AGRONOMIC CHARACTERISTICS AND BAKING QUALITY OF *TRITICUM SPELTA* L.

Petr KONVALINA[1], Jan MOUDRÝ [1], Ivana CAPOUCHOVÁ[2]

e-mail: konvalina@zf.jcu.cz

Abstract

As the winter forms of spelt wheat are more frequent than the spring forms, our experiment focused on the spring spelt wheat forms, and we studied and evaluated characteristics and qualities of genetic resources of the spring spelt wheat forms (*Triticum spelta* L.). Seven varieties belonging to genetic resources collections of the Gene bank in Prague-Ruzyně were included in the experiment and studied. SW Kadrilj, a spring wheat variety was chosen as a control variety. The crops were sown in two different localities in the Czech Republic and Austria and they were grown from 2010 to 2012. The organic farming principles were applied by the researchers. Particular significant agrotechnological characteristics were studied and evaluated in the growing season. After harvesting the crops, we analysed their baking quality-we applied standard methods there. Results of our research showed that the spring spelt wheat forms are suitable for low-input farming systems. They also confirmed the suitability of spelt wheat for the low-input farming systems-it has less strict requirements for land conditions and it is able to absorb nutrients from lower soil layers. It is quite resistant to common wheat diseases and competitive to weeds, which are two significant advantages of spelt wheat. On the other hand, it is characterised by lower spike productivity and yield rate, than modern wheat varieties are. However, spelt wheat compensates the lower yield rate by better quality parametres. High proportion of proteins in grain is one of spelt wheat significant advantages-it was equal to 16% (more or less) in the experiment samples. Spelt wheat growing enhances the agrobiodiversity on arable land and helps to diversify the range of spelt wheat use by the food industry.

Key words: spelt, growing, quality

Spelt wheat (*Triticum spelta* L.) has been considered an obsolete cultural European wheat variety. Archaeological discoveries of spelt wheat which have been found in Europe originate from the Bronz Age (Abdel Aal and Hucl, 2005). Spelt wheat used to be grown in the Alps (Switzerland, Germany), Poland, England (Danebury) and Scandinavia. It also used to be widely grown in Central Europe-it is cold hardy and, grown on poor land, able to generate a sufficient yield rate (Feldman, 2001). As the following authors state [Abdel-Aal and Hucl (2005), or Troccoli and Codianni (2005)], spelt wheat is grown most frequently in the following European states: Germany, Spain, Switzerland, Austria, the Czech Republic, France, Italy and Poland. Table 1 shows the data Hůda (2013) has found out-growing of spelt wheat under the organic farming conditions in various European countries. As for the historical extension of spelt wheat areas within Europe, Abdel-Aal and Hucl (2005) mention the situation existing in Switzerland in 1910; spelt wheat areas represented 39,000 ha there. There was similar situation in Germany too; spelt wheat areas represented more than 300,000 ha before the First World War. As for the USA, spelt wheat areas represented more than 200,000 ha at the beginning of 1900. A downward trend was, nevertheless, evident in the USA; organic spelt wheat areas represented 5,000 ha in 1995 and 3,300 ha in 2005 (Neeson, 2011). Range of spelt wheat varieties has never been too wide in Europe. Fourty varieties have been registered in the Common catalogue of varieties of agricultural plant species. Winter spelt wheat forms prevail (10 varieties, see Table 2). There are not any spring spelt wheat forms available at the moment.

This article aims at mapping the existing spelt wheat areas in Europe. As the winter spelt wheat forms prevail in Europe, this article focuses on assessment and evaluation of elementary agrotechnological significant characteristics of the spring spelt wheat forms. Quality has also been assessed and evaluated.

[1] University of South Bohemia in Č. Budějovice, Faculty of Agriculture, Studentská 13, České Budějovice, CZ 370 05
[2] Czech University of Life Sciences, Kamýcká 120, Prague, CZ 165 21

Table 1

Spelt wheat areas in various European countries (adjusted to Hůda, 2013)

Country	Area [ha]				
	Year				
	2007	2008	2009	2010	2011
Czech Republic	-	1,982	2,560	2,231	2,158
Denmark	-	-	40	40	40
France	2,480	3,267	3,444	3,853	-
Italy	-	-	500	-	-
Germany	17,500	24,000	30,000	27,000	-
Poland	-	-	-	2,000	2,500
Austria	-	-	8,523	7,978	7,769
Switzerland	-	745	3,288	4,136	4,200

Table 2

Range of spelt wheat varieties grown in particular European countries (adjusted to Hůda, 2013)

Country	Range of varieties	Country	Range of varieties
Czech Republic	Rubiota	Austria	Ebners Rotkorn
Denmark	Oberkulmer Rotkorn		Ostro
Germany	Franckenkorn	Poland	Schwabenkorn
	Ceralio		Franckenkorn
	Oberkulmer Rotkorn		Ostro
	Schwabenkorn		Oberkulmer Rotkorn
	Schwabenspelz		Rokosz
	Zollernspelz		Wirtas (spring)

MATERIAL AND METHOD

The varieties used in experiments came from the Gene bank of the Crop Research Institute in Prague-Ruzyně. The following varieties were used: Ruzyně; Tábor 22; Tábor 23; Špalda bílá jarní; VIR St. Petersburg; Kew; No. 8930 and control variety of bread wheat *(Triticum aestivum* L.) SW Kadrilj. See Table 3 for more details on the varieties. Varieties were sown in a randomized, complete block design on the organic certified research area in Edelhof (Austria) and České Budějovice (Czech Republic) in 2010 and 2012. The seeding rate was adjusted for a density of 350 germinable grains per m^2. Rows were 125 mm wide. The crop stands were treated in compliance with the European legislation [the European Council Regulation (EC) No. 834/2007, the European Commission Regulation (EC) No. 889/2008]. Agronomically important traits: Inclination to lodging, length of plants, length of spike, infestation with wheat diseases, number of spikes and yield rate were assessed and evaluated for the growing period. DON content: At first, the toxin was extracted from the sample (deionized water was used as a solvent): 100 µl of the extract was diluted in 1 ml of buffer and 300 µl of the diluted extract was applied on the strip (ROSA®-DON Quantitative test), which was incubated for 10 min at 45°C (ROSA® - M Incubator). The test was assessed by ROSA®-M Reader (results in ppb). Baking Quality Analyses were tested according to The International Association for Cereal Chemistry (ICC) methods: crude protein content (ICC 105/2); Zeleny test (ICC 160/1); wet gluten content (ICC 106/2) and gluten index (ICC 155). For the milling we used standard mills and the particle size of scrap was determined according to above mentioned norms. Data were processed by the Statistica 9.0 (StatSoft. Inc., USA) program. The comparison of varieties and their division into statistically different categories were provided by the LSD test.

Table 3

Genetic resources – the variety applied in small-plot trials

Number	Name of variety	Identificator[1)]	Origin	Botanical variety
Triticum spelta L.				
SP1	*Triticum spelta* (Ruzyně)	01C0201257	CZ	*arduini* (MAZZ.) KOERN.
SP2	*Triticum spelta* (Tabor 22)	01C0204322	CZ	*duhamelianum* KOERN.
SP3	*Triticum spelta* (Tabor 23)	01C0204323	CZ	*duhamelianum* KOERN.
SP6	VIR St. Petersburg	01C0204865	CZ	*album* (ALEF.) KOERN.
SP7	Špalda bílá jarní	01C0200982	CZ	*album* (ALEF.) KOERN.
SP8	*Triticum spelta* (Kew)	01C0200984	GB	*caeruleum* (ALEF.) KOERN.
SP9	*Triticum spelta* No. 8930	01C0204506	DK	*album* (ALEF.) KOERN.
Triticum aestivum L. – control variety SW Kadrilj		01C0204877	SWE	*lutescens* (ALEF.) MANSF.
[1)] http://genbank.vurv.cz/genetic/resources/asp2/default_c.htm				

RESULTS AND DISCUSSIONS

Average length of a plant was 122.39 cm. The variety called No. 8930 grown at Edelhof station had got the longest stalks (141 cm). Length of a plant was a variable characteristic. There were differences in the length of a plant between the varieties and localitites (it related to nitrogen

content in the soil). The plants grown at Edelhof station were longer than the plants at ČB station because there was much more soil nitrogen at Edelhof station than at ČB station where it was considered low.

Average length of a spike was 7.93 cm. The variety called No. 8930 had got the longest spikes (12.62 cm). The different nitrogen content in the soil which had been noticed at two different stations did not have any effect on the length of a spike. Sometimes, the length of a spike does not have any effect on the productivity of a spike. Short spikes must be, nevertheless, compensated by dense ones-not the case of spelt wheat, however. Mean values of the assessed and evaluated morphological characteristics indicate that spelt wheat is suitable for the organic farming system. However, there are differences between the individual genetic resources of spelt wheat. Every farmer should pay attention to these differences before starting growing spelt wheat forms.

The assessed genetic resources showed a resistance to fungal diseases during the growing season. They were not infested with any fungal diseases at all, or they were little infested. The crop stand grown at Edelhof station was damaged by lodging in 2012, whereas it was not damaged seriously in the other years, as e.g. Suchowilska *et al.* (2009) state. Most of the assessed spelt wheat genetic resources did not contain any DON, some of them were contaminated a little. It is caused by sparse spikes spelt wheat plants have got. Thanks to being sparse, the spelt wheat spikes get dry very easily and fast and they are not endangered by disease infestation (Konvalina *et al.*, 2011).

Average number of spikes per area unit amounted to 346 spikes per square meter in field conditions. All the assessed spelt wheat genetic resources reached the lowest mean values (280 spikes per square meter) at ČB station in 2010. The assessed control bread wheat variety reached the lowest mean values as well. On the other hand, all the assessed spelt wheat genetic resources hit the highest mean values (405 spikes per square meter) at Edelhof in 2012. Yield rate reflected the above-mentioned findings too; mean yield rate values reached 0.49 t/ha at ČB locality in 2010. Such a low yield rate was influenced by negative overabundant precipitation amount which was arriving during the emergence period. The spelt wheat crop stand grown at Edelhof station hit the highest mean yield rate (3.55 t/ha) in 2012. Generally said, the experiment produced better results at Edelhof station than ČB station (yield rate values in particular, see Table 4). It may be caused by different proportion of nitrogen in the soil in these two localities. According to Konvalina *et al.* (2011), crude yield rate usually varies from 2.5 to 5.0 t/ha under the organic farming conditions, having the percentage of hulls between 32 and 37 %. It mostly corresponds to the results of our experiment. Comparing our experiment results to data the Institute of Agricultural Economics and Information published in 2012 (winter forms of spelt wheat produced the yield rate of 2.75 t/ha in 2011), we realise the assessed spring spelt wheat genetic resources produced higher yield rate than the above-mentioned winter forms of spelt wheat.

Table 4

Agronomically important parameters of spelt wheat varieties (mean±SD)

Variety	Plant length (cm)	Spike length (cm)	Mildew resistance	Wheat rust resistance	DON ($\mu g.kg^{-1}$)	Index of lodging
Ruzyně	128±12	8±2	8,7±0,4	7,9±1,0	0±0	7,7±2,0
Tábor 22	119±13	7±2	8,9±0,3	7,6±1,2	0±0	7,9±1,7
Tábor 23	123±8	7±1	8,9±0,3	7,3±1,2	17±41	7,8±1,9
Špalda bílá jarní	120±13	8±1	8,7±0,4	7,3±1,2	4±10	7,7±1,9
VIR St. Petersburg	124±9	8±1	8,9±0,2	6,8±1,7	4±10	8,0±1,2
Kew	125±15	8±2	8,7±0,4	7,0±1,7	4±10	7,6±2,0
No. 8930	118±18	8±3	8,8±0,3	6,7±1,6	0±0	7,1±2,7
Mean of spelt wheat	122±13	8±2	8,8±0,3	7,2±1,4	4±10	7,7±1,9
Bread wheat SW Kadrilj	87±13	6±1	8,8±0,4	8,2±1,0	171±347	9,0±0,0

Spelt wheat varieties were characterised by high protein content in grain (15.9 % on average). Kew variety reached even higher protein content in grain (17.2%, see Table 5). On the other hand, although grown in the same environmental conditions, SW Kadrilj control bread wheat variety reached lower protein content in grain (by 3.9%).

The high protein content in grain is one of the advantages of the landraces (Dotlačil *et al.*, 2012). Wet gluten content reached high values in all of the spelt wheat varieties (it varied from 40 to 46 % whereas it reached 26 % in SW Kadrilj, the control wheat variety). Wet gluten content was stable (relative standard deviation varied from 10 to 15%).

Table 5

Quality parameters of spelt wheat varieties (mean ± SD) and LSD test ($P < 0.05$)

Variety	Protein content (%)	Wet gluten content (%)	Gluten index	Zeleny test (ml)	Falling number (s)
Ruzyně	15.8±1.8[a]	43±6[a]	34±26[a]	28±4[a]	361±59[a]
Tábor 22	15.8±1.8[a]	44±6[a]	51±18[ab]	35±5[a]	361±51[a]
Tábor 23	15.9±1.7[a]	44±7[a]	46±19[ab]	34±5[a]	329±74[a]
Špalda bílá jarní	15.2±1.6[a]	41±6[a]	36±27[a]	29±4[a]	366±59[a]
VIR St. Petersburg	16.0±1.8[a]	46±6[a]	40±31[a]	33±6[a]	364±64[a]
Kew	17.2±2.3[a]	40±5[a]	44±28[a]	29±8[a]	347±69[a]
No. 8930	16.0±1.8[a]	45±7[a]	45±23[ab]	32±4[a]	347±63[a]
Mean of spelt wheat	15.9±1.7[a]	43±6[a]	42±24[b]	32±5[a]	355±60[a]
Bread wheat SW Kadrilj	12.0±1.9[b]	26±5[b]	72±2[b]	35±10[a]	223±43[b]
Location Edelhof	15.4±1.9[a]	40±7[a]	43±16[a]	35±6[a]	331±56[a]
Location Č. Budějovice	15.4±2.4[a]	43±9[a]	49±31[a]	30±5[b]	347±86[a]

Spelt wheat varieties reached similar Zeleny test values to SW Kadrilj control variety. They ranged from 28 to 35 ml. If we process spelt wheat varieties, we will produce the baking products of a small volume (Abdel Aal and Hucl, 2005). Spelt wheat varieties reached lower gluten index values than the control bread wheat variety (by 27 on average). There were considerable differences between the varieties (Ruzyne – 34; Tábor 22 – 51). Therefore, the dough will be sticky; it is hard to work it (Abdel Aal and Hucl, 2005). Careful selection of varieties may provide some spelt wheat varieties which are suitable for common baking (Wiwart *et al.*, 2011). Spelt wheat varieties, they reach low values of gluten index. Therefore, they are not suitable for common bakery processing and they have to be used in a different way. A production of mixtures is one possibility of their use (e.g. high protein content in spelt wheat varieties together with high sedimentation rate values in bread wheat varieties). Moreover, there are a lot of products made from the hulled wheat species, e.g. pasta, non yeast bread, biscuits, etc.

CONCLUSIONS

Results of our research and experiments have made it evident that spring forms of spelt wheat are suitable for the low-input farming systems. They have the following advantages: low requirements for land and the soil, absorption of nutrients from lower soil layers, certain resistance to diseases and competitiveness to weeds. Spelt wheat varieties are characterised by lower spike productivity and yield rate than modern bread wheat varieties. They have, however, some specific positive morphological, biological and economic characteristics. From the quality point of view, the spelt wheat landraces had a lot of favourable characteristics making the landraces very attractive, e. g. high protein content in grain (even though they reach the high protein content in grain under organic farming conditions). The technological grain quality requirements are different from the common baking quality requirements of bread wheat varieties. The hulled wheat varieties provide an opportunity for the production of various food products which are very different from the common conventional products.

ACKNOWLEGMENTS

Supported by the Ministry of Agriculture of the Czech Republic – NAZV, Grant No. QJ1310072.

REFERENCES

Abdel Aal, E-S.M., Hucl, P., 2005 - *Spelt: a speciality wheat for emerging food uses*. In: Abdel Aal, E-S.M. and Wood, P. (eds.). Speciality grains for food and feed. Minnesota: American Association of Cereal Chemists Inc. p. 109-142.

Dotlačil, L., Stehno, Z., Faberová, I., Michalová, A., 2002 - *Research, conservation and utilisation of plant genetic resources and agro-biodiversity enhancement – contribution of the Research Institute of Crop Production Prague-Ruzyně*, Czech Journal of Genetics and Plant Breeding, 38: 3-15.

Feldman, M., 2001 - *Origin of cultivated wheat*. In: Bojean, H.P. and Angus, W.J. (eds.). The world wheat book: A history of wheat breeding. Paris: Lavoiser Publishing. p. 3-56.

Hůda, P., 2013 – *Genetické zdroje pšenice špaldy (Triticum spelta L.) v Evropě a možnosti jejich využití v ekologickém zemědělství*, Diploma thesis, University of South Bohemia, Czech Republic, 91 p.

Konvalina P., Stehno Z., Capouchová I., Moudrý J., 2011 - *Wheat growing and quality in organic farming*. In: Nokkoul, R. (Ed.): Research in Organic Farming, Intech, Rijeka, Croatia, pp. 105-122.

Neeson, R., 2011 - *Organic spelt production*. Primefact 1091 first edition, Climate and Water Research, Yanco, Australia, pp.1,6.

Suchowilska E., Wiwart M., Borejszo Z., Packa D., Kandler W., Krska R., 2009 - *Discriminant analysis of selected field components and fatty acid composition of chosen Triticum monococcum, Triticum dicoccum and Triticum spelta accessions*. Cereal Science, 49: 310-315.

Troccoli, A., Codianni, P., 2005 - *Appropriate seeding rate for einkorn, emmer, and spelt grown under rainfed condition in southern Italy*, European Journal of Agronomy, 22: 293-300.

Wiwart, M., Perkowski, J., Budzyński, W., Suchowilska, E., Buśko, M., Matysiak, A., 2011 - *Concentrations of ergosterol and trichothecenes in the grains of three Triticum species*, Czech Journal of Food Sciences, 29: 430-440.