

PERFORMANCE OF LATVIAN SPRING BARLEY (*HORDEUM VULGARE* L.) VARIETIES IN CONDITIONS OF ORGANIC FARMING

Legzdiņa L¹, Bleidere M², Prauliņa O², Gaile Z³, Vigovskis J⁴ and Švarta A⁴

¹ Priekuli Plant Breeding Station, Zinatnes iela 1a, Priekuli, Latvia

² State Stende Plant Breeding Station, Dizstende, Latvia

³ RSF "Vecauce", Latvia University of Agriculture, Akademijas iela 11a, Auce, Latvia

⁴ Skriveri Research Institute, Latvia University of Agriculture, Skriveri-1, Latvia

Abstract

In order to recommend the most appropriate spring barley varieties for organic farming, trials in certified organic fields were carried out in four Latvian research institutions. The article summarises the data about grain yield, quality, plant height, the length of vegetation and infection with diseases of six registered barley varieties, which were tested in 2003 (2 test sites) and 2004 (4 test sites). The mean grain yield of varieties 'Ruja', 'Malva' and 'Rasa' was significantly higher if compared to the check variety 'Abava' ($P = 95\%$). The influence of genotype and test site on grain yield was significant (p -value = 0.004 and <0.0001 , respectively). The highest mean TGW (thousand grain weight) was estimated for varieties 'Idumeja' (47.0 g) and 'Ruja' (46.7 g). None of the varieties exceeded the mean grain volume weight of standard variety 'Abava' (679 g l^{-1}). The influence of genotype on the content of crude protein and starch in grain was not significant. The duration of vegetation of variety 'Idumeja' was on average 8 days shorter than that of check 'Abava'. The mean plant height of check variety 'Abava' significantly surpassed the rest of tested varieties. None of the varieties showed complete resistance to loose smut (*Ustilago nuda*); the lowest infection level was detected for varieties 'Malva' and 'Idumeja', which can be recommended for organic farming from this point of view.

Key words: spring barley, organic farming, yield, grain quality, loose smut

Introduction

Organic farming is a comparatively new and growing direction of agriculture in Latvia. There are plans to expand the area of agricultural land, which is certified for organic farming from 1% to more than 3% in the year 2010 (Programme for development..., 2003). Special varieties for growing in organic agriculture are not registered in Latvia yet and the choice of appropriate varieties is essential for farmers.

The modern European varieties are created mostly for high input growing conditions where high amounts of mineral fertilizers and pesticides are used. It is not proved yet, if the differences between organic and conventional farming systems are large enough to motivate breeding and testing of varieties in both environments. Large-scale comparison of 120 barley varieties and variety mixtures in organic and conventional conditions is carried out in Denmark. Plant height was found to be one of the traits, which correlates with grain yield differently in organic and conventional conditions (Ostergaard, Jensen, 2004). Some of the Latvian barley varieties are bred for different growing conditions, compared to most European countries. Due to economical reasons, varieties were often selected on fields with comparatively low application of fertilisers and pesticides. The plant height of most Latvian barley varieties exceeds the European ones.

It is essential for organic farming (particularly for seed production) to put more focus on the control of seed borne diseases. The choice of resistant varieties is an important component of preventative strategy. Loose smut of barley (*Ustilago nuda*) can be mainly controlled by choosing resistant varieties (Borgen, 2004). Since only organically grown seed will be allowed for organic farming in the future and the number of infected plants with loose smut is restricted by Latvian seed legislation, it is essential to choose varieties resistant to this disease.

The aim of the study was to summarise the results obtained from testing six registered Latvian barley varieties in organic farming conditions in various environments in four Latvian agricultural research institutions.

Materials and Methods

The trials were carried out in certified organic fields. Six registered spring barley varieties, which were recommended by the breeders as most suitable for organic farming ('Abava', 'Idumeja', 'Sencis', 'Malva', 'Rasa', and 'Ruja'), were included in the study. The testing was arranged in geographically distinctive locations: in 2003 in Priekuli (NE Latvia) and Stende (NW Latvia) and in 2004 in Priekuli, Stende, Vecauce (SW Latvia) and Skriveri (SE Latvia). Abava, the oldest currently grown barley variety in Latvia with good

adaptation ability to poor growing conditions, was used as check. The soil characteristics and growing conditions in all locations are shown in Table 1. The number of replications was four; random plot layout or systematic layout in blocks using simple repetition method (in Skriversi) was used. The weed control was done by harrowing. Emergence was calculated as the percentage of emerged seedlings from the sown seeds able to germinate in 0.5 m². Lodging was assessed at the maturity stage (1 – completely lodged, 9 – no signs of lodging). Infected spikes with loose smut (*Ustilago nuda* (Jens.) Rostr.) were counted in each plot. Infection with powdery mildew (*Blumeria graminis* f.sp. *hordei*) and net blotch (*Drechslera teres* (Sacc.) Shoem) was assessed in points 0–4 (0 – no infection, 4 – very strong infection) in Priekuli and in Stende. Crude protein content was determined by Kjeldahl and starch content by Evers method or by express method (for Priekuli in 2004).

Table 1. Characteristics of soil and growing conditions

Indices	2003		2004			
	Priekuli	Stende	Priekuli	Stende	Vecauce	Skriveri
Soil type	sod-podzolic sandy loam	sod-podzolic loamy sand	sod-podzolic sandy loam	sod-podzolic loamy sand	sod-gleysolic sandy loam	sod-podzolic sandy loam
pH _{KCl}	6.4	6.3	5.8	6.3	6.8	6.4
Organic matter, g kg ⁻¹	21	21	21	23	32	36
P, mg kg ⁻¹	64.2	92.1	123.9	111.3	39.7	64.6
K, mg kg ⁻¹	148.6	124.5	190.9	110.4	65.6	123.7
Previous crop	rape (green manure)	buckwheat (green manure)	perennial grass	buckwheat (green manure)	potatoes	winter rye
Seed rate, seeds able to germinate per m ²	400	500	400	500	430	500
Sowing date	12.05.	26.04.	21.04.	13.04.	15.04.	30.04.
Plot size, m ²	23.1	20.6	23.1	20.6	21.8	30.0

The beginning of growing season in 2003 (April in both sites and also May in Priekuli) was wet (Fig. 1); the monthly amount of rainfall was by 38–42% higher than the long-term average.

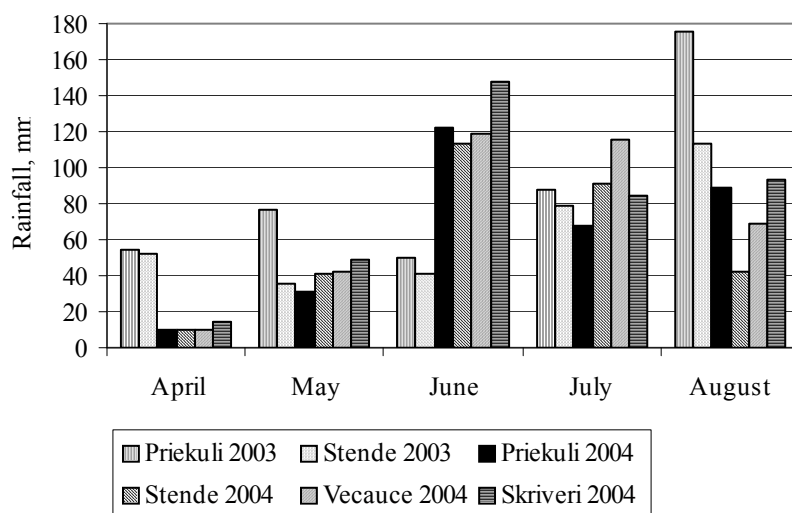


Figure 1. The amount of rainfall during the vegetation

It ensured sufficient moisture for germination and establishment of plants. Very dry conditions were observed in the beginning of June (9 and 1.6% of the long-term average amount of rainfall in Priekuli and Stende, respectively), middle of July in Priekuli (24% of long-term average) and 1st decade of August (52 and 13%). The mean air temperature in the middle of June was by 2.1–2.3 °C lower, but in July by 3 °C higher than in long-term period. High amount of precipitation in the 2nd and 3rd decade of August (270 and 186% of long-term average in Priekuli and Stende, respectively) interfered harvesting and caused lodging and sprouting. In 2004, the dry conditions in April and May hindered plant emergence. In the 2nd and 3rd

decade of May, considerable frosts (-5 to -7 °C) partially damaged the seedlings, nevertheless most of the plants were able to continue the growth. Low temperatures in May promoted tillering, and resulted in sufficient amount of productive tillers. High amount of rainfall was registered at the end of June (245, 366, 232 and 355% of the long-term data in Priekuli, Stende, Vecauce and Skrīveri, respectively) and in the middle of August (particularly in Priekuli). The mean air temperature in May, June and July was below the long-term data.

ANOVA (two factor with or without replication) was used for data analysis. The data was analysed as if it was from 6 test sites; the influence of the year was calculated for Stende and Priekuli.

Results and Discussion

The mean grain yield of varieties 'Ruja', 'Malva' and 'Rasa' was significantly higher if compared to the check 'Abava' ($P = 95\%$, Table 2).

Table 2. Grain yield and quality

Variety	Grain yield, $t\ ha^{-1}$	TGW, g	Volume weight, $g\ l^{-1}$	Crude protein*, %	Starch**, %
Abava	3.71	45.2	678.8	12.8	60.9
Idumeja	3.88	47.0	635.1	12.4	60.5
Sencis	3.70	41.4	678.5	12.7	61.2
Malva	3.95	40.0	666.6	12.6	61.5
Rasa	3.93	40.9	659.7	12.6	61.6
Ruja	4.08	46.7	675.1	12.0	61.9
LSD _{0.05}	0.213	1.21	20.51	0.59	1.06
p-value (genotype)	0.004	< 0.0001	0.003	0.14	0.2
p-value (site)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

* Priekuli, Stende, Vecauce;

** Priekuli, Vecauce.

The mean yield of 'Idumeja' and 'Sencis' did not differ significantly from that of 'Abava'. Variety 'Ruja' was significantly higher yielding than 'Abava' in 3 sites (Stende, 2003; Priekuli and Vecauce, 2004); only in Skrīveri, 2004) it had the lowest yield (difference not significant). None of the varieties had a significantly lower yield than the check except 'Rasa' in Priekuli in 2003 (this was the only case when 'Abava' had the highest yield among the tested varieties, Fig. 2).

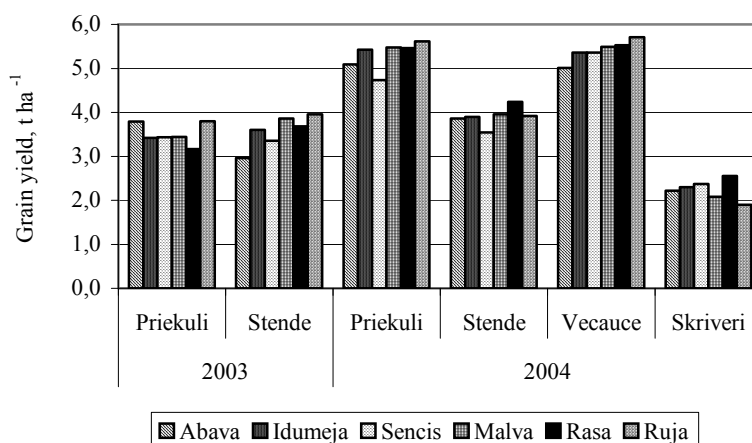


Figure 2. Grain yield of barley varieties

The influence of the genotype on grain yield was significant if data from all test sites was analysed together (p -value = 0.004); it was significant also in all test sites separately (p -value < 0.03) except in Vecauce (p -value = 0.17). Test site influenced the yield significantly (p -value < 0.0001). The highest yield level was achieved in Vecauce and in Priekuli in 2004 (mean yield – 5.41 and 5.30 $t\ ha^{-1}$, respectively), but the lowest yields were in Skrīveri (mean – 2.24 $t\ ha^{-1}$), which could be caused by very high amount of rainfall in June as

well as by lower amount of nitrogen in soil after the previous crop – winter rye. The influence of agrometeorological conditions of the growing year was not significant in Stende (p -value=0.3), but it was highly significant in Priekuli mainly because of the differences in soil characteristics (p -value<0.0001). The reasons for various yield performance of varieties in organic farming may be explained by differences in ability to uptake nitrogen and other fertilizing elements from soil. Variation of the competitive ability with weeds among barley varieties has been stated (Doll, 1997).

The highest mean TGW was estimated for varieties 'Idumeja' (range 40.3–50.2 g) and 'Ruja' (38.7–53.0 g), which significantly surpassed that of 'Abava' (Table 2). None of the varieties exceeded the mean grain volume weight of the check variety 'Abava' (range 612–713 g l⁻¹), but the volume weight of 'Idumeja' (579–679 g l⁻¹) was significantly lower than that. No significant influence of the genotype on the content of crude protein and starch in grain was observed. The mean crude protein content of 'Ruja' was significantly lower than that of 'Abava'. The highest mean starch content was stated for 'Ruja'.

The highest mean seedling emergence was registered for variety 'Sencis' and it was lower for 'Idumeja', but the differences between the varieties were not significant (Table 3). Low emergence (50–64%) was registered in Priekuli in 2004 due to insufficient soil moisture in spring. Emergence can be essential to ensure optimal plant density, which results in the ability of plants to compete with weeds. H. Doll (1997) reported that normal plant density of barley was more important for the competitiveness with weeds than it was for obtaining high grain yield.

Table 3. Some plant growth characteristics and resistance to lodging and diseases

Variety	Field emergence, %*	Plant height, cm	Lodging, 1-9*	Length of vegetation, days*	Loose smut, spikes per m ²	Powdery mildew, 0-4*	Net blotch, 0-4**
Abava	73.8	95	8.3	103	0.204	2.6	2.3
Idumeja	71.4	84	8.6	95	0.093	2.2	2.2
Sencis	81.0	87	7.6	98	2.180	1.2	2.5
Malva	75.5	85	8.2	100	0.076	1.9	2.4
Rasa	79.1	88	8.4	100	0.128	1.8	2.4
Ruja	73.0	90	8.7	103	1.119	3.0	1.8
LSD _{0.05}	11.19	4.5	0.69	1.8	1.35	1.00	0.77

* Priekuli, Vecauce, Skrīveri;

** Priekuli, Stende.

The duration of vegetation of variety 'Idumeja' was on average 8 days shorter than that of check variety 'Abava', which had the longest growing period together with variety 'Ruja'. Earliness can be a useful trait for organic farming because of rapid development of plants, which can be related to better ability to compete with weeds and use the nutrients from soil, as well as a possibility to harvest the grain earlier and have a longer growing period for following crop (e.g. green manure).

The mean plant height of check variety 'Abava' (range 78–108 cm) significantly surpassed the rest of tested varieties. Shortest plants were registered in Skrīveri (mean of all varieties – 69 cm), but the highest plants were in Priekuli (mean – 98 cm). H. Ostergaard and J. W. Jensen (2004) stated that plant height is one of the important characteristics of spring barley for organic farming and it is related to competition ability with weeds. In our study the variety with the highest plants did not prove to be the best yielding one. Lowest mean lodging resistance was observed for variety 'Sencis', the assessments of other varieties did not differ significantly. There were no signs of lodging registered in Skrīveri. Lodging is usually not considered a problem in organic farming due to the relatively low amount of nitrogen in soil.

The main seed-borne disease observed in the trials was loose smut. None of the varieties showed complete resistance to loose smut; the lowest infection level was detected for 'Malva' and 'Idumeja' (Fig. 3, Table 3). The most infected variety was 'Sencis', which had infected spikes in all test sites. Considerably high infection was stated also for 'Ruja'. Infection with loose smut for 'Abava' and 'Rasa' was registered only once (Priekuli, 2004). Barley leaf stripe (*Drechslera graminea* Ito) was observed only in Priekuli for varieties 'Malva', 'Abava', and 'Sencis'. Most susceptible was the variety 'Malva' with 1.5 (2003) and 8 (2004) infected plants per plot.

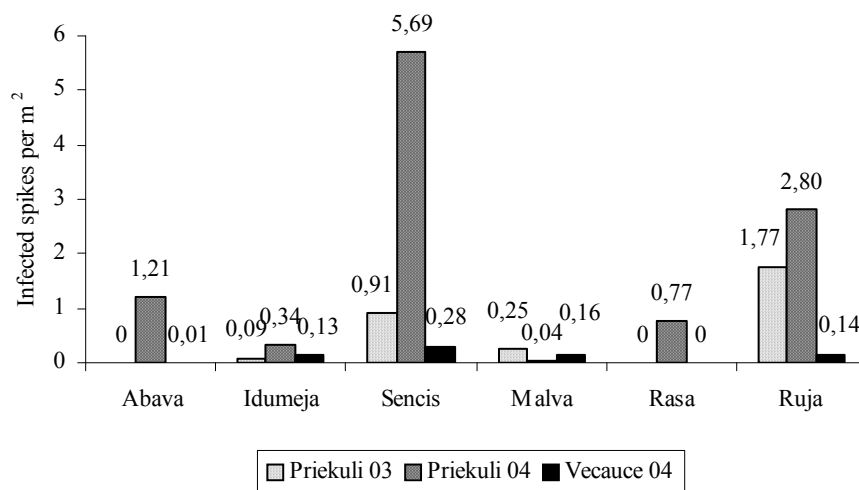


Figure 3. Infection of barley varieties with loose smut in Priekuli and Vecauce

There are no Latvian barley varieties with known resistance genes against loose smut registered, but some of them (e.g. 'Abava' and 'Idumeja') flower with closed flowers, and the infection level is usually low. Variety 'Ofir', which is resistant to loose smut, is included in the pedigree of 'Malva' (Belicka, 2001). Since 'Idumeja' flowers comparatively early, it is possible that there are less sources of infection available at that time and it is a reason for better resistance. In the case 'Ruja' is chosen for growing in organic farming (due to its good yield potential), it is necessary for seed production to treat the seed against loose smut. Seed pre-treatment with warm water followed by hot water treatment was reported to have 98–99% efficiency in loose smut control (Nielsen *et al.*, 2000), but this method might be not economical. Other possibility to reduce loose smut infection is by seed separation and use of only largest fraction for sowing (Borgen, 2004).

The highest mean infection level with powdery mildew was recorded for 'Ruja' (range 2–3.6 points). Significantly lower infection was found for 'Sencis'. The infection with net blotch was medium high and did not significantly differ in between the varieties.

Conclusions

No one of the tested varieties was ideally suited for organic farming, but several of them can be recommended to organic farmers as most appropriate for growing in organic conditions.

The positive traits of 'Idumeja' were earliness, low infection with loose smut and high TGW, but the yield level was medium and volume weight low. 'Malva' was comparatively resistant to loose smut and good yielding, but infection with leaf stripe was registered. The best yielding variety was 'Ruja', but seed treatment against loose smut in seed production is required. 'Rasa' is good yielding, but infection with loose smut is possible. 'Abava' had the highest plants, but the yield was comparatively low. 'Sencis' can not be recommended for organic farming due to high infection with loose smut and low yield.

Acknowledgements

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