REALIZATION OF THE QUALITY POTENTIAL OF COMMON WINTER WHEAT CULTIVAR *ENOLA* DEPENDING ON THE METHOD OF POST HARVEST RESIDUE TREATMENT

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Abstract

Stoeva I., G. Milev. Realization of the quality potential of common winter wheat cultivar Enola depending on the method of post harvest residue treatment. FCS 9(1): 21-29

The investigation was carried out with the aim of determining the influence of the factor environment and some biological elements of the growing technology of cultivar Enola on its quality potential. The investigation was done on the territory of DAI – General Toshevo during 1997 – 2012. The most popular, distributed and productive common winter bread wheat cultivar Enola was involved. The methodology of performing the field trials has been described in detail in previous publications. The technological analysis of grain was carried out in the Bread Making Quality Laboratory of DAI – General Toshevo on the basis of mean grain sample according to approved and adopted Bulgarian State Standard (BSS) methods. The experimental data were processed with the help of the statistical software Statistica 7. The results showed that the realization of the genotypic potentials of cultivar Enola with regard to quality depended on the interaction of the cultivar with the year conditions. The manageable formation of the cultivar's strength needs greater attention to the regularities under which this interaction occurs. By experimenting with contemporary biological elements from the growing technology of the cultivar, high expression of its quality potential was achieved. Against the background of optimal fertilization with $N_{12}P_{12}$ and incorporation of the post harvest plant residues from sunflower and bean, a considerable improvement of the values of wet gluten in 70 % flour, and of the parameters of the rheological and baking properties was obtained. The treatment of the post harvest residues with the cellulose digestive products Bactofil C and NLA (Nutri Life Accelerate) had positive effect on the quality of cultivar Enola.

Key words: Wheat - Quality indices of grain - Fertilization, Stubble digesters – Plant residue

Резюме

Стоева И., Г. Милев, Реализация на качествения потенциал на сорт обикновена зимна пшеница Енола в зависимост от начина на третиране на следжътвените остатъци. FCS 9(1): 21-29

Изследването е проведено с цел определянe отражението на фактора външна среда и на някои биологични елементи от агротехниката на отглеждане на сорт Енола върху неговия качествен потенциал. Проучването е извършено в опитното поле на ДЗИ - Ген. Тошево през периода 1997-2012 г. Използван е най-популярният, райониран и продуктивен сорт зимна хлебна пшеница Енола. Методологията на заложените полски опити е описана в детайли в предишни наши публикации. Технологичният анализ на зърното е извършен в лабораторията на ДЗИ-Ген. Тошево на база средна проба зърно по утвърдени общоприети методи съгласно БДС. Експерименталните данни са обработени с помощта на статистическа програма Statistica 7. Резултатите показват, че реализацията на генотипните заложби на сорт Енола по отношение на качеството зависи от взаимодействието между сорта и условията на годината. Управляемото формиране на силата на сорта се нуждае от засилено внимание към закономерностите, при които се осъщесвява това взаимодействие. С експериментирането на съвременни биологични елементи от технологията на отглеждане на сорта е постигната висока изява на неговия качествен потенциал. На фона на оптимално торене с $N_{12}P_{12}$ и инкорпориране на следжътвените растителните остатъци от слънчоглед и фасул е достигнато значително подобряване в стойностите на мокър глутен в 70% брашно, в параметрите на реологичните и хлебопекарни свойства. Обработката на следжътвените растителните остатъци с целозоразлагащите препарати Бактофил С и NLA (Nutri-Life Accelerate) повлиява положително качеството на сорт Енола.

Ключови думи: Пшеница - Качество на зърното – Торене – Растителни остатъци

INTRODUCTION

The increasing requirements of agricultural production toward more high-quality grain impose the necessity of constantly updating and optimizing the wheat growing program which allows better use of the factors of production, agro technology, fertilization, etc. Due to the variability of climatic conditions, the producers can choose not only the technology but also the suitable cultivar to achieve high results (Alabushev, 2011).

Most of the contemporary cultivars possess sufficiently wide range of productivity and quality indices. In this sense the choice of a specific cultivar and additional investments in the agro technology help to solve to a great extent the problem of obtaining sufficient and stable quantity of food grain. Wheat yield and quality remain currently unstable. The potentials of the cultivars with regard to yield and quality genetically planned by the breeder have not been entirely revealed. The agronomy practices wheat growing, which are friendly to human health and to the environment, have not been sufficiently developed (Schoenau and Campbell, 1996; Opoku G., and Vyn, 1997; Donkova and Tonev, 2005).

To solve this problem, investigations were carried out with the aim to determine the significance of the factor environment and of some biological element from the agro technology of cultivar Enola quality management in the region of DAI - General Toshevo.

MATERIAL AND METHODS

The investigation was carried out in the trial field of DAI – General Toshevo during 1997 – 2012. The most popular, distributed and productive common winter wheat cultivar Enola was used. The methodology of the conducted field trials has already been described in details in our previous publications (Stoeva et al. 2006; Milev, 2002; Milev, 2011).

The technological analysis of grain was carried out at the Bread making quality Laboratory of DAI on the basis of a mean grain sample according to approved Bulgarian State Standard methods. The experimental data were processed using the software Statistica 7.

The hydro-thermal conditions during the investigated years were contrasting and reflected the climatic peculiarities of the region. During most of the investigated period they were unfavorable for formation of quality grain. Seasons 1997, 1998, 1999, 2005 and 2010 were characterized with rainfalls above the norm and temperature conditions close to the norm for March – June. Often the rainfalls were accompanied by storms, lodging and partial germination of grain (1997, 2010).

The period 1999 – 2000 was also unfavorable for production of quality grain. The excessive rainfalls during the early stages of the cultivar's development were common. The temperature fluctuations in May (from 6.5° C до 32.8 ° C), and especially the frost at the beginning of the month caused partial sterility of spikes. Later, the hot winds and the high temperatures (reaching in certain days of the month 32.8 ° C) forced grain maturation and impeded the normal accumulation of gluten in grain.

During harvest year 2001 the development of the cultivar proceeded at normal rate. The severe drought in the autumn of the preceding year 2000 caused non-uniform emergence of the crop and drying of some of the plants. The wheat crop entered the period of winter colds without hardening. The scarce precipitation in spring at stage grain filling – maturation, as well as the high temperatures in June in combination with dry wind caused wilting and accelerated ripening of the crop. Grain was with deteriorated physical and technological indices. Similar meteorological situation was observed also in harvest years 2002 and 2007.

In harvest year 2003 the wheat crops remained short and irregular due to partial freezing and severe Sunn pest attack early in spring. Grain filling occurred under hot and dry weather. The formed amount of gluten was low, although of good quality. In 2004 and 2012 the cultivar realized high production potential of satisfactory quality. Years 2006, 2008, 2009 and 2012 can be considered moderately favorable for the quality of cultivar Enola.

RESULTS AND DISCUSSION

The range of variation and the mean values of the separate indices characterizing the grain quality of cultivar Enola are given in Table 1. In all years of the investigation, the test weight of the cultivar exceeded the standard of first class wheat (averagely 81 kg; 78÷84.4); this is an advantage of the cultivar implying higher potential for flour yield. The variations in vitreousness were high and depended on the year (from 31% in 2010 to 100% in 2001).

Table 1. Quality characteristics of cultivar Enola during 1997-2012

Indices	x	min - max	St. dev	Vc
1. Test weight, kg	81±0.66	78÷84.4	2.63	3.24
2. Grain glassiness, %	75±522	31÷100	20.89	27.8
3. Grain hardiness, %	101.6±6.68	64.6÷142.9	267	26.3
4. Sedimentation, ml	47±1.73	36÷63	6.91	14.7
5. Wet gluten yield in 70% flour, %	22.4±0.71	16.8÷25.8	2.85	12.7
6. Dough stability, min	4,32±0.55	1.45÷10.10	2.21	51.20
7. Softening degree of dough, min	96±7.30	45÷162	29.21	30.4
8. Quality value by farinograph, cond. un.	58±5.06	39÷124	20.25	34.9
9. W by alveograph, al.un.	162.9±16.40	100.7÷289.1	65.60	40.3
10. P/L	1.92±0.30	0.45÷5.00	1.22	63.5
11. Bread volume, ml	689±14.29	630÷825	57.15	2.2
12. Form resistance (H:D)	0.47±0.01	0.40÷0.59	0.05	10.6
13. Bread crumb quality (rank 0-5)	4.9±0.03	4.5÷5.0	0.14	10.6

Vitreousness exceeded the requirements of the standard in 81 % of the years and according to the classification norm the cultivar can be defined as valuable. Grain hardiness as a conditional index of the structural and mechanical properties of the grain is related to peculiarities of grain milling. From the point of view of the standard requirements, cultivar Enola can be ranked very high by this index (mean value of the index of grain hardiness

101.6 %), which is favorable with a view of flour yield. Significant variation in the category of grain hardiness was registered in the unfavorable years 1997 and 1998.

Obviously, the reasons for deterioration of the physical properties of grain are related to the meteorological conditions, and on the first place – to the variations of moisture at full maturity, in parallel with prolonged harvesting. The degree of their variation occurs at different speed depending on the structure of the endosperm and the quality and quantity of protein in it. When the ripe grain is attached to the still not harvested plant and there are permanent rainfalls (1997, 1998, 1999, 2005 and 2010), the diurnal moisture in it is high.

Due to the higher air humidity, dew and fogs, as well as the lower night temperatures, the grain expands in size, while during the day it shrinks back when temperatures get higher but does not reach its previous volume. This daily "pulsation" of the grain leads to deterioration of its physical status (Nettevich et al., 1986; Nettevich, 1999; Humphreys and Noll, 2002; Yang Y. et al., 2007).

The estimation of the cultivar's quality is related also to the content of wet gluten in flour. Gluten plays an important role in the processes of dough formation of bread. The dough properties and the quality of bread depend on its characteristics. It was found that the amount of wet gluten in the flour of cultivar Enola was variable. Depending on the year and the damages caused by Sunn pest (when treatment with insecticides was not possible), the variation of this index was within a wide range (16.8 – 25.8 %). In 4 of the years the cultivar formed over 25 % gluten, in 6 of the years – over 22 %, and during the rest of the years – below 22 %.

Averaged for the investigated period, the strength of dough determined by farinograph and alveograph corresponded to the classification norm for medium-high quality. Good results for dough strength by farinograph and alveograph were obtained in 2003 when grain filling occurred in hot and dry weather. By shortening the time of accumulation of carbohydrates in grain, drought contributed to improvement of the relative component of gluten in grain (2001, 2002 and 2007).

It is interesting to note that in some of the years with higher rainfalls during maturation and harvesting, significant deviations of the alveographic and farinographic characteristics of the cultivar were not found, which demonstrated the complexity and the multi-factor effect on the rheological properties of grain. The mean value of the farinographic quality was 58 farinographic units (f.un.), the variation being from 39 f.un. to 124 f.un; the mean value of dough relaxation by farinograph was 96 f.un., the variation over years being from 45 f.un. in 2003 to 162 f.un. in 2010; the value of W was 162.9 alveographic units (al.un.), with variation from 100.7 al.un. to 289.1 al.un. and high ratio (P/L) of 1.92 mm (0.45÷5.0).

The variability of the rheological characteristics is related to the changeable year conditions. The frequent rainfalls during full maturity stage, although not causing visible symptoms of germination, often reduce the values of flour strength. This according to some authors is due to the hidden activity of the alpha amylase or to defective genes (Mares et al., 2008); according to other researchers it is due to half-open expression of genes responsible for quality or to cause agents of diseases (brown and yellow rust, etc.) which reduce the amount of gluten proteins (Dimmock, 2002; Biddulph,2008).

The breadmaking properties of cultivar Enola were considerably influenced by the year conditions. The results from the laboratory baking determined it as a cultivar of very good bread making characteristics (mean bread volume 682 ml; H:D – 0.47; quality of bread crumb 4.9).

The data from the correlation analysis of the indices of cultivar Enola investigated during 1997 – 2012 revealed the following: 1) high positive correlation between test weight and glassiness, test weight and grain hardiness, sedimentation value and dough stability, dough stability and farinographic quality value, W and H:D; 2) moderate positive correlation between glassiness and grain hardiness, glassiness, P and L, grain hardiness and softening degree of dough by farinograph, sedimentation and wet gluten content in 70 % flour, sedimentation and farinographic quality value, sedimentation and W, sedimentation and bread volume, sedimentation and quality of bread crumb (Table 2). The low positive correlation between bread loaf and the softening degree (r = 0.078) showed that the baking properties were affected positively in some of the years when higher dough relaxation was observed.

Table 2. Correlations of the quality characteristics of cultivar Enola

Indices	1	2	3	4	5	6	7	8	9	10	11	12
1.Test weight, kg												
2.Grain glassiness, %	0.740*											
3.Grain hardiness, %	0.867*	0.502*										
4.Sedimentation, ml	-0.230	0.003	-0.268									
5.Wet gluten yield in 70% flour, %	-0.294	0.081	-0.385	0.420								
6.Dough stability, min	-0.545*	-0.335	-0.500*	0.747*	0.421							
7.Softening degree of dough, min	0.257	-0.154	0.422	-0.590*	-0.169	-0.523*						
8.Quality value by farinograph, cond.un.	-0.457	-0.396	-0.400	0.556*	0.163	0.898*	-0.490					
9. W by alveograph, al.un.	-0.498*	-0.160	-0.563*	0.487	0.127	0.289	-0.553*	0.226				
10. P/L	0.369	0.509*	0.473	-0.255	0.051	-0.255	0.005	-0.160	-0.161			
11.Bread volume, ml	-0.445	-0.490	-0.326	0.435	-0.084	0.314	0.078	0.294	0.481	-0.599*		
12. Form resistance (H:D)	-0.686*	-0.508*	-0.586*	0.218	0.249	0.251	-0.161	0.063	0.655*	-0.282	0.339	
13.Quality of bread crumb (rank 0-5)	-0.211	-0.267	-0.254	0.405	0.327	0.309	-0.011	0.255	0.208	-0.211	0.337	0.053

*- *Significance at: p< 0.05%*

Table 3. Effect of fertilization at norm $N_{12}P_{12}$ on the quality of cultivar Enola against background of plowed post harvest plant residues (A_1) and not plowed plant residues (A_0) from the previous crops (2006- 2007)

Variant	Indices											
	Wet gluten yield in 70% flour, %		Sedimentation, ml		Quality value by farinograph, cond.un.		Bread volume, ml		H:D		Quality of bread crumb, rank 0-5	
Year	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
*$A_0N_0P_0$ after bean	20.2	20,4	41	47	41	47	690	675	0.44	0.43	5.0	5.0
$A_0N_{12}P_{12}$ - bean	24.7	29,8	41	55	41	59	770	700	0.44	0.47	5.0	4.8
$A_0N_0P_0$ - maize	17.2	18,3	34	39	34	43	660	570	0.47	0.41	4.6	5.0
$A_0N_{12}P_{12}$ - maize	24.6	32,4	43	58	43	57	715	700	0.42	0.43	5.0	5.0
$A_0N_0P_0$ - sunflower	14.8	10,2	35	33	35	45	647	630	0.45	0.41	4.4	4.8
$A_0N_{12}P_{12}$ - sunflower	22.9	29,8	45	51	45	53	680	750	0.48	0.43	5.0	5.0
*$A_1N_0P_0$ after bean	16.7	21,7	37	46	37	50	675	660	0.42	0.42	5.0	5.0
$A_1N_{12}P_{12}$ - bean	26.5	30,2	43	67	43	68	745	710	0.45	0.53	5.0	5.0
$A_1N_0P_0$ - maize	17.1	16,2	35	39	35	45	630	525	0.48	0.42	5.0	4.0
$A_1N_{12}P_{12}$ - maize	23.4	34,0	33	56	33	58	790	650	0.43	0.48	4.8	5.0
$A_1N_0P_0$ - sunflower	11.9	26,4	36	45	36	45	640	500	0.44	0.42	4.8	4.0
$A_1N_{12}P_{12}$ - sunflower	27.4	35,8	50	63	50	58	775	790	0.46	0.43	5.0	5.0

Key: *A_0 - not plowed plant residues; A_1 – plowed plant residues*

Table 4. Flour quality of cultivar Enola after treatment with cellulose digesters of different previous crops (2010 – 2012)

Variant	Wet gluten yield in 70% flour, %	Sedimentation, ml	Quality value by farinogrpah, cond. un.	Bread volume, ml	H:D	Quality of bread crumb, rank 0-5	Dough resistance, min
Check-after maize	14.2	43	50	610	0.42	4.9	3.27
Bactofil C- after maize	20.1	44	61	650	0.46	4.9	2.40
*NLA- after maize	19.1	46	61	653	0.46	4.9	4.33
Check-after sunflower	18.4	44	58	628	0.44	5.0	3.57
Bactofil C – after sunflower	20.8	50	63	675	0.50	5.0	4.50
NLA- after sunflower	19.4	48	65	663	0.48	5.0	3.37
Check-after bean	15.7	45	44	608	0.45	4.6	2.50
Bactofil C – after bean	16.9	47	49	623	0.41	4.7	3.13
NLA- after bean	23.4	44	51	668	0.47	50	3.43

Key: *NLA – Nutri-Life Accelerate*

As all intensive type cultivars, Enola responded positively under high level of the applied agronomy practices. The application of rational fertilization and the good choice of a previous crop can improve the quality of the cultivar. Depending on the amount, composition and mineralization of the plant residues from the previous crop, the nutrients remaining in soil, including nitrogen, are variable. The result from the post effect and the mutual influence of the fertilization, the previous crop and the post harvest residue from it (incorporated or not incorporated) on the quality characteristics of cultivar Enola showed improvement in the values of wet gluten in the variants without fertilization after plowing of the plant residue from the predecessors bean and sunflower (Table 3). The high temperatures and drought during grain filling and maturation in 2007 shortened the time of carbohydrates accumulation in grain; this had positive effect on the amount of wet gluten, the physical properties of dough and the baking characteristics. The ranking of the variants by yield of wet gluten in 70 % flour, sedimentation, farinographic quality value, volume and quality of bread depended on the applied fertilization, the year conditions and the plowing of the plant residues from the previous crop ($A_1N_{12}P_{12}$ – sunflower > $A_1N_{12}P_{12}$ - bean).

The use of micro biological products for decomposition of the post harvest residues is recently becoming increasingly topical. The use of such environment-friendly technologies contributes to higher quality of wheat. Thus, for example, our results from the use of the micro biological cellulose digesters Bactofil C and NLA (Nutri-Life Accelerate) for accelerated decomposition of the post harvest residues from maize, sunflower and bean were related to positive changes in the quality of cultivar Enola (Table 4). After treatment of the post harvest residues from sunflower and bean with Bactofil C, maximum addition to the amount of wet gluten in 70 % flour was obtained (20.8 % and 20.1 %, respectively), and after treatment of sunflower plant residues with NLA, the highest value of gluten was reached (23.4%). The effect on sedimentation was insignificant, while with regard to the physical properties of dough the reaction was related to change of the quality category of the cultivar. The treatment of the post harvest plant residues with Bactofil C and NLA had positive effect on the baking properties.

CONCLUSIONS

The realization of the genotype potential of cultivar Enola with regard to quality depended on the interaction of the cultivar with the year conditions. The manageable formation of the cultivar’s strength requires higher attention to the regularities under which this interaction occurs.

By experimenting with contemporary biological elements from the technologies of the cultivar’s growing, high expression of its quality potential was achieved.

Against the background of optimal fertilization with $N_{12}P_{12}$ and incorporation of the post harvest plant residues from sunflower and bean, a significant improvement of the values of wet gluten in 70 % flour was obtained, as well as of the parameters of the rheological and baking properties. The treatment of the post harvest residues with the cellulose digesters Bactofil C and NLA had positive effect on the quality of cultivar Enola.

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