Int. Agrophysics, 2005, 19, 147-152

INTERNATIONAL
Agrophysics
www.ipan.lublin.pl/int-agrophysics

Genetic conditionings of the quality of grain of new lines of *Triticum durum* Desf.

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Received November 17, 2004; accepted March 31, 2005

A b s t r a c t. Kernels of 6 new lines of durum wheat cultivated in the climatic and soil conditions of the Lublin region were studied in detail with respect to their physico-chemical and technological characteristics. The analyzed lines were characterized by high values of the hardness index ranging from 82.2 to 86.9 and high gluten percentage – more than 36.2%. The values for the falling number for lines LGR 900/3a, LGR 1359/8, LGR 899/62a and LGR 8/780/90 were favourable and they ranged between 400 and 350 s. Analysis of gliadin subunits (A-PAGE) showed high polymorphism of these proteins and the presence of subunits 45-γ and 42-γ occurring with varying frequency in the studied lines. Identification of high molecular weight glutenins (SDS-PAGE) pointed to average values of the coefficient Glu-1. Kernels of lines LGR 896/64a, LGR 896/23 and LGR 8/780/90 had the same composition of HMW glutenins on 1B 7+8. An evaluation of the grains of the new lines indicates their good adjustment to the agroclimatic conditions and possibility of further cultivation of durum wheat.

K e y w o r d s: durum wheat, physico-chemical characteristics of grain, A-PAGE of gliadin proteins, SDS-PAGE of glutenin proteins

INTRODUCTION

Semolin from durum wheat – the basic raw material for the production of pasta – is obtained in Poland exclusively from imported cultivars. The possibilities and success of cultivating *Triticale durum* in our climatic conditions will depend both on the economic efficiency of production and on the quality features of the grain determining the value of pasta. (Fabriani and Lintas, 1988; Szwed-Urbaś *et al*., 1995). An initial evaluation of the Polish lines of durum wheat grown in the Lublin region points to a possibility of obtaining a number of genotypes that can be a valuable material for growing our own cultivars (Szwed-Urbaś *et al*., 1995; 1996). In the quality evaluation of durum wheat most often such features are taken into consideration as: semolin extract, gluten content and quality, vitreousness and hardness of the grain, pigment level, falling number and sedimentation test (Kowalczyk and Makarska, 2000; Sissons *et al*., 2000; Hentschel *et al*., 2002; Marchylo *et al*., 2001; Ciołek and Makarska, 2004). Pasta characteristics described by resistence parameters or viscosity are also influenced by the kind and composition of gluten proteins – the gliadins and glutenins fractions (Marchylo *et al*., 2001; Porceddu *et al*., 1998; Turchetta *et al*., 1995; Ruiz and Carrillo, 1995).

The aim of the study was to evaluate the quality parameters of the grain of six new lines of durum wheat with their usability for further cultivation (reproduction) as well as for industry.

MATERIALS AND METHODS

Kernels of six morphologically established lines of spring durum wheat (LGR 1359/8, LGR 900/3a, LGR 899/62a, LGR 896/64a, LGR 896/23, LGR 8/780/90) derived from a few combinations of crossings in the Institute of Genetics and Plant Cultivation of the Agricultural University of Lublin were the invstigated material. Term of harvest - 2001.

Physico-chemical characteristics of the kernels included the mass of a hectoliter, the protein content according to Kjeldahl-(Nx5.7), gluten content as determined in the Glutomatic apparatus type 2200, and sedimentation test according to Zeleny. For characterization of wheat kernels technological properties the Single Kernel Characterization System (SKCS, type 4100) was used. This

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model provides an easy and accurate way to classify samples according to single kernel hardness and weight (Miś and Grundas, 2004; Sissons *et al*., 2000). The falling number was determined in the Falling Number System apparatus (Perten, 1964). Extraction and Acid-PAGE electrophoresis of the gliadin fraction from durum wheat grain was conducted by the method described by Brzeziński *et al.* (1989). Extraction and SDS-PAGE electroforesis of the glutenin fraction was conducted by the method according to Brzeziński and Łukaszewski (1998). For electrophoresis of durum wheat glutenins the wheat cultivars Megadur, Jaguar and Capdur were used as models, since the composition of their glutenin subunits is known. The quality score of glutenin subunits was defined and that of Glu-1 was counted according to Payne *et al.* (1987).

RESULTS AND DISCUSSION

The characteristics of physico-chemical features of durum wheat show differentiation of test weight kg hl^{-1} and weight of a single kernel (Table 1). Lines LGR 1359/8 and LGR 896/23 had a bigger and similar weight of single kernels. Line LGR 8/780/90 was characterized by the lowest value of this index and the lowest mass of one hectoliter. On the other hand, kernels of this line had the highest protein content, which confirms that there is a negative correlation between fertility of particular lines and protein level occurring in almost all cereals (Table 2).

Hardness of cereal grain is often positively correlated with its vitreousness. There are studies proving a strict dependence of grain texture on permanence and cohesion of protein structure in ripening endosperm cells and starch grains growing in this structure. There are studies confirming the existence of a close connection between hardness of ripening wheat grain and proportions as well as the resultant charge of gliadin proteins, and a different interaction between them in the hard and soft endosperm (Doekes,1985; Huebner and Gaines, 1992).

The analysis in the SKCS system made in the present work classifies wheat into quality groups on the basis of tests of grain hardness and texture. Basing on the hardness indexes, kernels of all the lines were classified as hard and the indexes ranged from 82.2 to 86.9 (Table 1). The kernels of lines LGR 900/3a, LGR 899/62a, and LGR 896/23 had higher and similar values of the indexes. Line LGR 8/780/90, with the lowest weight of a single kernel, also showed the lowest average hardness index. Examples of hardness index values are presented in Fig. 1. Vitreousness of kernels from the analyzed strains was also high, ranging from 80 to 90%, and it had a positive correlation with hardness (Table 1).

A general physico-chemical appraisal of durum wheat grains shows good adjustment of selected strains of this species to agroclimatic conditions in a particular cultivation year.

An appraisal of the grains resistance to sprouting was made by an indirect method through determining the falling number is the index of the kernel biological condition in the current harvest period. The value of the falling number does not always reflect the genetic resistance to sprouting of the

T a b l e 1. Mean values of physico-chemical characteristics of durum wheat grains

Lines	Parameters from SKCS: Single kernel weight (mg)	Parameters from SKCS: Hardness Index	Vitreosity (%)	Volume weight (kg hl^{-1})
LGR 1359/8	38.7 ± 9.5	83.0 ± 15.9	84 ± 2.8	75.4 ± 0.5
LGR 900/3a	37.8 ± 8.7	86.9 ± 16.9	80 ± 1.4	76.2 ± 0.5
LGR 899/62a	34.6 ± 8.8	86.9 ± 15.8	90 ± 2.8	75.7 ± 0.4
LGR 896/64a	36.3 ± 10.0	83.4 ± 15.6	84 ± 1.4	74.0 ± 0.8
LGR 896/23	38.6 ± 9.5	86.2 ± 18.3	82 ± 2.8	74.3 ± 0.8
LGR 8/780/90	32.7 ± 10.4	82.2 ± 16.7	84 ± 1.4	72.4 ± 0.5

T a b l e 2. Mean values of technological characteristics of durum wheat grains

Lines	Total protein (Nx5.75%)	Wet gluten (%)	Sedimentation value (cm^3)	Falling number (s)
LGR 1359/8	12.9 ± 0.4	37.2 ± 1.1	10.7 ± 0.9	366 ± 10
LGR 900/3a	12.5 ± 0.7	39.9 ± 1.1	17.0 ± 3.0	402 ± 14
LGR 899/62a	12.6 ± 0.4	37.8 ± 0.8	19.7 ± 1.9	349 ± 8
LGR 896/64a	13.9 ± 0.7	38.5 ± 0.7	21.0 ± 1.4	287 ± 11
LGR 896/23	13.9 ± 0.9	36.3 ± 0.9	19.0 ± 1.4	266 ± 5
LGR 8/780/90	14.4 ± 0.1	38.9 ± 0.5	19.0 ± 0.7	377 ± 15

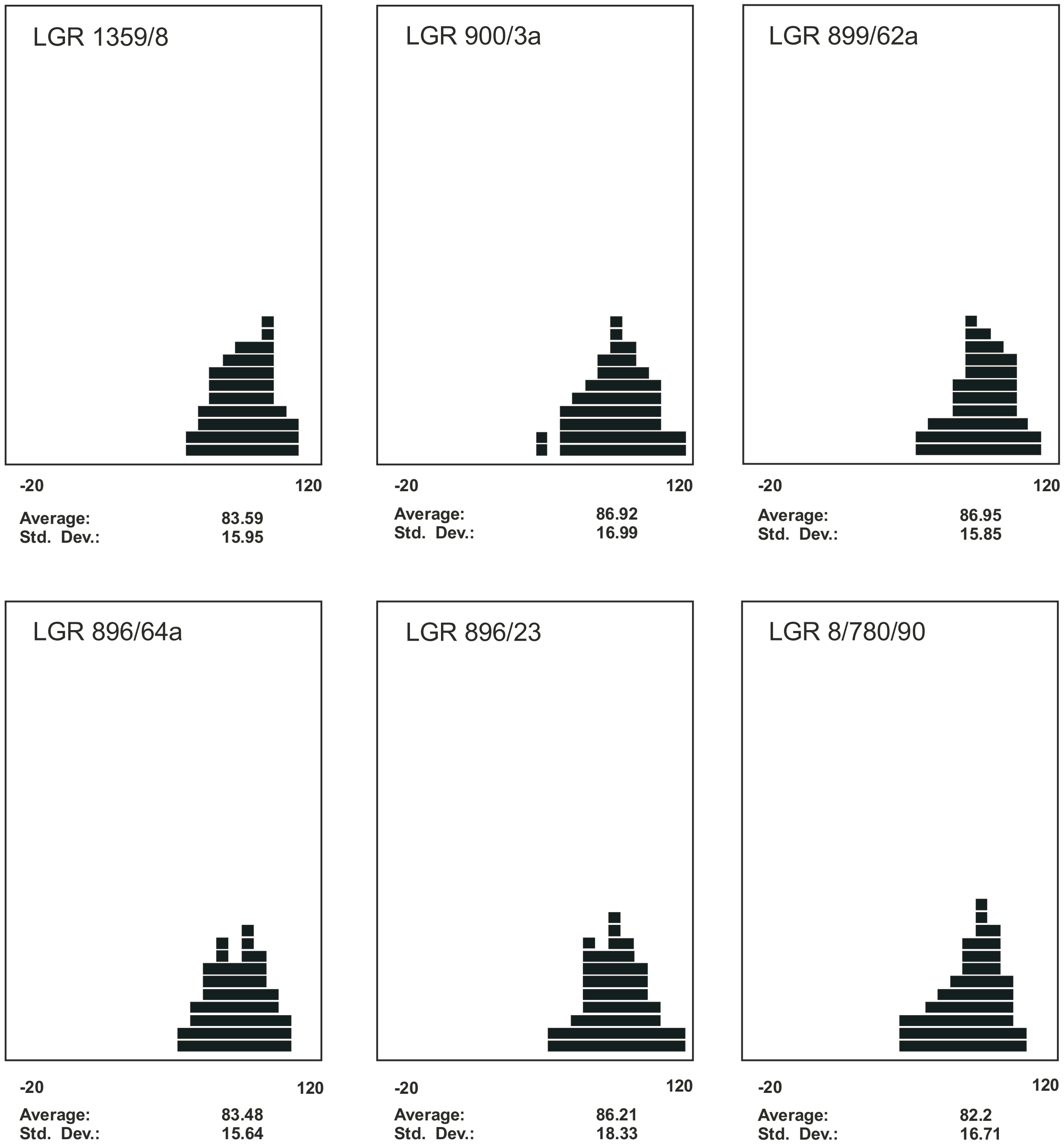

Fig. 1. Hardness indices for grains of 6 lines of durum wheat.

given cultivar, as it may be totally determined by unfavourable atmospherical conditions (Kriger, 1972). Analysis of the falling number in the flours from durum wheat of particular lines showed significant differences in the rapidity of starch pasting (Table 2). Line LGR 900/3a had the most favourable index of the falling number (above 400 s). Lines LGR 1359/8, LGR 899/62a and LGR 8/780/90 showed a lower falling number, but it ranged between 350 and 380 s. Line LGR 896/23 had the shortest time of falling. The low falling number, as for this wheat cultivar, may point to increased amylolytic activity of the grain and be connected with impossibility of obtaining good pasta from it.

In the quality appraisal of durum wheat such characteristics should be included as: protein content, as well as the amount and quality of gluten. Protein content total ranged between 12.5 and 14.4% (Table 2). Kernels of LGR 8/780/90 with the lowest weight of single kernel showed the highest protein content. Lines LGR 900/3a and

LGR 899/62a had the lowest level of this component, and they were characterized by the highest hardness.

Gluten from durum wheat has a somewhat different structure from common wheat gluten. In the general characteristic it is said that it is less flexible, more breakable, and this is why flour from durum wheat is mainly used for producing cakes and unfermented products, *ie* pasta, couscous, bulgur (Fabriani and Lintas, 1988; Szwed-Urbaś *et al*., 1995).

The amount of wet gluten in the flour of the studied lines was high and ranged from 37.2 to 39.9%, *ie* much above the minimum requirements of the Polish standards – 28% (BN-/9131-04). The least gluten was washed out of flour obtained from LGR 896/23 and that was gluten with the highest flowness (11.5 mm).

The content and quality of storage proteins in the grains of durum wheat may influence, by up to 30-40%, the differentiation of quality features of the pasta as well as its behavior when boiling (Fabriani and Lintas, 1988; Marchylo *et al*., 2001).

In the grain of the studied lines the gliadin fraction was analyzed by the A-PAGE method and subunits 45-γ and 42-γ were identified (Fig. 2). The electrophoretic separation gave ~27-32 gliadin subunits and showed a considerable polymorphism of those proteins. The genetic polymorphism with respect to gliadin proteins proves that there is differentiation on the short arms of chromosomes A and B of the first and sixth homeologous groups of wheat (Cottenet *et al*., 1984; Fabriani and Lintas, 1988). The lack of genetic uniformity with respect to gliadin proteins found in the present work was not accompanied by differentiation of morphological features of wheat.

On the electrophoretic diagram subunits 45-γ and 42-γ were identified in all the analyzed lines of durum wheat. The presence of these proteins is often used for evaluation of the quality of pasta. It was found that these components, coded for by co-dominating alleles of a single gene on chromosome 1B, have the same molecular mass and a similar amino-acid composition. The proteins differ in their hydrophobity. Subunit 45-γ, characterized by a higher hydrophobity, may point to higher technological properties with respect to pasta (Fabriani and Lintas, 1988; Cottenet *et al*., 1984; Stoyanova *et al*., 2000).

Because of the high level of gliadins polymorphism found in the work the frequency of occurrence of subunit 45-γ correlating positively with pasta quality and of subunit 42-γ correlating negatively is variable. Lines LGR 1359/8 and LGR 896/23 were characterized by a higher frequency of subunit 45-γ occurence in the grain. Subunits 42-γ were more often present in the genotypes of LGR 896/64a and LGR 8/780/90.

Genes coding for high-molecular subunits of glutenins (HMW) are localized on the long arms of chromosomes 1A, 1B and 1D, respectively Glu-A1, Glu-B1 and Glu-D1 (Payne and Lawrence,1983; Payne *et al*., 1987). Durum wheat (*Triticum durum*) belongs to a tetraploid species and is devoid of group D chromosomes occurring in *Triticum aestivum*. Studies are being conducted that point to a close

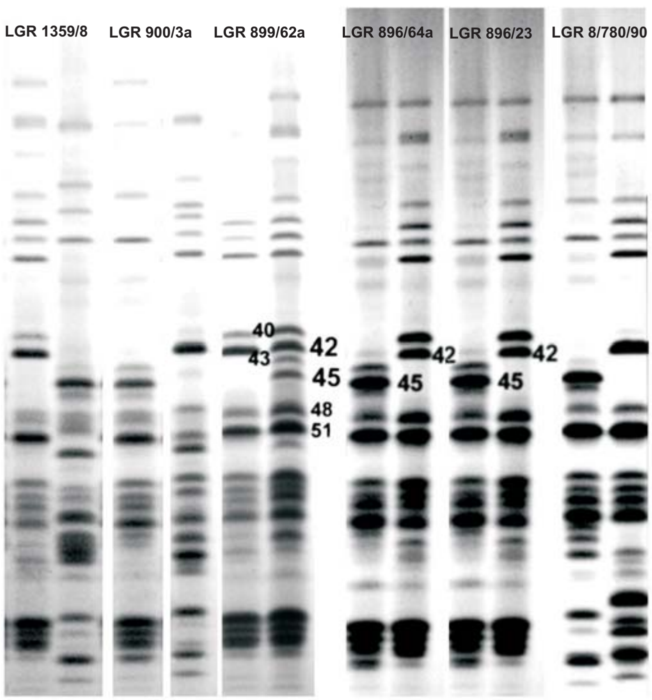

Fig. 2. A-PAGE electrophoresis of durum wheat gliadins: localization of 42-γ and 45-γ gliadins.

correlation between HMW composition and quality of durum wheats (Ruiz and Carrillo, 1995) or pasta quality (Marchylo *et al*., 2001; Wang and Kovacs, 2002). The separation and identification of glutenin high-molecular subunits present in the six studied lines of durum wheat reported in the present paper are shown in Table 3 and Fig. 3. The values of factor Glu-1 (Payne *et al.*, 1987) were average: 2-4 quality points. In all the lines locus Glu-A1 occurred as null allel without synthetizing any protein subunits. Kernels of lines LGR 896/64a, LGR 896/23 and LGR 8/780/90 had the same glutenin subunits composition on 1B- 7+8. The lowest value of Glu-1 was shown by line LGR 1359/8 (2 quality points). The line was characterized by a very low value of sedimentation test compared to other wheats.

CONCLUSIONS

1. It may be stated that physico-chemical characteristic of the grain of the studied lines points to a good adjustment to agroclimatic conditions and to a good possibility of further cultivation of durum wheat.

2. Electrophoretic analysis of the gliadins and glutenins fraction revealed a great diversity of subunits allowing (despite the polymorphism) evaluation of the degree of genetic differentiation between the lines.

3. Identification of HMW on the basis of Glu-1 may be used to make a prognosis of the technological quality of a line and may make it easier to select a line with the optimum composition of these proteins.

T a b l e 3. Composition of glutenin subunits Glu-A1 and Glu-B1 loci for durum wheat lines included in the electrophoresis analyses

Lines durum-wheat	Subunits		Quality score* (Glu-1)
	Glu-A1	Glu-B1	
LGR 1359/8	Null	6+8	2
LGR 900/3a	Null	7+8	4
LGR 899/62a	Null	17+18	4
LGR 896/64a	Null	7+8	4
LGR 896/23	Null	7+8	4
LGR 8/780/90	Null	7+8	4
	Durum-wheat pattern		
Megadur	2*	17+18	6
Jaguar	Null	7+8	4
Capdur	Null	6+8	2

*Score range is 10 to 1.

a

b

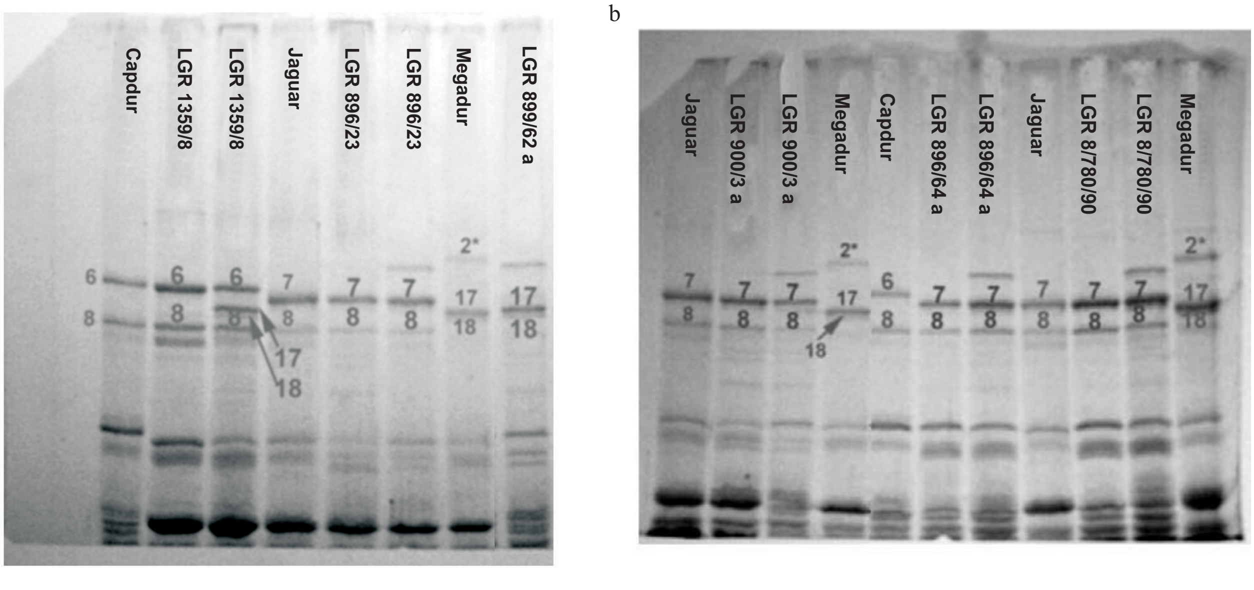

Fig. 3. SDS-PAGE electrophoresis of durum wheat glutenins: localization of subunits coded for on 1A and 1B chromosomes a) LGR 899/62a, LGR 896/23, LGR 1359/8; b) LGR 8/780/90, LGR 896/64a, LGR 900/3a.

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