Technological characteristics of newly developed mutant common winter wheat lines

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ABSTRACT

Fifteen hybrid-mutant lines and two direct mutant lines were studied in terms to their technological quality in 2000 and 2001 vegetation years. The hybrid-mutant lines were produced using chemical mutagen sodium azide at a concentration of 1mM on F_2 seeds. For parent cultivars, promising and well adapted Bulgarian and foreign common winter wheat cultivars were used. The direct mutant lines were obtained by gamma-irradiation and sodium azide treatment of dry seed from cultivars. The differences of the following three characteristics: quality index, softening of dough and energy for dough deformation (W) of MX 77/14 compared to the total mean value are positive and statistically significant. Crude protein, softening of dough, and energy for dough deformation (W) of MX 84/37 are also significantly different in relation to the total mean value. Both wheat lines refer to the group of common winter wheat with very good technological quality. This fact was confirmed of higher values of energy for dough deformation (W), than strong wheat cultivar Pobeda.

Keywords: wheat hybrid-mutant lines; technological quality; rheological properties

Improvement of grain quality is a major objective of most wheat breeding programs. Beside for enhancement of biological and nutritive value of end-use product the quality components of grain play an important role in the economic value of new cultivars determining.

Recently scientists associate the progress in plant breeding with presence of diverse source material, its evaluation and continuous enrichment with new germplasm, including such created by breeders (Boyadjieva 1994, Kronstad 1998, Merezko 1998).

To resolve this problem in wheat breeding for high quality different approaches were followed:

The germplasm with various geographical aeries and genetic origins were collected and evaluated (Boyadjieva et al. 1999).

The induced mutations in wheat were also widely employed to modify some protein subunits determining the grain quality (Kiribuchi-Otobe et al. 1998, Yasui et al. 1998, Maluszynski et al. 2001).

The objective of this investigation is to evaluate newly created mutant lines of common winter wheat in terms of its technological properties.

The approaches used in this study gives the possibility for selection of new mutant lines with high quality of grain, which can be used as source material in breeding programs.

MATERIAL AND METHODS

Fifteen hybrid-mutant lines, two direct mutant lines and two Bulgarian cultivars (cv. Sadovo as standard for yield and strong wheat cv. Pobeda as a quality standard) were included in this investigation.

The lines studied were developed in a mutation-breeding program for common winter wheat at the Institute of Plant Genetic Resources in Sadovo, Bulgaria. Field trails were carried out during 2000–2001, according to Latin rectangle scheme.

The hybrid-mutant lines were produced using chemical mutagen sodium azide at a concentration of 1mM on F_2 seeds by method of Savov (1976). For parent cultivars, promising and well adapted Bulgarian and foreign common winter wheat cultivars were used (Table 1). The direct mutant lines were obtained by gamma-irradiation and sodium azide treatment of dry seed from cultivars Table 1.

All laboratory analyses were performed in four replications for each wheat line.

The following physical-chemical characteristics of grain have been determined. Vitreousness, crude protein and grain hardness by Inframat 8600-H. The sedimentation value (according to the method with 2% acetic acid), wet gluten, quality index (the ratio between the sedimentation value and the grain protein content) by Halverson and Zeleny (1988), to assess the protein quality.

After cold conditioning the grain was milled into 70% flour in a laboratory mill.

Using Farinograph and Alveograph instruments we evaluated rheological properties of dough.

And significant differences between technological indices and the total mean value was evaluated using the method of Konstantinov (1952).

RESULTS AND DISCUSSION

The mean values of the technological characteristics of tested mutant lines for the studied period are shown in Table 2.

Vitreousness and hardness of wheat grain were not equivalent indices. The hardness index contains more information for grain functionality than the vitreousness index, which determines the expedience of its application in research work and practice of grain quality evaluation and processing of the wheat. Grain hardness is twice as strong determined by the variety and less variable depending on the environment rather than vitreousness. (Belcheva 1996).

The mean part of the evaluated mutant lines refers to the group of common winter wheat whit hard and medium hard endosperm. A tendency was expressed that the higher the vitreousness is, the higher the hardness is. The mutant line MX 129/61 was characterized as wheat whit soft endosperm (48%) and very low vitreousness.

Protein content and gluten strength are the chief components of baking quality. Mutants are rich in protein in particular lines MX 110/18 and MX 84/37 as well as have high protein quality expressed by quality index. All studied lines have also high content of strong gluten (except of MX 96/33), but less values than standard Pobeda.

In the first decade of June 2000 the daily maximum temperatures reached 36.5°C, and 38.6°C in the last decade. There was extremely dry weather during May and June. In June 2001 the daily maximum temperatures were also above 35°C.

Viscoelastic properties of dough results were significantly affected by the temperature treatments. In the presence of a prolonged period or in the presence of a short but repeated period with daily maximum temperatures above 35°C, a weakening effect was found both in durum and bread wheat interpreted by the result of increased gliadin/glutenin ratio.

Corbellini et al. (1996) reported another biochemical mechanisms that explain the dough weakening effect of heat stress during grain filling. High temperatures seemed to effect mainly the composition of polymeric fraction (soluble/insoluble polymers) without influencing their synthesis.

Keeping in mind the origin of mutant lines (Table 1) and well-known quality behavior of Pobeda as strong wheat, it is seen that the rheological properties of dough are poorer than expected.

Nevertheless our data shows that mutant lines MX 116/26, MX 105/26, MX 77/14 and MX 84/37 have good rheological properties.

A significant difference between technological indices and their mean values of 10 characteristics of studied wheat mutant lines are shown in Table 2.

The differences of the following three characteristics: quality index, softening of dough and energy for dough deformation (W) of MX 77/14

Table 1. Origin of wheat mutant lines

Wheat mutant line	Origin
MX 41/9	Altimir × Pobeda
M 343	1802P (mutant of cultivar Pobeda)
MX 122/58	Sadovo1 × Record
MX 87/40	Slavjanka × Pobeda
MX 116/26	Slavjanka × Roland
MX 54/8	(Momchil × Courtaue) × Pobeda
MX 129/61	1012M (mutant of cultivar Momchil) × Pobeda
MX 138/16	(Sadovo1 × Momchil) × KC 139
MX 77/14	Charodeika × Katja
MX 113/1	Katja × Vrazha
M 342	Mutant of cultivar Katja-combining treatment whit 0.1mM NaN_3 +100 Gy gamma ryes
MX 86/31	Bezostaja 1 × Bononija
MX 110/18	Garant × Bononija
MX 101/55	Slavjanka × Pobeda
MX 105/26	Sadovo 1 × Vrazha
MX 96/33	1115K × Jantar (1115K-mutant of Katja)
MX 84/37	Pobeda × 1381P (mutant of cultivar Pobeda)

X – hybrid-mutant lines produced after treatment of hybrid-seeds F_2 whit NaN_3 at a concentration of 1mM

Table 2. Technological characteristics of wheat mutant lines

Mutant line	Vitreousness	Hardness	Crude protein	Sediment value	Wet gluten	Quality index	Dough stability	Dough softening	Valorimetric value	Deformation energy	P/L
	%	%	%	ml	%		min	U		$W.10^{-4}$	
Variation	20–78	48–69	12.6–16.7	41.2–61	23.3–42.8	2.2–4.1	4.0–10.3	60–130	48–79	99.4–282.5	0.7–2.0
Mean value	58.7	60.5	14.5	41.2	30.9	2.9	7.4	90.1	64.3	164.7	0.89
Pobeda	74^{+++}	69	15.2^{+++}	50.2	36.6	3.3	9.13	95	73	171.1	0.83
Sadovo1	59	61	14.1	32.2^{---}	29.5	2.3^{---}	6.58	95	62	156.9	1.2^{++}
MX 41/9	59	61	13.4^{---}	35.7	28.7	2.7	6.1	100	75	111.2^{---}	0.62
M 343	61	62	14.4	46.8^{+++}	34.6	3.3	8.1	100	68	163.8	0.71
MX 122/58	54	62	13.4	38	28.6^{--}	2.8	8.2	85	69	161.3	1.35
MX 87/40	57	63.5	13.4^{-}	39.7	29.2	3	8.2	70	69	187	1.03^{+}
MX116/26	58	60.5	14.1	49.8	33.5	3.5	9.1	65^{---}	73	186.8	0.51^{---}
MX 54/8	52	6.1	13.1^{--}	35	28.7	2.7	6.1^{---}	110	59^{---}	118.1^{--}	0.99
MX 129/61	16^{---}	48.5^{---}	15.6	37.5^{-}	28.2^{-}	2.4	7.3	95	65	130.4	0.65
MX 138/16	60	59	14.7	40.3	33.8	2.8	6.1	90	60	146.5	0.7
MX 77/14	64	62	14.9	46.8	30	3.1^{+++}	7.3	75^{--}	66.5	202.1^{+}	0.78
MX 113/1	56	60	14^{---}	40.5	25.9^{---}	2.9	6.5	113^{++}	61^{-}	159.6	0.96
M 342	65	62.5	14.8	41.2	30.3	2.8	6	90	61	156.6	0.8
MX 86/31	58	58.5	14.7	42.9	30	2.9	6.2^{-}	80	60^{--}	166.1	1.05
MX 110/18	60	62	15.8	42.9	34.2	2.7	6.4	95	63	159.3	0.9
MX 101/55	67	64.5	14.7	37.3	28.9^{-}	2.5	6.2	88	61	158	0.9
MX 105/26	53^{---}	57.5	14.8	39.7	28.3^{---}	2.7	8.5	78	70	188.4	0.75
MX 96/33	66	59.5	15	40.5	27.5^{-}	2.7	6.2^{--}	95	60	166.9	1.15
MX 84/37	68	67	16.4^{+++}	48	36.6	2.9	7.3	70^{--}	67	201.4^{+}	0.7

compared to the total mean value are positively statistically significant.

Crude protein, softening of dough and energy for dough deformation (W) for MX 84/37 also is significantly different in relation to the total mean value. Both wheat lines refer to the group of common winter wheat whit very good technological quality. This fact was confirmed by higher values of energy for dough deformation (W), than standard.

The differences of four characteristics of MX 129/61 and MX 113/1 are negatively statistically significant compared to the total mean value, and have inferior technological quality in relation to the all evaluated wheat lines (Table 2).

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ABSTRAKT

Technologická charakteristika nových mutantních linií ozimé pšenice

V letech 2000–2001 byla sledována technologická jakost u patnácti mutantních kříženců a u dvou přímých mutantních linií pšenice. Mutantní kříženci byly získány použitím chemického mutagenu azidu sodného v 1mM koncentraci na osivo F_2 generace. Jako rodičovské genotypy byly použity významná bulharská odrůda a zahraniční odrůdy ozimé pšenice. Přímé mutantní linie byly navozeny gama zářením a azidem sodným. Mutageny byly u odrůd pšenice aplikovány na suchá semena. Linie MX 77/14 se statisticky průkazně odlišovala od průměrných hodnot u těchto jakostních parametrů: index kvality, pokles konzistence těsta a deformační energie. Linie MX 84/37 se statisticky průkazně odlišovala od průměrných hodnot u obsahu hrubých proteinů, indexu kvality, poklesu konzistence těsta a deformační energie. Obě linie byly zařazeny do skupiny ozimé pšenice s velice dobrou technologickou jakostí. Tento závěr byl potvrzen tak, že obě linie vykazovaly vyšší hodnotu deformační energie než odrůda pšenice Pobeda.

Klíčová slova: mutantní kříženci linií pšenice; technologická jakost; rheologické vlastnosti

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