SPRING BARLEY VARIETIES – YIELD AND QUALITY IN ECOLOGICAL AGRICULTURE*

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Interest in varieties for low-input growing, for ecological agriculture, or for conditions with controlled regime of growing, such as protected landscape regions and zones of hygienic protection of water resources, have came to the front position of concern in recent years. However, general recommendations or general characteristics of spring barley varieties suitable for ecological agriculture cannot be deduced from the above results of variety trials. The occurrence of some varieties in front positions would indicate some reactions to low inputs and suitability into conditions of ecological agriculture, but it is not statistically significant. It has been proved that varieties with highest yields in ecological agriculture were often most yielding also in conventional growing. Therefore, it can be presupposed that most yielding varieties with good health condition will be suitable also for ecological growing. It would follow from this that it would not be necessary to test the suitability of spring barley varieties for ecological agriculture in separate experiments. It has been confirmed from evaluation of malting quality of spring barley varieties from ecological and conventional (intensive) growing that most of indicators of malting quality are decisively affected by weather pattern in experimental year. The differences that arose can be explained by evaluation of pattern of weather and precipitation. In majority of quality traits was manifested stronger effect of weather than nitrogen fertilization or growing system. Significant differences among years were recorded in the content of nitrogen substances, in relative extract, Kolbach index, diastatic power and degree of fermentation. The growing system was displayed most in the content of β-glucans where its content was surprisingly low in ecological growing, the effect of growing system was partly proved also in Kolbach index and friability. It has been confirmed that ecological growing brought better malting quality of barley than conventional system. It was proved convincingly by the so-called indicator of malting quality that was higher by 1.3 points in ecological growing than in conventional system.

barley; ecological agriculture; yield; malting quality

INTRODUCTION

In recent decades we have met searching for alternatives to conventional, intensive growing of field crops. There are several reasons, of which over-production in the countries with developed agriculture is certainly dominant together with increasing prices of inputs and falling prices of products. Support of programmes to decrease intensity of growing of main crops follows from it in the countries of the European Union, while respecting principles of continuous-sustainable agriculture.

Integrated systems of management are among alternatives, followed by low-input growing and development of ecological agriculture. However, it should be emphasised that these systems do not mean only limitations or discharge of agrochemicals, but they also represent a complex, scientifically prepared growing system with a lot of measures that contribute to elimination or substitution of these inputs. The same like in the other systems of growing, suitable varieties play here an important role. The aim of our research was searching for these varieties in spring barley.

The problem of varieties suitable for low-input growing, and hence also varieties for ecological agriculture, is topical more than twenty years. The most detailed knowledge from this field were brought by the conference of breeders in Gumpenstein in 1990 (Kratzsch, Damisch, 1990; Haas, Friedt, 1990).

Such a variety can be included into low input growing that reaches identically high yields under lower inputs compared with the other varieties cultivated conventionally. It can utilise nutrients better and other growing factors and is adequately resistant to diseases and well reacts to procedures controlling harmful agents, weeds, diseases and pests.

Since 1980 many publications have been written studying the first of all the tasks of the utilisation of nutrients in different varieties and conclusions following from it regarding suitability for low-input growing (Sarič, Loughman, 1983; El Bassam et al., 1990; Attene et al., 1996). Complex solution and hence a rigorous requirement have been appeared with the development of ecological agriculture, where along with efficiency of nutrients comes also competitiveness

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against weeds and more permanent resistance to diseases (Pommer, 1985; Köpke, 1990). Variety trials for ecological agriculture and low-input growing procedure were carried out in Scotland by Richards (1990), who found different behaviour of varieties and thus also a suitability for these methods of growing. Modern high yielding varieties with a good resistance to diseases were mostly well manifested. This author studied and also confirmed a different competitive ability of varieties against weeds (Richards, 1990). Eltun (1996) found lower yields by 20–33% in spring barley in ecological growing compared with conventional growing. Habětínek (1994) studied the varieties suitable for ecological agriculture under conditions of the Czech Republic in 1991 and 1992 and found the highest yields in barley varieties Orbit and Akcent. In Slovakia Drobný et al. (1994) carried out such trials. We reported earlier a yield response to low inputs in winter wheat (Petr, Škeřík, 1999) and we found significant differences among varieties. It has been proved that these are modern varieties of the present assortment and we mentioned their characteristic traits and qualities and peculiarities of yield formation. However, in spring barley varieties we expect different behaviour, because barley, particularly that intended for malting purposes, is generally less demanding for intensification inputs, varieties are of rather similar breeding origin and identical character of yield formation.

The quality of production from ecological agriculture is usually characterised by decrease in the content of crude proteins, percentage of front grain (Eltun, 1996). Complex evaluation of malting quality has not been published till now.

MATERIAL AND METHODS

Traditional variety trials were conducted during six years by the method used for testing and registration of varieties by the state control and testing institute ÚKZÚZ (Central Institute for Supervising and Testing in Agriculture).

The trials were established at the Experimental Station of the Czech University of Agriculture Prague-Uhříněves under ecological growing without fertilizers and pesticides according to IFOAM (International Federation of Organic Agriculture Movements) and Methodological Instruction for Ecological Agriculture of the Czech Republic. Pedological survey was carried out to assess the uniformity of plot and the content of heavy metals and foreign substances. Fall-outs of these substances that are below limit values are monitored at the site of experiments. The experiments were established by the split-plot method. Sowing was done in the first April days. The stands were dragged with weed harrow to reduce the weeds.

The Station is situated in fertile sugar beet-growing region at the altitude 295 m above sea level with luvisol clay soils and their production capacity 84 points. The content of available nutrients in soil (Mehlich II) in experimental years on the plot of trials ranged in mg/kg: P 94–96, K 173–188, Mg 112–129, Ca 2730–3263, pH 6.88–7.23, the humus content fluctuated between 1.6% and 2.53%. The N_{min} content ranged in spring about 12 mg/kg into the depth of 30 cm.

We evaluated also the yields from intensively conducted experimental trial at the Breeding Station in Stupice for comparison. There are practically identical soil and weather conditions together with the same weather pattern, the same seed was used, identical fertilisers were applied, seed-treated and the same herbicides or insecticides were used. Sugar beet was used as a forecrop with ploughed in trash. More favourable soil reaction, high P content, good K content, lower content of Mg and Ca and less favourable ratio Mg : K were recorded in Stupice. The content of mineral nitrogen (N_{min}) at the 0–30 cm depth of soil was higher in majority of months in Stupice than in Uhříněves, except June and July of 1996 (Stehno, 1998). Fertilizers were applied in the form of the combined fertilizer NPK close before sowing at the rate of 30–40 kg N, 30–40 kg P_2O_5 and 30–40 kg K_2O. Herbicides were applied post-emergently and also insecticide against white cockle (*Lema malanopus*) was used in 1997.

Complete analyses of malting quality were performed after the harvest in the laboratories of the Brewery and Malting Research Institute Brno. The samples were malted in micro-malthouse by the procedure as recommended for international tests EBC and modified by the mentioned institute that consists in shortening of the total malting time from 168 hours to 144 hours (Psota et al., 1998). Barley and produced malt were analysed by the methodologies EBC (1987) and MEBAK (1979). The trial included the best-known Czech and Slovak varieties of malting barley: Akcent, Amulet, Jubilant, Sladko, Kompakt and Forum.

The values of quality indices can be assessed by judging, number of points which is 9 points for the best values and 1 point for the worst values. The importance of a trait that is 0.25 for the contents of extract in relative extract (RE) at 45 °C and for the remaining traits it is only 0.1. Then we can express each value in point ratings and determine the so-called "indicator of malting quality". That was done for average values from three-year trials where each trait, its average value are evaluated in point ratings.

The results were evaluated by the statistical program SAS, version 6.12, the method of variance analysis, multiple comparison of means after Tukey.

The weather pattern is in Table I.

RESULTS

The set of varieties was partially changing over the experimental years. Deleted varieties were excluded and the varieties newly registered in the State Variety Book were included.

I. Weather pattern in experimental years 1994–1999, average monthly air temperature (°C) and monthly sum of precipitation (mm)

Year	1993–1994		1994–1995		1995–1996		1996–1997		1997–1998		1998–1999		Long-term average	
Month	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm
9.	13.1	68.0	14.4	56.5	13.2	89.2	10.7	48.9	13.7	41.5	17.3	57.6	14.0	49.0
10.	8.3	48.3	6.9	309	10.9	10.3	9.8	23.1	7.2	34.1	9.3	24.3	8.6	41.0
11.	1.1	50.2	6.7	22.7	1.7	31.5	5.2	28.6	3.3	38.1	2.9	22.6	3.2	34.0
12.	3.5	52.8	–2.6	55.1	–1.4	30.6	–4.4	21.5	1.9	46.4	1.7	33.1	–0.5	34.0
1.	3.0	17.0	–0.6	27.1	–3.5	9.8	–4.4	21.5	1.6	12.9	1.5	34.1	–2.1	28.0
2.	–0.2	15.4	5.2	12.4	–3.0	19.9	3.4	22.4	4.4	14.1	–0.2	29.2	–0.8	27.0
3.	6.9	75.4	3.5	63.7	0.3	21.8	5.2	44.8	4.7	38.1	5.97	26.9	3.4	31.0
4.	8.9	48.2	9.5	0.0	9.5	23.3	6.3	35.1	11.1	9.9	10.1	18.5	8.2	46.0
5.	13.7	76.2	13.2	115.2	13.0	169.7	14.6	25.7	15.0	27.0	15.1	54.1	13.4	65.0
6.	17.5	46.6	15.5	89.4	16.8	110.6	17.0	84.1	18.1	107.7	18.1	66.8	16.3	74.0
7.	22.4	35.4	21.1	32.6	16.5	105.7	17.8	110.2	18.0	89.0	19.8	78.1	18.2	74.0
8.	18.1	84.4	18.7	99.3	17.6	57.5	19.5	60.5	18.2	30.3	17.7	33.9	17.5	72.0
Annual average of temparatures/sum of precipitation	9.7	618	9.3	605	7.6	680	8.4	526	9.8	489	9.9	479	8.3	575

II. Yields of spring barley varieties in Uhříněves and Stupice 1994–1996

1994	Uhříněves (ECO)	Stupice (INT)	1995	Uhříněves (ECO)	Stupice (INT)	1996	Uhříněves (ECO)	Stupice (INT)
Variety	yield (t/ha)	yield (t/ha)	variety	yield (t/ha)	yield (t/ha)	variety	yield (t/ha)	yield (t/ha)
Jarek	6.61	6.26	Amulet	6.77	6.36	Pejas	5.62	5.97
Jubilant	6.32	6.56	Pax	6.51	5.88	Amulet	5.43	4.89
Orbit	6.25	6.39	Orbit	6.46	6.28	Krona	5.15	5.44
Ladík	6.16	6.31	Terno	6.24	6.07	Sladko	5.07	4.80
Profit	6.09	6.71	Viktor	5.90	6.13	Lumar	5.04	5.62
Pax	6.08	6.57	Primus	5.74	5.72	Forum	4.97	6.03
Novum	6.01	6.50	Stabil	5.68	6.06	Famin	4.89	5.04
Sladko	5.95	5.75	Forum	5.67	5.79	Signal	4.78	5.78
Viktor	5.93	6.35	Novum	5.58	5.50	Rubín	4.77	4.84
Krystal	5.91	6.34	Akcent	5.56	6.16	Primus	4.71	5.37
Stabil	5.90	6.87	Lumar	5.52	5.87	Pax	4.66	5.55
Akcent	5.89	6.51	Kompakt	5.46	5.57	Viktor	4.61	5.38
Svit	5.84	6.35	Jarek	5.34	5.64	Ditta	4.60	5.89
Terno	5.74	6.35	Jubilant	5.24	5.51	Jarek	4.54	4.84
Rubín	5.72	5.83	Sladko	5.13	5.44	Stabil	4.23	5.36
Jaspis	5.35	6.68	Ladík	5.12	5.97	Atribut	4.19	5.36
Malvaz	5.25	6.31	Jaspis	5.10	5.39	Ladík	4.14	5.02
Forum	5.11	6.27	Profit	5.01	5.61	Novum	4.13	5.21
Min. signif. difference	0.885	0.510	Svit	4.99	5.80	Terno	3.99	5.03
			Rubín	4.85	5.39	Akcent	3.73	4.61
			Malvaz	4.76	5.03	Kompakt	3.70	5.18
			min. signif. difference	1.141	0.540	Olbram	3.66	4.98
						Orbit	3.65	5.88
						Jubilant	3.64	4.49
						min. signif. difference	1.451	0.670

III. Yields of spring barley varieties in Uhříněves and Stupice 1997–1999

1997	Uhříněves (ECO)	Stupice (INT)	1998	Uhříněves (ECO)	Stupice (INT)	1999	Uhříněves (ECO)	Stupice (INT)
Variety	yield (t/ha)	yield (t/ha)	variety	yield (t/ha)	yield (t/ha)	variety	yield (t/ha)	yield (t/ha)
Scarlett	6.13	6.90	Lumar	4.70	5.09	Forum	5.49	7.36
Lumar	6.05	6.52	Primus	4.48	5.34	Primus	5.45	7.35
Ditta	5.97	6.49	Madonna	4.28	5.62	Orthega	5.43	7.85
Pejas	5.96	6.82	Nordus	3.91	5.33	Prosa	5.33	7.72
Signal	5.93	6.52	Akcent	3.77	5.47	Tolar	5.05	7.60
Viktor	5.91	6.89	Amulet	3.75	4.89	Scarlett	5.02	7.47
Atribut	5.83	6.31	Scarlett	3.73	5.53	Atribut	4.98	7.09
Forum	5.75	6.38	Heris	3.72	5.31	Heris	4.94	8.12
Amulet	5.71	6.21	prosa	3.68	5.69	Ditta	4.87	7.54
Kompakt	5.71	5.72	Ditta	3.58	5.52	Maridol	4.86	7.48
Stabil	5.70	6.19	Tolar	3.54	5.06	Pax	4.84	7.11
Krona	5.69	6.56	Kompakt	3.53	5.51	Madonna	4.51	7.95
Novum	5.60	6.32	Atribut	3.51	5.22	Madeira	4.43	7.22
Famin	5.43	5.87	Forum	3.44	5.43	Nordus	4.35	7.37
Primus	5.37	6.52	Novum	3.30	5.24	Amulet	4.24	7.18
Tolar	5.36	6.78	Famin	3.20	5.39	Pejas	4.16	7.46
Pax	5.13	6.35	Olbram	3.18	5.25	Novum	4.08	7.42
Jubilant	4.96	5.83	Pejas	3.02	5.15	Olbram	4.03	7.47
Olbram	4.94	5.72	Pax	2.83	4.99	Akcent	3.90	7.05
Akcent	4.75	5.99	Krona	2.66	5.26	Kompakt	3.67	7.54
Sladko	4.70	5.80	min. signif. difference	2.163	0.460	Krona	3.61	7.19
Min. signif. difference	1.480	0.440				min. signif. difference	1.6211	0.320

Winter wheat was used as a forecrop in experiments in the years 1994–1996. Yield sequence of varieties was different each year. In 1994 the varieties Jarek, Jubilant and Orbit were dominant. In intensive trial the varieties Stabil, Profit and Jaspis were the most yielding. The yield of set of varieties ecologically cultivated was lower by 0.49 tons than the yield of intensively cultivated set.

In 1995 the varieties Amulet, Pax and Orbit were the most yielding in ecological growing, and Amulet, Orbit and Akcent in intensive growing. The difference between both these growing systems was identical with that in the previous year – 0.48 tons, i.e. 8%.

The year 1996 was unfavourable regarding weather pattern what has been manifested on the lower level of yields particularly in ecological growing. The varieties Pejas, Amulet, Krona and Sladko were the most yielding in the latter system, while Forum, Pejas, Ditta and Orbit were most yielding in intensive growing. The difference in the yield between both these systems was much greater under unfavourable weather (0.95 tons), i.e. 18%.

In further years the pea was a forecrop. In 1997 the varieties Lunar, Pejas, Signal and Viktor brought the highest yields. The varieties Scarlet, Viktor, Pejas, Tolar and Krona brought them under intensive growing.

The year 1998 was the second unfavourable year in the series of variety trials and moreover, plants were damaged during vegetation by voles. Greater damage was, however, monitored in ecological trial than in trial when fertilizers and pesticides were applied.

In 1999 the highest yields in ecological growing were recorded in the varieties Forum, Primus, Orthega, Prosa, Tolar and Scarlet. In intensive growing these were the varieties Heris, Madona, Orthega and Tolar. In this year was greatest difference in average yield of the set of varieties from ecological and intensive growing, and amounted to 38%.

Malting quality of spring barley ecologically and conventionally cultivated

Tables II and III bring an outline of results of yields from three-year trials and different growing systems together with mean values of point rating, the so-called indicators of malting quality are presented in Tables IV and V. This table also indicates statistical significance calculated by variance analysis.

The content of grain protein was different in different years, but on an average of three years it was not significantly different according to the growing system.

It was similar in the extract as well as relative in the extract at 45 °C, where it was significantly higher in two

IV. Quality indices of malting barley varieties from different growing systems

Index	Year	1995			1996			1997			1995–1997			Average of all systems and years
	growing system	CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	
Grain protein (%)	Akcent	11.8	11.2	11.8	10.5	9.7	9.4	10.5	11.8	10.8	10.9	10.9	10.7	10.8
	Amulet	11.9	11.2	11.4	10.4	9.6	10.0	10.4	11.8	11.8	10.9	10.9	11.1	11.0
	Forum	11.3	11.1	11.1	10.4	9.5	9.3	10.4	10.7	9.3	10.7	10.4	9.9	10.3
	Jubilant	11.3	10.9	11.5	10.8	10.0	9.6	10.8	11.0	10.9	11.0	10.6	10.7	10.8
	Kompakt	11.3	11.7	11.8	10.3	9.4	10.6	10.3	10.9	9.8	10.6	10.7	10.7	10.7
	Sladko	11.0	11.3	11.6	10.6	10.1	10.3	10.6	11.9	10.7	10.7	11.1	10.9	10.9
	Average	11.4	11.2	11.5	10.5	9.7*	9.9*	10.5	11.4*	10.6	10.8	10.8	10.7	10.7
Extract (%)	Akcent	80.7	81.8	80.6	81.1	82.7	83.2	81.1	81.2	81.9	81.0	81.9	81.9	81.6
	Amulet	81.4	82.7	81.2	81.9	83.6	84.3	81.9	82.2	80.6	81.7	82.8	82.8	82.3
	Forum	82.1	82.9	81.4	81.6	84.2	84.8	81.6	82.6	83.5	81.7	83.2	83.2	82.7
	Jubilant	81.3	82.1	80.7	80.7	83.2	83.5	80.7	82.1	82.2	80.9	82.5	82.5	81.9
	Kompakt	81.9	82.1	81.2	82.1	83.7	84.2	82.1	82.6	83.5	82.0	82.8	82.8	82.6
	Sladko	81.5	82.1	80.8	81.8	83.4	83.8	81.8	81.3	82.2	81.7	82.3	82.3	82.1
	Average	81.5	82.3	81.0	81.5	83.5*	84.0*	81.5	82.0	82.3	81.5	82.6*	82.6*	82.2
Relative extract at 45 °C	Akcent	45.7	50.5	48.1	44.6	49.5	55.0	44.6	40.4	41.9	45	46.8	48.3	46.7
	Amulet	38.5	40.4	38.2	36.4	45.8	48.2	36.4	35.6	34.1	37.1	40.6	40.2	39.3
	Forum	39.0	42.2	38.8	37.5	41.5	47.2	37.5	38.2	38.4	38	40.6	41.5	40.0
	Jubilant	44.8	48.2	46.2	42.0	53.1	54.9	42	43.1	41.4	42.9	48.1	47.5	46.2
	Kompakt	46.9	48.7	46.5	49.0	53.9	55.6	49	35.3	43.6	48.3	46.0	48.6	47.6
	Sladko	50.6	52.7	53.1	48.1	56.4	58.7	48.1	43.5	45.6	48.9	50.9	52.5	50.8
	Average	44.3	47.1	45.2	42.9	50.0	53.3*	42.9	39.4*	40.8*	43.4	45.5	46.4	45.1
Kolbach index	Akcent	44.5	52.2	49.9	45.0	50.9	54.0	45.0	42.8	46.2	44.8	48.6	50.0	47.8
	Amulet	44.7	49.7	47.8	45.1	52.7	55.2	45.1	43.1	41.1	45.0	48.5	48.0	47.2
	Forum	46.0	52.3	49.2	44.5	49.6	54.7	44.5	44.6	48.3	45.0	48.8	50.7	48.2
	Jubilant	45.9	49.1	48.2	43.9	52.2	57.0	43.9	43.4	47.0	44.6	48.2	50.7	47.8
	Kompakt	50.1	51.8	51.8	49.9	55.9	55.6	49.9	47.5	51.5	50.0	51.7	53.0	51.6
	Sladko	51.3	54.3	54.2	47.8	53.9	57.4	47.8	44.6	50.0	49.0	50.9	53.9	51.3
	Average	47.1*	51.6	50.2	46.0*	52.5	55.7	46.0	44.3	47.4	46.4	49.5	51.1	49.0

N.B.: * Evidently different values

years in ecological growing. The Kolbach index, too, was mostly higher in ecological growing, but weather pattern had a decisive effect in the experimental year.

Diastatic power was higher in two years in ecological growing, what is probably connected with activity of enzymes that is usually higher in ecological products, what was found in the quality of wheat (Petr et al., 1998). The achieved degree of fermentation does not manifest significant differences by the method of growing, but by the year. Friability is again much higher in ecological growing. Surprising differences were, however, found in the content of beta glucans, which is much lower in ecological growing compared with intensive what is more favourable for quality beer.

In both growing systems the variety Kompakt reached the best quality indices. In intensive growing the varieties Kompakt, Jubilant, Sladko reached the best technological qualities and the variety Akcent had the worst technological quality. Ecological growing suited the best to the varieties Forum, Kompakt, Sladko regarding the quality obtained and the least it suited to the variety Amulet. In ecological growing majority of monitored varieties got better quality parameters than in conventional growing (Table VI). Indicator of malting quality on average of all studied traits was highest in ecological growing. The results obtained should be evaluated also with respect to the fact that only varieties of excellent malting quality were chosen for the research.

DISCUSSION

Neither general recommendations, nor general characteristics of spring barley varieties suitable for ecological agriculture can be concluded from the above-mentioned results of variety trials. The occurrence of some varieties in front positions should indicate certain reactions to low inputs and suitability into conditions of ecological agriculture but it is not statistically significant. It

V. Quality indices of malting barley varieties from different growing systems

Index	Year	1995			1996			1997			1995–1997			Average of all systems and years
	growing system	CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	
Diastatic power (WK)	Akcent	358	350	375	310	290	235	310	325	330	326	322	313	320
	Amulet	368	360	335	320	280	305	320	390	415	336	343	352	344
	Forum	403	415	400	380	320	315	380	380	340	388	372	352	370
	Jubilant	299	315	335	325	295	230	325	335	325	316	315	297	309
	Kompakt	355	370	385	318	235	350	318	335	280	330	313	338	327
	Sladko	319	325	355	318	245	310	318	320	310	318	297	325	313
	Average	350	356	364	329	278*	291*	329*	348*	334*	336	327	330	331
Final attenuation (%)	Akcent	82.8	84.7	82.8	81.5	83.3	82.8	81.5	80.2	81.5	81.9	82.7	82.4	82.3
	Amulet	82.5	82.3	81.5	80.6	84.8	83.9	80.6	80.2	79.6	81.2	82.4	81.7	81.8
	Forum	83.4	84.6	83.1	82.6	84.5	85.0	82.6	81.0	83.5	82.9	83.4	83.9	83.4
	Jubilant	81.6	82.0	81.1	80.8	82.3	80.0	80.8	79.9	79.8	81.1	81.4	80.3	80.9
	Kompakt	82.3	83.2	80.2	81.7	83.8	83.3	81.7	80.3	80.5	81.9	82.4	81.3	81.9
	Sladko	84.9	84.9	84.0	82.9	84.6	84.8	82.9	80.1	81.1	83.6	83.5	83.3	83.4
	Average	82.9	83.6	82.1	81.7	83.9*	83.3*	81.7	80.3*	81.0	82.1	82.6	82.2	82.3
Friability (%)	Akcent	80.4	87.0	85.8	78.8	84.3	91.4	79.0	70.0	88.0	79.4	80.4	88.4	82.7
	Amulet	77.3	83.0	80.8	77.0	87.9	87.2	77.0	77.0	74.0	77.1	82.6	80.7	80.1
	Forum	86.8	91.0	93.5	86.0	85.8	93.3	89.0	89.0	97.0	86.3	88.6	94.6	89.8
	Jubilant	84.5	89.0	91.6	83.5	86.5	90.0	84.0	84.0	89.0	83.7	86.5	90.2	86.8
	Kompakt	88.9	91.0	91.3	87.3	90.0	89.2	85.0	85.0	95.0	87.7	88.7	91.8	89.4
	Sladko	84.8	88.0	88.0	80.8	89.2	90.5	73.0	73.0	91.0	81.9	83.4	89.8	85.0
	Average	83.8	88.2	88.5*	82.2	87.3	90.3*	79.7	79.7	89.0*	82.7	85.0	89.3*	85.7
Beta glucans (mg)	Akcent	193	149	88	273	259	198	291	291	241	246	233	176	218
	Amulet	140	160	106	278	191	164	201	201	221	232	184	164	193
	Forum	145	79	51	243	241	153	267	267	173	210	196	126	177
	Jubilant	98	108	43	191	184	158	214	214	158	160	169	120	150
	Kompakt	65	59	42	199	149	153	151	151	148	154	120	114	129
	Sladko	123	81	59	285	173	122	296	296	188	231	183	123	179
	Average	127	106	65*	245	200	158*	237	237	188*	206	181	137*	174

N.B.: * Evidently different values

has been proved that varieties with highest yields in ecological growing were mostly most yielding even in conventional growing. Therefore, it can be expected that most yielding varieties with good health conditions will be suitable indeed for ecological growing. It is evident the fact that recently registered varieties that were registered for their higher yielding capacity are placed among front positions in terms of yields, in our trials too right away in the first year after introduction into the set of tested varieties. It can indicate that it would not be necessary to test the suitability of varieties of spring barley for ecological agriculture in independent tests. Bengtsson (1996) thinks the same and came to similar conclusions. Such experiments conducted in Austria, as reported by Oberforster et al. (2000), proved that suitable varieties for ecological agriculture or for low-input systems, respectively, could be selected from conventional variety trials. The fact that under unfavourable weather pattern varieties in ecological growing varieties are more vulnerable, they have higher variation coefficient (variability of replications – see the values of minimum significant difference). In conventional growing the use of fertilizers and pesticides reduced the effect of unfavourable conditions, particularly weather.

In a lot of countries the experiments were conducted with these purposes because the task of growing with both low inputs and ecological agriculture was highly topical since the 1980s. The study of these problems was rather extensive in the past (e.g. Kratzsch et al., 1991; Mills, Wells, 1997; Jensen, Munk, 1993 and many others) and finished by the real effort to breed varieties for this system of growing (El Bassam et al., 1997).

These studies helped to suppress an opinion that obsolete varieties, original land races will be suitable for ecological agriculture originating from the times when fertilizers and pesticides were not utilised. This possibility has been considered by introduction of historical bar-

VI. Average of malting quality

Year	Growing system	Grain protein (%N x 6.25)	Extract (%)	RE 45 °C (%)	Kolbach index	Diastatic power (WK)	Final attenuation (%)	Friability (%)	Beta glucans (mg dm of wart)	
1995	ECO	11.5	81.0	45.1	50.2	364	82.1	88.5	65	
	INT	11.2	82.1	47.1	51.5	356	83.6	88.1	106	
	CR	11.4	81.5	44.2	47.0	350	82.9	83.8	127	
1996	ECO	9.8	83.9	53.3	55.6	291	83.3	90.3	158	
	INT	9.7	83.4	50.0	52.5	277	83.9	87.3	199	
	CR	10.5	81.5	42.9	46.0	328	81.6	82.2	245	
1997	ECO	10.5	82.3	40.8	47.3	333	81.0	89.0	188	
	INT	11.3	82.0	39.3	44.3	347	80.2	79.6	237	
	CR	10.5	81.5	42.9	46.0	328	81.6	82.0	245	
Average	ECO	10.6	82.4	46.4	51.0	329	82.1	89.2	137	
	INT	10.7	82.5	45.4	49.4	326	82.5	85.0	180	
	CR	10.8	81.5	43.3	46.3	335	82.0	82.6	205	
Bonity evaluation 9–1	ECO	8.33	8.5	9.0	9.0	9.0	9.0	9.0	9.0	8.74
	INT	9.0	9.0	9.0	9.0	9.0	9.0	7.9	4.1	7.45
	CR	9.0	4.0	9.0	9.0	9.0	9.0	5.1	1.0	5.26

ley variety Norimberský of 1832 which was propagated by Prof. G. Aufhammer and Prof. Fischbeck in 1955 and their results were published in 1964. This historical variety had an average yield in 1963 3.63 tons; modern varieties in ecological growing had the yield 4.32 tons. In 1997 the yield of modern varieties was 5.55 tons and the variety Norimberský 3.98 tons per 1 hectare. This variety had longer stem by 12–18 cm, easily lodging (by 2–3 points worse evaluation) and its health condition was worse, too (by 2–3 points in powdery mildew of cereals and grasses, by 2 points in net blotch of barley and stronger incidence of loose smut). It produced tillers less and hence it had fewer spikes than modern varieties, but identical spike productivity (number of grains per spike and 1000-kernel weight TKW). Such variety could not compete to present modern varieties.

Yield differences between ecological and conventional growing in our experiments were different in different experimental years. They were given by a suitable forecrop and nitrogen fertilization that allowed to plants of spring barley to establish the stand with a sufficient number of tillers and finally, of spikes (there were by 200 spikes more per 1 m^2) what had not happen in ecological growing.

When evaluating health condition of stands cultivated ecologically, lower infestation by leaf diseases was monitored than in conventional growing, where nitrogen was used as fertilizer. Kratzsch et al. (1990) and Jensen and Munk (1993), who mentioned adequate growth of infestation with diseases with increasing nitrogen rates applied, drew attention to this in spring barley. In our experiments with winter wheat, too, where we compared ecological and conventional growing, we recorded lower incidence of diseases in ecological growing Prokinová et al. (2000). However, in intensive stands where fungicides were applied even under higher infestation with disease, their application brought significant yield increase.

Evaluation of the quality of malting barley from ecological and conventional growing brought a lot of marked knowledge. Above all, a decisive effect of weather in the experimental year as affected most quality indices has been confirmed. Relationships of the effect of weather and quality of malting barley are studied by Prugar and Hraško (1989) and Ulonska (1960–1962). They evaluated the effect of agroecological conditions on the percentage of front grain 65%, on the content of proteins in the malt 76%, in the Kolbach index, and diastatic power only 50%. The lowest effect was recorded in extract and friability where is the decisive effect of variety. In our experiments the effect of the year was not manifested only in friability. The best malting quality was obtained in ecological growing in the years 1996 and 1997. In 1995 the lowest values of extract and increased values of the content of proteins in grain were reported.

In three-year observation of the quality the values of the content of grain protein were in an optimum range 10.7–11.2%. None of the samples exceeded the value 11.9%. Extract values, too, were on an excellent level. The varieties Forum, Kompakt and Amulet reached the best level in extract.

In relative extract at 45 °C the values 36–38% are required. In Kolbach the values 38–42% are now required. In the used micro-malting all varieties manifested a disposition to proteolitic overmodification. The values found were not decreased by any of the growing systems.

Activity of amylolytic enzymes was in all samples on excellent level. It did not fall below the limit 220 WK in any case.

The composition of unhopped wort was also on optimum level. Obtainable degree of fermentation fell below 80% only in two cases in 1997.

The friability values and the content of beta glucans were favourably affected in ecological growing. Considerable decrease of the content of beta glucans, which cannot be explained from these experiments, and that is very desired in technological aspect, is fully exceptional finding.

It can be deduced from the results that significantly better values of malting quality of barley were obtained under ecological growing. This can be proved by the values of indicators of malting quality (Table IV and V) what is a complex expression of quality based on evaluation of meaning (weight) of different quality criteria.

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Odrůdy jarního ječmene – jejich výnos a kvalita v ekologickém zemědělství.

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Zájem o odrůdy pro pěstování s nízkými vstupy, pro ekologické zemědělství, případně pro podmínky s nařízeným režimem pěstování, jako jsou chráněné krajinné oblasti a pásma hygienické ochrany vodních zdrojů, vystoupil v posledních letech do popředí zájmu.

Z výše uvedených výsledků odrůdových pokusů nemůžeme však vyvodit obecná doporučení nebo obecnou charakteristiku odrůd jarního ječmene vhodných pro ekologické zemědělství. Výskyt některých odrůd na předních místech by mohl naznačovat jisté reakce na nízké vstupy a vhodnost do podmínek ekologického zemědělství, ale není to statisticky průkazné. Prokázalo se, že odrůdy s nejvyššími výnosy v ekologickém způsobu pěstování byly většinou nejvýnosnější i v konvenčním způsobu pěstování. Lze tedy předpokládat, že odrůdy nejvýnosnější, s dobrým zdravotním stavem budou vhodné i do ekologického způsobu pěstování. Z toho by vyplývalo, že by nebylo nutné v samostatných pokusech zkoušet vhodnost odrůd jarního ječmene pro ekologické zemědělství.

Z hodnocení sladovnické jakosti odrůd jarního ječmene z ekologického a konvenčního (intenzivního) pěstování se potvrdilo, že na většinu ukazatelů sladovnické jakosti měl rozhodující vliv průběh počasí v pokusném roce. Vzniklé rozdíly lze vysvětlit hodnocením průběhu teplot a srážek. U většiny jakostních znaků se prokázal silnější vliv počasí než např. hnojení dusíkem či způsobu pěstování. Průkazné rozdíly mezi ročníky byly u obsahu dusíkatých látek, u relativního extraktu, Kolbachova čísla, diastatické mohutnosti a dosaženého stupně prokvašení. Způsob pěstování se projevil nejvíce na obsahu β-glukanů, kde u ekologického způsobu pěstování byl obsah překvapivě nízký. Také u obsahu extraktu, částečně i u Kolbachova čísla a friability byl prokázán vliv způsobu pěstování.

Prokázalo se, že ekologický způsob pěstování přinesl lepší sladařskou jakost ječmene než způsob konvenční. Přesvědčivě to dokazuje tzv. ukazatel sladovnické jakosti, který byl při ekologickém pěstování o 1,3 bodu vyšší než při konvenčním pěstování.

ječmen; ekologické zemědělství; výnos; sladovnická jakost

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