

EVALUATION OF SUITABILITY OF EMMER WHEAT VARIETIES (*TRITICUM DICOCCUM* SCHUEBL) FOR ORGANIC FARMING

P. KONVALINA, J. MOUDRÝ

University of South Bohemia,
Faculty of Agriculture
Czech Republic
e-mail: konvalina@zfjcu.cz

*Emmer wheat, *Triticum dicoccum* SCHUEBL, is an old variety of cereals which has been traditionally grown in aride areas. Nowadays, it is mainly grown in Italy, Spain, Turkey, Austria and in the Czech republic. The surface of the growing areas is usually several tens of ha. The renewed interest in this variety has its origin in favourable quality parametres of emmer wheat grain and a beneficial effect on human organism. This article deals with a study of 10 varieties of emmer wheat (which have been chosen from the collection of gene bank at the Research institute of Crop Production in Prague-Ruzyně and in České Budějovice). The particular morphological and biological features were screened during all the vegetation period. Postharvest analysis was carried out after that and the economic characters were set up. Respect of the variety ideotype for organic farming was evaluated too. Concerning the morphological characters, emmer wheat is a suitable genus for condition of low-input farming systems. Plants of emmer wheat are middle tall or tall and they have suitable flag leaves. Spike is supposed to be dense. The biological characters are represented by the resistance to diseases and they are supposed to be very good. Varieties are usually not affected by funga diseases. Emmer wheat is very resistant to drought. When the economic characters evaluated, high degree of diversity of the varieties was found out. Spike is usually dense, it has high TGW and grain weight per spike is 1 g. Harvest index is lower than usual, because emmer wheat is not breded variety. Some materials which achieve sufficient spike productivity and may provide a relevant yield may be found among the varieties. Some of the chosen varieties reached a sufficient evaluation, therefore, they are suitable for low-input farming systems in less favoured areas.*

Keywords: *emmer wheat, evaluation of varieties, organic farming*

Emmer wheat (*T. dicoccum* SCHUEBL, tetraploid species: $2n=28$, AABB genom) which is divided into 99 botanic varieties (MICHALOVÁ *et al.*, 2002) belongs to glumeous varieties of wheat that have a long tradition of growing and use as human diet (MARCONI, CUBADDA, 2005). Finding of the fact that, at least once, it was inserted to the cropping and growing (it was domesticated) also

demonstrates the human interest in this species (BROWN and HAGELBERG, 1999).

The Levant region (Iran, Iraq, Jordan, Syria and Palestine) is its area of origin. Wild predecessor of emmer wheat (*T. dicoccoides*) may be still found there (DOTLAČIL, 2002). Emmer wheat has never been bred and nowadays just landraces and wild forms may be found. As a part of human diet, it played very important role in the period of ancient nations (the Babylon nation, the Assyrian nation, the Egyptian nation) (MICHALOVÁ *et al.*, 2002).

Considering increasing requirements for richness, diversity and good-quality of foodstuff products, the interest in this species of wheat has been still increasing (HAMMER and PERINNO, 1995; OLSEN, 1998; NIELSEN and MORTENSEN, 1998). Such a renewed interest in emmer wheat varieties has its origin in countries with well-developed intensive agriculture. On the other hand, the surface of areas of emmer wheat has been decreasing in countries with less developed farming sector (MARCONI and CUBADDA, 2005).

It is grown in extreme montane conditions in the Pyrenees and Alps (BAREŠ *et al.*, 2002), in Italy, Spain, on smaller areas in the Balkan, Turkey, Caucasia and in India, it is still grown in Ethiopia (REDDY *et al.*, 1998). Considering European countries, it is the most grown species of cereals in Italy. MARCONI and CUBADDA (2005) state the fact that the surface of the areas of emmer wheat is about 1 500 ha and the total yield varies from 2 500 to 3 000 t without glumes. KARAGOZ (1996) speaks on 10 000 ha of emmer wheat in Turkey in 1993. Several hectares may be found in Spain, in the Asturias region. Considering Central Europe, for example Meierhof biodynamic farm in Waldwiertel in Austria (ANONYM, 2006) and several organic farms in the Czech republic (KONVALINA and MOUDRÝ, 2007) grow it too. It was also grown in Slovakia in the 1950's (BAREŠ *et al.*, 2002).

T. dicoccum species is a suitable one for growing in marginal areas and in the conditions of organic farming where modern conventional varieties are not able to develop its production potential very well because they had been selected for different land and climatic conditions. The growing of emmer wheat may be useful and economical for a farm just in the cases mentioned above (MARCONI and CUBADDA, 2005).

MATERIAL AND METHOD

In 2006, 10 varieties of emmer wheat have been chosen from the collection of the Gene bank in the Crop research Institute in Prague-Ruzyně (RI) (Table 1). 10 other modern varieties of *Triticum aestivum* L. have been chosen from the world assortment to compare them with modern varieties. Considering small amount of seeds, the varieties were seeded into rows on a research parcel of the University of South Bohemia in České Budějovice and at the RI in Prague-Ruzyně. Particular morphological and biological characteristics were being evaluated during the growing season, postharvest analysis of spikes were carried out after the harvest to evaluate and compare their productivity.

Descriptor Genus *Triticum* L. which is used for the international evaluation of genetic resources of wheat has been arranged to the evaluation of the chosen varieties. It had to meet the requirements for a particular ideotype of wheat variety for organic farming. According to the results and final figures, theoretical yield was calculated and the figures were evaluated in Statistica program.

Table 1

List of varieties

code of variety	ECN	BCHAR	name	SP	<i>Triticum dicoccum</i> (SCHRANK) SCHUEBL:
D1	01C0200117	412064	Horny Tisovnik	CZ	var. <i>rufum</i> SCHUEBL
D2	01C0200947	412048	Ruzyne	-	var. <i>rufum</i> SCHUEBL
D3	01C0201262	412051	Tapioszele 1	-	var. <i>serbicum</i> A. SCHULZ
D4	01C0201282	412017	Tapioszele 2	-	var. <i>rufum</i> SCHUEBL.
D5	01C0201877	412017	Mestnaja	GRU	var. <i>fictesemicanum</i> FLAKSB.
D6	01C0203453	412021	Kromeriz	-	var. <i>atratum</i> (HOST.) KOERN.
D7	01C0203989	412013	Kahler Emmer	D	var. <i>dicoccum</i>
D8	01C0203990	412013	May-Emmer	CH	var. <i>dicoccum</i>
D9	01C0204012	412019	Sort. Schiemann	-	var. <i>fuchsii</i> (ALEF.) KOERN.
D10	01C0204501	412013	No. 8909	-	var. <i>dicoccum</i>
Note: ¹ ECN = identifier ; ² BCHAR = taxonomical code ; ³ SP = origin					

RESULTS AND DISCUSSIONS

Morphological characteristics: Generally spoken, emmer wheat is suitable for organic farming from the point of its morphological features. Semi-erect tuft shape during the tillering was considered as a negative feature (Tab. 2) because the planofile situation of leaves ($>45^\circ$) in the first stages of the growth causes higher degree of shading of land surface and it causes worse conditions of growth for weeds (HOAD, NEUHOFF, DAVIES, 2005). The average height of plant is 106,8 cm (it means 144 % of the length of stalk of modern varieties). Higher varieties are more competitive to weeds (KUNZ, KARUTZ, 1991; MÜLLER, 1998, KÖPKE, 2005) but they may cause some problems as lodgingn (KRUEPL *et al.*, 2006). The evaluated genotypes have flag leaf which is 13 cm shorter and wider than leaves of soft wheat. The position of the first leaf of $<15^\circ$ or $15-45^\circ$ prevail.

When comparing the morphological characteristics, we find out that its productivity is well influenced by density ($28,3 \text{ spikelets} \cdot 10 \text{ cm}^{-1}$), modern varieties may achieve the density which is about 1/3 lower. Length of spike is very fluctuating feature, CV of 19,59 % and the variability of varieties is also considerable (5,3 cm in case of D1 Horny Tisovnik, D3 Tapioszele 1, D5 Mestnaja and 9,1 cm in case of D4 Tapioszele 2, D9 Sort. Schiemann). Higher figures of spike density mentioned above may seem to be negative because they may contribute to a creation of a favourable climate for the development of funga diseases which may affect spikes (LAMMERTS van BUEREN, 2002).

Table 2

Morphological characters of emmer

variety	plant	flag leaf			spike		
	length (cm)	length (cm)	width (cm)	position (°)	length (cm)	density (spikelet. 10 cm ⁻¹)	Position (°)
D1 Horny Tisovnik	96	20,1	1	15-45	5,3	29,3	46-90
D 2 Ruzyne	118	22,6	1,3	<15	8,3	25,5	46-90
D 3 Tapioszele 1	88	17,6	1	15-45	5,3	35,6	46-90
D 4 Tapioszele 2	118	22,6	1,3	<15	9,1	28,0	46-90
D 5 Mestnaja	88	17,6	1	<15	5,3	28,0	46-90
D 6 Kromeriz	111	17,6	1,3	15-45	9,1	25,5	46-90
D 7 Kahler Emmer	118	21,3	1,4	<15	7,6	31,8	15-45
D 8 May-Emmer	118	21,3	1,3	15-45	8,3	25,5	15-45
D 9 Schiemann	88	20,1	1,4	46-90	8,3	25,5	15-45
D 10 No.8909	118	18,8	1,3	<15	6,8	29,3	46-90
mean	106,8	20,1	1,23	-	7,4	28,3	-
SD	13,39	1,89	0,15	-	1,45	3,08	-
CV (%)	12,53	9,4	12,19	-	19,59	10,88	-
mean of 10 modern varieties of <i>Triticum aestivum</i> L.							
mean	74	33,1	1,1	-	8,6	20,1	-
<i>Note: upper quartile: plant length - 118 cm; flag leaf – length - 21,3 cm, width - 1,3 cm; spike – length - 8,3 cm, density - 29,3 spikelets. 10 cm⁻¹</i>							

Caryopsis of emmer wheat has to be peeled before the processing in mill, the ratio of peeled grains and glumes is about 2/3. A lot of the other authors confirm this fact, for example MARCONI and CUBADDA (2005) – 70-75 %; CASTANGA *et al.* (1996) – 75 %; LAGHETTI *et al.* (1999) – 64,1-72,8 %; BAREŠ *et al.* (2002) and MICHALOVÁ *et al.* (2002) – 63-83 % - the ratio of nonglumeous grains to glumeous ones. The caryopsis of the evaluated varieties is very elongated or elongated. Most of the caryopsis have slightly puckered or smooth matted light brown or amber brown surface. The crease shape of the caryopsis is shallow and narrow or wide.

Biological characteristics: Fast creation of fytomass in the growing season of growth and more fluent generative period are very important features because of the competitiveness to weeds (LAMMERTS van BUEREN, 2002). The average length of the growing season reached 93 days, nevertheless there were considerable differences between the varieties (D1 Horny Tisovnik – 86 days, D5 Mestnaja – 100 days). From the point of view of the fast creation of fytomass in the growing season, D3 Tapioszele 1 – 55 days and D1 Horny Tisovnik – 56 days are supposed to be good ones. The length of the growing season in the generative period is supposed to be positive in case of D5 Mestnaja – 38 days; this figure was influenced by the total length of the growing season.

Considerable affection by diseases was not noticed, D1 Horny Tisovnik and D3 Tapioszele 1 were affected by *Septoria nodorum*, but just a little. Affection by the other leaf diseases was noticed in sporadic cases. It was influenced by a positive development of summer weather and low pressure of diseases. The fact that the pressure of diseases is usually lower in low-input farming systems than in

conventional ones should be taken into account too (LAMMERTS van BUEREN, 2002).

Economic characteristics: There is the evaluation of economic characteristics of the evaluated varieties of emmer wheat in Table 3. The tested varieties have TGW of 31,1 g and CV of 13,9%. MARCONI and CUBADDA (2005) state the range from 30 to 45 g. The average harvest index is 0,35 and CV of 12,3%. Grain weight in spike is very fluctuating feature and the average one is of 0,95 g and CV of 28,5%. Number of grains in spike is of 30,19 and 20,24 spikelets and CV is the same (over 19%). On the other hand, number of grains in spikelet is the most stable feature, the average figure reaches 1,5.

When comparing theoretical yield of the varieties of emmer wheat and modern varieties, we find out that the average theoretical yield (weight of grain in spike x optimal number of spikes per area unit) reaches 3,78 t.ha⁻¹, therefore, 72,4 % of the theoretical yield of modern varieties. According to Tab. 3, D10 variety No. 8909 exceeds this yield level. The other varieties (D2 Ruzyně, D9 Sort. Schiemann) also approach this yield level. STALLKNECHT *et al.* (1996) states the yield of emmer wheat grown in the USA; he states the range from 0,2 to 3,7 t.ha⁻¹. This author also emphasizes the fact that the plants reached the yield from 1,5 to 2,5 t.ha⁻¹ (48-84 % of the yield of spring wheat) after the selection of yield genotypes in the conditions of aride station. The research which had been carrying out between 1995 and 2000 at the RI in Prague-Ruzyně has brought the following results: the yield of peeled grains – 1,5-4,4 t.ha⁻¹, it means 60-65 % of the yield of spring wheat (BAREŠ *et al.*, 2002; MICHALOVÁ *et al.*, 2002).

Table 3

Economic characters of emmer

variety	TGW (g)	HI	Grain per spike (g)	Grains per spike	Spikelets per spike	Grains per spikelets	Yield (t.ha ⁻¹)
D1 Horny Tisovnik	34,0	0,39	0,86	25,67	13,60	1,9	3,44
D 2 Ruzyně	29,0	0,35	1,07	37,01	22,85	1,6	4,28
D 3 Tapioszele 1	28,5	0,39	0,59	20,58	16,10	1,3	2,36
D 4 Tapioszele 2	32,5	0,32	1,00	34,68	23,55	1,5	4,00
D 5 Mestnaja	34,0	0,34	0,73	23,12	14,45	1,6	2,92
D 6 Kromeriz	30,0	0,33	0,88	26,42	21,85	1,2	3,52
D 7 Kahler Emmer	23,5	0,27	0,68	31,85	21,50	1,5	2,72
D 8 May-Emmer	26,5	0,37	0,98	37,50	22,85	1,5	3,92
D 9 Schiemann	37,0	0,31	1,14	30,96	24,20	1,3	4,56
D 10 No.8909	36,0	0,41	1,53	34,12	21,45	1,6	6,12
mean	31,1	0,35	0,95	30,19	20,24	1,50	3,78
SD	4,33	0,04	0,27	5,92	3,95	0,2	1,09
CV (%)	13,9	12,3	28,5	19,6	19,5	13,3	28,5
mean of 10 modern varieties							
mean	34,8	0,48	1,3	36,4	18	2,04	5,2
Note: upper quartile: TGW – 34 g; HI – 0,39; Spike: grain per spike - 1,07 g; Number of grains per spike – 34,68; number of spikelets – 22,85; Number of grains per spikelets – 1,6; Yield – 4,28 t.ha ⁻¹							

Quality characteristics: Emmer wheat provides the production of very good-quality grains. According to several authors, crude protein content in grain is very high. It may achieve 20 % (MARCONI and CUBADDA, 2005).

CONCLUSIONS

According to the results of the evaluation of the morphological and biological characteristics, emmer wheat is very well adapted to organic and low-input farming systems (it means that it has very good prerequisites for higher competitiveness to weeds etc.). The affection by diseases was not noticed very much.

Each parameter of productivity of spike achieves lower level that in case of modern varieties (about 1/3 lower). D10 variety No. 8909 exceeds the yield level of modern varieties (it has higher TGW, weight of grain in spike, lower number of grains which is compensated by higher number of spikelets and positive effect on the theoretical yield).

A lot of authors appreciate grain of emmer wheat, they think it is favourable for human organism. Therefore, the other qualitative parameters of grain and products made of emmer wheat are about to be evaluated in the following paper. Emmer wheat is supposed to firm its situation in organic farming in the future. Quality of foodstuffs is the main parameter of organic farming. It is not able to compete with modern varieties from the point of view of the amount of yield, nevertheless it provides very good-quality grains. Growing of emmer wheat contributes to an extension of agrobiodiversity in the countryside. The effects of human health are also considerable, local producers may not only produce good and healthy local foodstuffs, but they may also contribute to sustainable development of a region.

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