Comparison of important parameters of spring and winter barley cultivated in sugar beet production area of Czech Republic

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ABSTRACT

Both spring and winter barley were sown after a forecrop of winter rape. Three registered model varieties of six row and two row winter barley reached in the period 1999–2001 significantly higher yield than three model varieties of spring barley. Two row spring and winter varieties produced significantly higher thousand grain weight (TGW) than six row winter barley. The resistance to diseases and lodging (correlation coefficient with resistance to powdery mildew represent 0.68**, rust 0.72**, lodging 0.61**) was the most important factor determining the yield. Resistance to rust has influenced sieving on 2.5 mm, correlation coefficient reached value 0.88**. No significant differences were determined in any malting quality parameter when varieties of two row winter barley variety (Tiffany), and spring barley varieties (Akcent and Tolar) were compared. Variety Tolar reached higher parameters for friability and a beta glucan content. Between years, significant differences were found in following parameters: protein content and apparent degree of attenuation. Due to reduction of area sown with spring barley and reduced yield potential, two row winter barley varieties with comparable malting parameters are recommended to be cultivated as the reserve crop for malting barley industry demands.

Keywords: spring barley; winter barley; yield; malting quality; *Hordeum vulgare* L.

Spring barley is traditional commodity of our agriculture directly as grain or in form of malt, produced from barley grain. In the period, 1975–2000 there was a significant reduction in area of spring barley cultivation (Špunar et al. 2000). The decline was not dramatic for malting industry as only about 40% of the total barley production was used for malting. The situation got worse particularly after the year 1995 due to reduction of production area accompanied by reduction of average yield. This reduction was accompanied by increased attack of ear diseases, particularly by fusarium. All these unfavorable factors have cumulated in the year 2000 and due to great shortage of malting barley; the import from abroad was necessary. Production of Tiffany, the first winter malting barley registered in Czech Republic was not sufficient. The objective of presented paper was to evaluate economically important parameters of spring and winter barley with particular respect to two row winter malting barley Tiffany.

MATERIAL AND METHODS

The trials were established on the fields of Agricultural Research Institute Kroměříž, Ltd. The locality is situated at 236 m above sea level with average year temperature 8.9°C and average precipitation 599 mm. The records of temperature and precipitation in individual years are presented in Figures 1–3. The soil is Luvi-haplic Chernozem with pH 6.1–6.8.

Sowing was carried out after forecrop winter rape in optimal agro-technological terms for both sowing winter and spring barley, spring barley was sown in the period 15 March to 15 April. Winter barley in the period 20–30 September. Fertilization was carried out before sowing in both autumn and spring: 30 kg N, 36 kg P, 36 kg K.ha^{-1}.

Weeds were controlled by herbicides: winter barley – autumn – Glean 75WG (7 g.ha^{-1}), Brodal 50EC (0.25 l.ha^{-1}), in spring – Starane (0.5 l.ha^{-1}), Granstar (25 g.ha^{-1}). Spring barley – Granstar 20 g.ha^{-1}, Starane 0.3 l.ha^{-1}, Lontrel 0.3 l.ha^{-1} No fungicide treatment was used.

Growth regulator Terpal at rate 2.5 l.ha^{-1} was used on winter barley exclusively in the period of flag leaf appearance. Determination of malting quality was carried out according to methodology of EBC. Trials were established in random distribution, plot size 10 m^2, four replications. Statistical evaluation by the statistic software S-Plus 4.5 and Statgraphics.

CHARACTERIZATION OF VARIETIES

6-row winter barley

Kromoz (CZ), registration 1992, medium late, medium stem length, medium thousand grain weight (TGW), lower proportion of grain on sieve 2.5 mm. Variety with medium performance suitable particularly to locations with worse climatic and soil conditions for cultivation of winter barley.

Luxor (CZ), registration 1996, medium late, medium stem length, medium to high TGW, medium to lower proportion of grain on sieve 2.5 mm. Variety with high performance suitable to all locations of winter barley cultivation.

Luran (CZ), registration 1998, medium early, medium stem length, high TGW, medium proportion of grain on sieve 2.5 mm. Variety with very high performance suitable to all locations of winter barley cultivation.

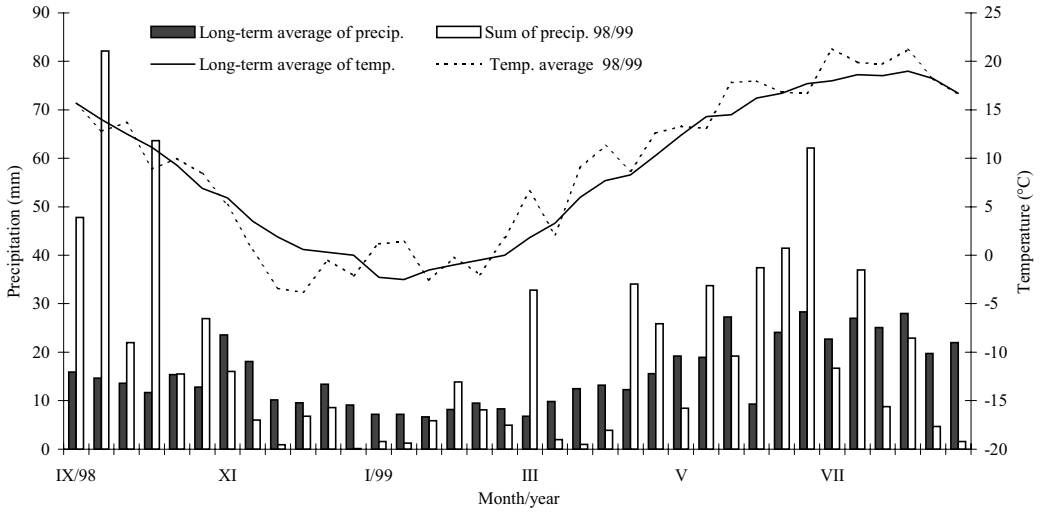

Figure 1. Course of temperature and precipitation in comparison to long-term average (Kroměříž, 1998–1999)

Figure 2. Course of temperature and precipitation in comparison to long-term average (Kroměříž, 1999–2000)

Figure 3. Course of temperature and precipitation in comparison to long-term average (Kroměříž, 2000–2001)

2-row winter barley

Monaco (F), registration 1995, medium early, medium stem length, low to medium TGW, medium proportion of grain on sieve 2.5 mm. Variety with high performance suitable to locations with low risk of winter kill.

Babylone (NL), registration 1997, early, medium stem length, high TGW, medium to high proportion of grain on sieve 2.5 mm. Variety with high performance suitable to all locations of winter barley cultivation.

Tiffany (D) registration 1999, medium late, medium stem length, high TGW, high proportion of grain on sieve 2.5 mm, malting quality. Variety with high performance suitable to locations with low risk of winterkill.

Spring barley

Akcent (CZ), registration 1992, medium late variety, medium stem length, high TGW, medium to high proportion of grain on sieve 2.5 mm, malting quality. Variety suitable to all areas of cultivation.

Viktor (CZ), registration 1995, medium late to late variety, high tillering capacity, semi dwarf type, medium to high TGW, medium to high proportion of grain on sieve 2.5 mm. Variety suitable particularly for humid areas.

Tolar (CZ), registration 1997, medium late variety, short to medium stem length, medium to high TGW, medium to high proportion of grain on sieve 2.5 mm, malting quality. Variety suitable to all areas of cultivation.

RESULTS

The recorded temperatures manifested that winters were very mild and it was suitable for comparison of winter and spring barley varieties. Figures 1–3 demonstrate that decline of temperatures in the winter was so low that there was no occurrence of winter kill. It is confirmed in Table 1, which demonstrates evaluation 7–9 as for winterhardiness. The beginning of heading manifested differences between winter and spring barley as winter barley started heading for 7–28 days earlier than spring barley. There were smallest differences in the heading time and

Table 1. Field evaluation of winter and spring barley performance trials (Kroměříž, 1999–2001)

		Variety	Winter-hardiness (1–9)	Heading day	Full ripeness (day)	Height (cm)	Resistances			
							lodging	mildew	rust	net blotch
							(1–9)	(1–9)	(1–9)	(1–9)
1999	6-row winter barley	Luran	7	11. 5.	8. 7.	85	8	7	4	9
		Luxor	7	17. 5.	15. 7.	93	8	7	5	9
		Kromoz	7	17. 5.	15. 7.	90	9	7.5	7	9
	2-row winter barley	Monaco	7	17. 5.	13. 7.	98	9	7	7	9
		Babylone	7	16. 5.	15. 7.	95	9	7	5	9
		Tiffany	7	18. 5.	16. 7.	95	9	7	4	9
	spring barley	Akcent		28. 5.	20. 7.	72	8	6	7	5
		Tolar		30. 5.	21. 7.	78	7	6	7	6
		Viktor		31. 5.	24. 7.	66	9	5	8	7
2000	6-row winter barley	Luran	9	5. 5.	28. 6.	84	9	9	9	9
		Luxor	9	8. 5.	2. 7.	83	9	9	9	9
		Kromoz	9	9. 5.	2. 7.	90	9	9	9	9
	2-row winter barley	Monaco	9	9. 5.	2. 7.	85	9		9	9
		Babylone	9	7. 5.	1. 7.	95	9	7	9	9
		Tiffany	9	11. 5.	3. 7.	85	9	7	9	9
	spring barley	Akcent		30. 5.	26. 7.	66	8	6	7	7
		Tolar		31. 5.	28. 7.	68	7	6	7	8
		Viktor		31. 5.	31. 7.	60	9	6	8	8
2001	6-row winter barley	Luran	9	7. 5.	5. 7.	91	9	7	9	9
		Luxor	8	14. 5.	8. 7.	89	9	9	9	9
		Kromoz	9	10. 5.	8. 7.	82	9	6	9	9
	2-row winter barley	Monaco	9	14. 5.	8. 7.	84	9	9	9	9
		Babylone	8	10. 5.	7. 7.	86	9	9	9	9
		Tiffany	9	15. 5.	10. 7.	87	9	9	9	9
	spring barley	Akcent		5. 6.	2. 8.	76	6	5	5	8
		Tolar		8. 6.	3. 8.	80	6	6	4	8
		Viktor		11. 6.	5. 8.	69	8	6	5	8

Table 2. Average values of important parameters in relation to year, character of growth, number of ear rows, two row and character of growth

	Parameter	Grain yield (t.ha^{-1})	*	TGW (g)	*	Sieving 2.5 mm (%)	*	Plant length (cm)	*	Lodging (9–1)	*
Year	1999	8.27	a**	42.98	a	82	a	82.80	b	8.22	a
	2000	8.85	a	47.56	a	94.9	b	76.01	a	8.46	a
	2001	8.42	a	45.03	a	85.34	ab	79.69	ab	8.00	a
Character of growth	spring	7.59	a	40.49	a	89.78	b	70.55	a	7.56	a
	winter	8.84	b	46.75	b	80.33	a	88.44	b	8.9	b
Row	two row	8.36	a	48.34	b	91.06	b	80.28	a	8.28	a
	six row	8.67	a	42.03	a	83.78	a	86.67	a	8.78	a
Character of growth	spring	7.69	a	45.21	a	86.33	a	70.56	a	7.55	a
(two row ear)	winter	9.02	b	51.48	b	95.78	b	90.00	b	9.00	b

* statistical significance of difference, ** significant difference ($P_{0.05}$) is indicated by different letters

full ripeness between spring and winter barley in the year 1999. The difference was shorter than 10 days. On the contrary, greatest differences 20–30 days were in the year 2001. The year 2000 was characterized by very early heading and full ripeness. The earliest variety as for heading was the variety Luran. Generally, higher occurrence of leaf diseases was in spring barley than in winter barley, particularly in the year 2001. The possible reason can be a longer vegetation period and delay in generative phase in spring barley in comparison to the winter barley and preceding years 1999 and 2000.

In the stem length, there were significant differences between winter and spring barley in spite of the fact that the stem of winter barley was shortened by the use of growth regulator Terpal. This fact has positively manifested in elimination of lodging as winter barley recorded 8.9 points and spring barley 7.6 points (Table 2). These values were recorded although winter barley manifested significantly longer stem in average 88 cm in contrast to 70.6 cm at spring barley.

According to average values (Table 2) and analysis of variance (Table 3), significant differences were determined between yield of spring and winter barley. Differences between varieties were statistically significant only in case the weakest testing criterion was applied. There were no differences among spring barley varieties. The significant differences were determined between spring barley varieties Akcent and Viktor and winter barley varieties Tiffany, Babylone, Monaco, and Luran. Between experiment years and number of rows in the ear, there was no significant difference.

As for TGW, the highest values were recorded in winter barley but this difference was due to high TGW of two row winter barley (51.5 g) which was significantly higher than in spring barley, which reached 45.2 g. As for varieties significantly higher were TGW of varieties Tiffany and Babylone. There were no significant differences among TGW within years. Variability of value in sieving on 2.5 mm sieve was so high that it has exceeded differences among varieties. The highest values were recorded in year 2000 these were significantly higher than in the year 1999. Significant differences were recorded between two row winter and two row spring varieties, the winter ones reached 9.5% higher sieving.

Among evaluated economically important parameters were calculated statistically significant differences (Table 4). The most relevant influence on the yield was resistance to diseases and lodging (correlation coefficient with resistance to powdery mildew represent 0.68**, rust 0.72**, lodging 0.61**). Resistance to rust has as well influenced

Table 3. Analysis of variance of yield, TGW, sieving 2.5 mm and plant height

Variety	Grain yield (t.ha^{-1})	*	TGW (g)	*	Sieving 2.5 mm (%)	*	Plant height (cm)	*
Akcent	7.50	a**	43.90	ab	82.67	a	71.33	ab
Babylone	8.92	bc	51.77	c	96.33	a	92.00	d
Kromoz	8.63	abc	40.00	a	81.00	a	84.08	cd
Luran	8.79	bc	45.73	abc	86.00	a	86.67	d
Luxor	8.59	abc	40.37	a	84.33	a	88.33	d
Monaco	8.84	bc	50.37	bc	96.00	a	89.00	d
Tiffany	9.32	c	52.30	c	95.00	a	89.00	d
Tolar	7.99	ab	46.30	abc	91.00	a	75.33	bc
Viktor	7.58	a	45.43	abc	85.33	a	65.00	a

* statistical significance of difference, ** significant difference ($P_{0.05}$) is indicated by different letters

Table 4. Correlation coefficients between important parameters (winter and spring barley, 1999–2001)

	Yield		TGW		Sieving 2.5 mm		Stem length		Lodging		Powdery mildew		Rust
TGW	0.57	**											
Sieving 2.5 mm	0.55	**	0.88	**									
Stem length	0.43	*	0.07		0.01								
Lodging	0.61	**	0.37		0.40	*	0.37						
Powdery mildew	0.68	**	0.30		0.33		0.52	**	0.55	**			
Rust	0.72	**	0.51	**	0.59	**	0.00		0.58	**	0.48	*	
Net blotch	0.34		–0.03		–0.07		0.65	**	0.46	*	0.58	**	0.15

*,** significant at $P_{0.05}$ and $P_{0.01}$

sieving on 2.5 mm, correlation coefficient reached value 0.88**.

Malting parameters of winter barley malting variety Tiffany and spring barley malting varieties Akcent and Tolar are compared in Table 5. Variety Tolar reached more convenient parameters for friability and a beta glucan content. Nevertheless, due to high years variability no significant difference was found. Among the years, significant differences were found in parameters as follows: protein content and apparent degree of attenuation.

DISCUSSION

Spring barley is an important source of raw material for malting industry not only in Czech Republic but as well as in other countries using extensively winter barley for malting purposes. For instance in France, which is main producer of malt in the world, both 6-row and 2-row winter barley are used for malting purposes. The main reason for using winter barley is about 20–30% higher yield in comparison to spring barley. Hébrard (1998) presents that total production of malt in France represented 60% from spring barley, 30% from 6-row winter barley, and 10% from 2-row winter barley. According to Bernicot et al. (2000), French farmers have extensive collection of registered varieties of spring and six and two row winter barley with required malting quality. Baumer et al. (2000), Rath et al. (2001) present results of two row winter barley varieties, which are comparable in malting parameters with spring barley of medium malting quality. Anonym (2001) presents the list of two row winter barley varieties that are fully accepted by malting industry in England. In the assortment of varieties of malting barley in Czech Republic in the year 2001, dominate spring barley varieties with high malting quality (Psota et al. 2001). Particularly varieties with high extract content and low beta glucan content like Kompakt and Nordus are strongly preferred by malting industry. Two row winter barley variety Tiffany did not reached these high parameters. There was no six row malting winter barley variety registered in Czech Republic until 2001.

In the period, 1975–2000 came significant decline of yield of spring barley and this has impact for reduction in the area of cultivation. (Špunar et al. 2000). The difference between spring and winter barley represents in average yield about 10%. Špunarová and Prokeš (1998) manifested influence of year on the values of protein content, final degree of attenuation and friability of spring barley. This is why winter barley with parameters similar level to those of variety Tiffany are attractive reserve for malting industry in case the parameters of spring barley are not satisfactory. Malting barley quality in different type of barley represents a complex of closely related characters. Vaculová and Heger (1998) confirmed that there is no significant difference between two row winter and spring barley for feeding quality. It means that if the two row winter barley varieties are not used for malting, they can be used for feeding like spring barley.

Winter wheat and winter rape became great competitors of spring barley due to mild winters, particularly in the

Table 5. Malting quality of representative spring and winter malting barley

	Parameter	A	*	B	*	C	*	D	*	E	*	F	*	G	*	H	*
Variety	Akcent	10.7	a**	81.5	a	45.4	b	46.0	a	335.3	b	81.8	a	78.6	a	252.0	a
	Tolar	10.5	a	82.3	a	38.8	a	45.2	a	395.7	c	82.1	b	88.7	a	188.7	a
	Tiffany	10.3	a	82.1	a	38.7	a	47.5	a	310.3	a	82.1	b	78.9	a	246.0	a
Year	1999	10.9	b	82.1	a	41.7	a	46.0	a	341.0	a	82.3	b	79.1	a	238.7	a
	2000	10.8	b	81.6	a	39.8	a	44.7	a	348.7	a	81.8	a	81.3	a	200.3	a
	2001	9.7	a	82.2	a	41.4	a	48.0	a	351.7	a	81.9	a	85.8	a	247.7	a

* statistical significance of difference, ** significant difference ($P_{0.05}$) is indicated by different letters
A = protein content (%), B = extract content (%), C = relative extract (%), D = Kolbach number, E = diastatic power (u. W.K.), F = apparent degree of attenuation (%), G = friability (%), H = beta glucan content (mmol/l)

period 1995–2001 which created better biological prerequisites for higher and stable yields. Our results for yield parameters, and malting quality are in accordance with results in other countries, which did not consider cultivation of winter barley particularly for malting purposes. In Slovak Republic, two row winter barley commenced to be tested and cultivated (Molnarova and Kufelj 2000). In the USA cultivation of winter barley, particularly in the state Oregon begins to be considered (Corey et al. 2000). According to Friedt et al. (2000) in addition to different course of growth and development phases like tillering, heading, maturation, particularly breeding progress in increased resistance to lodging, resistance to diseases and winter hardiness contributed to the higher production and quality of winter barley. Presented facts confirm that production of winter barley can positively contribute to stabilization of barley production and to the reduction of global warming impacts (Deudon et al. 2001).

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ABSTRAKT

Srovnání důležitých parametrů jarního a ozimého ječmene pěstovaného v řepařském výrobním typu ČR

Vybrané odrůdy ozimého a jarního ječmene byly pěstovány po stejné předplodině ozimé řepce. Tři registrované modelové odrůdy jak šestiřadého, tak dvouřadého ozimého ječmene dosáhly v období 1999 až 2001 vyššího výnosového potenciálu než jarní sladovnické odrůdy. Naopak dvouřadé ozimé a jarní odrůdy dosáhly průkazně vyšší HTZ než šestiřadé ozimé odrůdy. Nejvýraznější vliv na výnos prokázala odolnost vůči chorobám a poléhání (korelační koeficient mezi výnosem a odolností k padlí představuje 0,68**, rzi 0,72**, poléhání 0,61**). Rezistence rzi silně ovlivnila i podíl na sítě 2,5 mm, korelační koeficient dosáhl hodnoty 0,88**. Pokud jde o sladovnickou kvalitu, nebyly zjištěny průkazné odrůdové rozdíly ve sledovaných sladovnických parametrech mezi odrůdou dvouřadého ozimého sladovnického ječmene Tiffany a jarními ječmeny zastoupenými odrůdami Akcent a Tolar. Průkazné rozdíly byly zjištěny pouze mezi ročníky v obsahu bílkovin a v konečném stupni prokvašení. Na základě dosažených výsledků lze doporučit dvouřadý ozimý sladovnický ječmen s odpovídajícími sladovnickými parametry jako rezervní surovinu pro potřeby sladovnického průmyslu.

Klíčová slova: jarní ječmen; ozimý ječmen; výnos; sladovnická kvalita; *Hordeum vulgare* L.

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