Landraces and Obsolete Cultivars of Minor Wheat Species in the Czech Collection of Wheat Genetic Resources

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Abstract: The proportions of landraces in the Czech collection of wheat genetic resources significantly differentiates among wheat species, 4.2% in bread, 77.6% in emmer, and 80.0% in the einkorn wheat collections. A set of 10 selected emmer wheat landraces has been characterized by high molecular weight glutenin subunits (HMW-GSs). They were evaluated for 3 years in field trials, and described by grain quality parameters. Emmer wheat accessions differ considerably in the polymorphisms of HMW-GSs. Out of the total of 10 studied emmer wheat landraces, 5 accessions appeared to be homogeneous in the electrophoretic patterns of HMW-GSs; they were formed by a single glutenin line. Much higher crude protein content was detected in all of the emmer wheat accessions, in comparison with the control bread wheat cultivar. The proportion of this important component varied between 15.5% and 22.2%. On the other hand, SDS sedimentation, an important parameter of bread making quality, was very low (1.2–4.4 ml); and a similar situation has been recorded in the gluten index. Based on such results, the emmer wheat landraces can be considered potentially more suitable for other purposes than for the preparation of bread (*e.g.* for different grain mixtures, purée, etc.).

Keywords: emmer wheat; grain quality; HMW glutenin subunits; landraces; wheat species

The collection of wheat genetic resources (GR) in the Crop Research Institute in Prague contains accessions belonging to 29 species. Among 10 523 wheat accessions in the collection (Table 1) there are 697 landraces and obsolete cultivars. A large number of the landraces (382 accessions) belong to bread wheat (*Triticum aestivum*) species; however, they represent 4.2% of the accessions of this species. The proportion of landraces in minor wheat species is much higher (e.g. 77.6 % in emmer (*T. dicoccum*) and 80.0% in einkorn (*T. monococcum*)). Most of the wheat landraces have been collected during collecting missions.

Small seed samples of wheat landraces, obtained mostly by collectors, are primarily multiplied to get sufficient seed amounts for field trials. Landraces of minor wheat species are traditionally evaluated together with other wheat genetic resources in field experiments and laboratory tests. Evaluation is carried out according to the Descriptor List for Genus *Triticum* L. (Bareš *et al.* 1985). During evaluation, particular groups of characteristics are assessed:

- For taxonomic identification of accessions, the morphological characteristics described according to the descriptor list, mentioned above, are traditionally used. Storage protein electrophoresis was applied to a selected set of samples with the aim of identifying valuable accessions more precisely. The (originally) Czechoslovak and (current) Czech wheat accessions are preferably characterized by DNA, using the SSR technique.
- Development and growth stages are registered as the number of days to emergence, heading, flowering, wax ripeness, etc.

Table 1. The most numerous species in the collection of wheat genetic resources

Wheat species	No. of accessions
Triticum aestivum L.	9 081
T. araraticum Jakubz.	44
T. boeoticum Boiss.	47
T. carthlicum Nevski	14
T. compactum Host	44
T. dicoccoides (Koern. *ex* Aschers. *et.* Graeb.) Schweinf.	26
T. dicoccum (Schrank) Schuebl	116
T. durum Desf.	912
T. monococcum L.	55
T. polonicum L.	14
T. spelta L.	78
T. turgidum L.	45
T. urartu Thum. *ex* Gandil.	11
Others (less than 10 accessions per species)	36
Total	10 523

– The evaluation of disease resistance is targeted at fungal diseases: powdery mildew, leaf rust, gloom rust, and stem rust. Powdery mildew is scored under natural infections, because spontaneous infection used to be relatively strong. The response of wheat genetic resources to the mentioned rust species is tested under increased infection pressure. Disease development is scored in specific phases of vegetation, using a 1 to 9 scale.
– The stand is characterized by plant density (number of spikes per 1 m^2) and by lodging, scored on the scale mentioned above.
– Analyses of yield components are carried out after harvest. The harvest index is estimated as a ratio between the weight of above-ground biomass of a sample and the weight of grain obtained from it. Furthermore, the numbers of spikelets and kernels per spike are counted, lengths of the spikes measured, weight of 1 000 kernels (TKW) taken, as well as other characteristics.
– Grain quality parameters are determined by classical analyses, or using near-infrared spectroscopy (NIRS). Usually, we evaluate the crude protein content, gluten content, gluten index, Zeleny sedimentation value, and the falling number.
– The tetraploid emmer wheat belongs to the hulled wheat species, with a long tradition of being grown and its utilization in human nutrition. Despite that fact, the breeding of emmer has been marginal, and at present mostly landraces or wild forms are available. However, owing to the increasing demand for diversity and quality of food products, the interest in this crop also has been increasing (Nielsen & Mortensen 1998). These materials can be utilized as a source of genetic diversity for crop improvement, (e.g. as donors of some important agronomical characteristics such as adaptability, resistance to stresses, protein content, etc.) (Bradová *et al.* 2005).

MATERIALS AND METHODS

A set of 10 emmer wheat landraces were evaluated for three years. The characteristics of lodging resistance, plant height, earliness (number of days to heading, flowering, wax ripeness, and chlorophyll decomposition), as well as the response to field infection by powdery mildew were evaluated, according to the Descriptor List for Genus *Triticum* L. The results were compared to the control bread wheat cultivar Sandra. Previous to the field evaluation, the accessions were characterized by glutenin subunits with high molecular weight (HMW-GSs); plus simultaneously evaluated from the point of view of grain quality. The electrophoretic patterns of HMW-GSs were determined by one-dimensional sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE), using the Laemmli buffer system (Laemmli 1970). The acrylamide/bisacrylamide concentration (*T*) and the cross linker (*C*) used were as follows: $T = 10\%$ and $C = 2.60\%$. Particular alleles of HMW-GS were identified according to a published catalogue (Payne & Lawrence 1983). The following measurements of grain quality parameters were carried out for each accession: protein content (measured by near-infrared reflectance spectroscopy – NIRS); the SDS micro sedimentation test, done according to Axford *et al.* (1979) with Hýža's modification (1986); and gluten index (GI) in accordance to AACC 38-12.

Table 2. Results of field evaluations in years 2001, 2003 and 2004

T. dicoccon landraces	Lodging (scored 1–9)		Plant height (cm)		Days to heading		Days to flowering		Days to wax ripeness		Days to chlorophyll decomposition		Powdery mildew (scored 1–9*)	
	average	*CV*	average	*CV*	average	*CV*	average	*CV*	average	*CV*	average	*CV*	average	*CV*
T. dicoccon (Kroměříž)	6.0	16.7	94.0	18.8	60.3	19.8	64.0	20.3	94.3	18.1	94.0	16.5	5.7	44.4
T. dicoccon (Ruzyně)	8.0	12.5	100.2	21.6	66.0	15.8	70.7	16.6	97.7	12.9	96.7	13.1	7.3	28.4
Kahler Emmer	7.7	30.1	101.3	20.2	67.0	15.5	70.3	15.7	101.3	11.2	98.3	12.4	7.3	28.4
May-Emmer	8.0	12.5	108.0	17.9	64.7	17.9	68.3	19.9	97.0	13.5	96.3	12.7	7.3	28.4
Weisser Sommer	7.3	28.4	105.0	20.8	65.7	13.6	69.3	13.6	97.0	12.9	97.3	12.6	6.5	32.6
T. dicoccon (Tapioszele)	5.7	53.9	90.0	20.0	61.0	11.5	66.7	15.0	94.7	15.3	95.7	13.9	6.7	34.6
Krajova-Podbranc (Toman)	4.7	32.7	89.0	26.2	55.0	19.2	60.0	23.3	92.0	16.4	92.7	15.1	6.7	37.7
Poering Jaarma (Nachitchevan)	3.7	31.5	87.2	27.7	53.7	19.1	58.0	21.2	89.7	17.9	89.7	16.0	6.7	34.6
T. dicoccon (Balkan)	3.3	45.8	83.3	12.5	54.0	19.2	59.3	20.0	89.3	17.9	88.7	17.1	6.7	34.6
T. dicoccon (Brno)	3.7	41.7	84.0	12.1	57.7	17.1	62.3	17.9	91.3	16.1	91.0	14.5	7.0	37.8
Sandra – *T. aestivum* control	7.5	29.1	70.3	18.4	52.0	15.1	55.8	17.4	89.2	17.6	90.3	14.7	4.2	45.4

CV – coefficient of variation; *9 means the lowest powdery mildew occurence

RESULTS AND DISCUSSION

Based on a 3-year average, the differences in lodging resistance were observed (Table 2). The highest resistance (8), even higher than in the control bread wheat cultivar, was recorded in the accessions *T. dicoccon* (Ruzyně) and May-Emmer. They also had the lowest variability (coefficient of variability) of this characteristic in three years of evaluation. The resistance to lodging was not connected to plant height, as lodging resistant accessions were higher (108 resp.100 cm) than smaller ones, with lower resistance to lodging.

The variability of all characteristics describing plant earliness was relatively low, stable, and similar in most accessions. All emmer landraces were later than the control (*T. aestivum* cultivar Sandra).

Resistance to powdery mildew field infection strongly depended on differences among weather conditions in particular years. All of the evaluated emmer accessions overcame resistance to the powdery mildew of the control cultivar (4.2).

HMW glutenin markers and quality parameters

The composition of HMW-GSs, together with the quality parameters for each accession, are de-

Table 3. Quality parameters and HMW glutenin markers of *T. dicoccon* landraces

T. dicoccon landraces	Country of origin	Quality parameters: crude protein (%)	Quality parameters: SDS-mikro sedimentation (ml)	Quality parameters: gluten index	*Glu* lines	HMW-GSs: *Glu-A1*	HMW-GSs: *Glu-B1*	HMW-GSs: *Glu-1D*
T. dicoccon (Kroměříž)	CZE	22.2	2.8	31.8	A	1	7+8	–
					B	1	21	–
					C	1	6.7	–
T. dicoccon (Ruzyně)	CZE	20.6	2.8	61.8	A	1	7+8	–
Kahler Emmer	GER	20.5	3.0	15.3	A	1	7+8	–
May-Emmer	CHE	21.9	3.6	20.4	A	1	7+8	–
Weisser Sommer	GER	19.3	4.4	31.5	A	1	7+8	–
T. *dicoccon* (Tapioszele)	HUN	16.2	1.8	74.2	A	1	7+8	–
Krajova-Podbranc (Toman)	CSK	15.8	1.4	69.9	A	2*	21	–
					B	2*	6+9	–
Poering Jaarma (Nachitchevan.)	AZE	16.8	3.3	47.6	A	1	22	–
					B	1	7+8	–
					C	0	7+8	–
					D	2*	7+8	–
T. dicoccon (Balkan)	GER	16.6	2.6	82.6	A	2*	14+15	–
					B	0	14+15	–
T. dicoccon. (Brno)	CSK	16.8	1.2	14.4	A	2*	6+8	–
					B	2*	21	–
Sandra (*T. aestivum*) – control	CSK	12.6	6.0	88.3	A	2*	7+8	3+12
					B	2*	7+9	3+12
					C	1	7+9	3+12

CZE – Czech Republic; GER – Germany; CHE – Switzerland; HUN – Hungary; CSK – Czechoslovakia; AZE – Azerbaidzan scribed in Table 3. The results showed that emmer wheat accessions are considerably distinguishable in polymorphisms of HMW-GSs, contrary to the common wheat cultivars (Bradová & Šašek 2005). Out of the total number of 10 emmer wheat landraces studied, five accessions appeared to be homogeneous in the electrophoretic patterns of HMW-GSs; they were formed by a single glutenin line. Glutenin polymorphism was detected in five accessions and in the control bread wheat cultivar Sandra, as well. These accessions were characterized by a number of glutenin lines, from two to four. In the studied set of ten emmer wheat landraces, eighteen glutenin lines were found, and a total of ten different patterns were identified at the *Glu-1* locus Three and seven HMW-GS alleles were identified at the *Glu-A1 and Glu-B1* loci, respectively. The locus *Glu-B1* features the highest allelic variability of the HMW-GSs, which is characteristic of *Triticum aestivum*. HMW-GSs 21 and 22, which correspond to the *Glu-B* locus, were identified in accessions *T. dicoccon* – Kroměříž (21), Krajova-Podbranc – Toman (21), *T. dicoccon* – Brno (21), and Poering Jaarma – Nachitchevan (22). These HMW-GSs do not occur at all in modern common wheat (*Triticum aestivum)* varieties, (Branlard *et al.* 2003; Bradová & Šašek 2005). A subunit, marked 6.7 (Table 3), encoded at *Glu-B1*, which was found in one line of *T. dicoccon* (Kroměříž), and will probably require further study.

HMW-GSs are used to assess the bread making quality of common wheat. For the last few decades, the genetic potential for dough properties has been estimated from HMW glutenin subunit composition. This was done using the Payne score (Payne *et al.* 1987), which allocates scores for the respective subunits (alleles) in each of wheat's three genomes (*Glu-A1, Glu-B1, Glu-D1*). This is mainly associated with the HMW glutenin subunits encoded at the *Glu-D1* locus, which is obviously absent in emmer wheat. The bread making quality was low, as described by two other characteristics (micro SDS sedimentation and gluten index (GI)). Very low bread making quality can be expected in *T. dicoccon* (Brno) because of its low sedimentation value and gluten index. Therefore, several HMW-GS alleles encoded at *Glu-A1* and *Glu-B1*, which are known to have a favourable effect on dough properties (*Glu-A1*: subunits 1, 2*; *Glu-B1*: subunits 7+8, 7+9), occur more frequently in the set of emmer wheat; but their effect did not get exhibited. Subunits 21 and 22, encoded at *Glu-B1*, have not been studied with consideration to bread making quality. Subunit 2*, encoded at *Glu-A1*, which occurs less frequently in modern common wheat, could be used in breeding for increased glutenin diversity of common wheat; and consequently could open up new use possibilities in the baking industry.

Much higher crude protein content, compared with the control bread wheat cultivar, was detected in all emmer wheat accessions (Table 3). The proportion of this important component even reached 22.2% in the accession *T. dicoccon* (Kroměříž). On the other hand, SDS sedimentation, an important parameter of bread making quality, was very low (1.2–4.4 ml); and a similar situation has been recorded in the gluten index. Thus, such types of wheat can be used for purposes other than the preparation of bread (e.g. for different grain mixtures, purée, etc.).

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