poland during 2006 to 2007. Report of Technical Examination (30.11.2007, Slupia Wielka PL) was approved by the UPOV (the International Union for the Protection of New Varieties of Plants). During this test the description of morphological traits of barley variety 'Austris' was prepared to identify the variety in the seed production (Table 6).

Table 6

Description of morphological traits of barley variety 'Austris' by UPOV

No.	Characteristics	States of expression	Note
1	Plant: growth habit	semi erect	3
2	Lowest leaves: hairiness of leaf sheaths	absent	1
3	Flag leaf: anthocyanin coloration of auricles	medium	5
4	Plant: frequency of plants with recurved flag leaves	very low to low	2
5	Flag leaf: glaucosity of sheath	strong	7
6	Time of emergence	early	3
7	Awns: intensity of anthocyanin coloration of tips	strong	7
8	Ear: glaucosity	strong	7
9	Ear: attitude	horizontal	5
10	Plant length	medium	5
11	Ear: number of rows	two	1
12	Ear: shape	parallel	5
13	Ear: density	medium	5
14	Ear: length	short to medium	4
15	Awns: length (compare to ear)	long	7
16	Rachis: length of first segment	medium	5
17	Rachis: curvature of first segment	strong	7
18	Ear: development of sterile spikelet	full	2
19	Sterile spikelet: attitude	divergent	3
20	Median spikelet: length of glume and its awn relative to grain	longer	3
21	Grain: rachilla hair type	long	2
22	Grain: husk	present	9
23	Grain: anthocyanin coloration of nerves of lemma	weak	7
24	Grain: spiculation of inner lateral nerves of dorsal side of lemma	weak	3
25	Grain: hairiness of ventral furrow	absent	1
26	Grain: disposition of lodicules	clasping	2
27	Kernel: colour of aleirone layer	whitish	1
28	Seasonal type	spring type	3

Variety 'Austris' is recommended as well for cultivation in the organic management system. According evaluation results of official organic VCU field trials of the Plant Variety Testing Department for barley variety 'Austris' on average of two years grain yield, 1000 kernel weight, test weight and crude protein content in grain was higher than standard variety 'Rasa' (Table 7).

**Characteristic of spring barley variety ‘Austris’ in the conditions of organic farming,
2006-2007¹**

Rādītājs	‘Rasa’ (standard)			‘Austris’		
	2007	2008	Mean	2007	2008	Mean
Grain yield, t ha ⁻¹	3.08	2.64	2.86	3.39	2.56	2.98
Lodging resistance, scores	9.0	8.0	8.5	9.0	8.0	8.5
Plant height, cm	60	60	60	54	52	53
Period of vegetation, days	95	93	94	96	94	95
1000 kernel weight, g	40.3	41.8	41.0	49.4	50.3	49.9
Test weight, g L ⁻¹	635	650	642	663	660	661
Starch, g kg ⁻¹	610	632	621	611	610	610
Crude protein, g kg ⁻¹	128	111	119	130	119	124

¹Data of the State Plant Protection Service.

According to results of the State decision of the National Plant Variety Board No 373 the spring barley variety ‘Austris’ was included in the Latvian State Catalogue of Plant Varieties since 2009.

Summary

Barley variety ‘Austris’ is the first barley variety in Latvia created on the basis of DH line. The variety have high yield, good lodging resistance, increasing 1000 grain and test weight, good resistance to net blotch and moderate resistance to powdery mildew. Variety ‘Austris’ is recommended for cultivation in both conventional and organic management systems. Variety is mainly suitable for animal feeding. Since 2009 ‘Austris’ is included in the National Catalogue of Plant Varieties and is registered in the Latvian State Catalogue of Plant Varieties according to decision of the National Plant Variety Board No 373.

Bibliography

1. Grauda D. (1999) Obtaining of double haploid lines and their use in barley breeding. *Proceedings of the International Cereal Conference „Cereal Breeding: Achievements and Prospects for Improvements”*, 12-14 July, 1999, Estonia, Jõgeva Plant Breeding Institute, pp. 3-5.
2. Kiviharju, E., Weyen, J., Förster J. Schondelmaier, J.(2007) Molecular markers and doubled haploids in European plant breeding programmes. *Euphytica*, 158 (3), pp. 305-312.
3. Leistrumaite, A., Basiuliene, B. (2004) Agronomic performance of doubled haploid spring barley lines. *LLU Raksti*, 10 (305), pp. 26-31
4. Rashal I., Ornicane D., Gaiķe V. (1998) Effectiveness of haploid use in barley breeding. In: *Biotechnology in Plant Breeding. Proceedings of Scientific Conference*, Lithuanian University of Agriculture, October 8-9, Kaunas, pp. 14-18.

5. Tuvesson, S., Dayteg, C., Hagberg, P., Manninen, O., Tanhuanpaa, P., Tenhola-Roininen, T., Pickering R.A., Devaux P. (1992) Haploid production: Approaches and use in plant breeding. In: Shewry P.R. (ed). *Barley: Genetics, Biochemistry, Molecular Biology and Biotechnology*. CAB International, Oxford, pp. 519–547.