

INVESTIGATION ON THE YIELD AND GRAIN QUALITY OF COMMON WHEAT (*Triticum aestivum* L.) CULTIVARS GROWN UNDER THE AGROECOLOGICAL CONDITIONS OF CENTRAL BULGARIA

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Abstract

The field experiment was held in Slatina, Bulgaria during the period 2012 - 2015. The test was performed by using blocking with four repetitions; experimental field area - 15 m² with sunflower predecessor. The varieties common wheat Enola, Kristal, Pirineo, Bononia and Kapo, were studied. The growing of plants was performed in compliance with the standard technology. The aim of the present research was to carry out a comparison study of the yield and quality of some common wheat cultivars grown in Central Bulgaria. The analysis of the results showed that the highest grain yield was obtained from Pirineo variety - 7700 kg/ha, followed by Enola - 7567 kg/ha and the lowest one - from Kapo variety 6550 kg/ha. Among the studied common wheat cultivars, the highest values of thousand kernel weight and the wet gluten content was reported for Pirineo (51.7 g and 33.3%, respectively) and the highest values of test weight were reported for Bononia (84.7 kg).

The lowest value of the thousand kernel weight was recorded for Kapo variety (43.0 g); the lowest value of the test weight and the wet gluten content was reported for Kristal variety (78.7 kg and 26.1%, respectively).

Key words: wheat, grain yield, thousand kernel (grain) weight, test weight, gluten.

INTRODUCTION

Common wheat (*Triticum aestivum* L.) is one of the most widely grown and most consumed food crops all over the world. It is also a major field crop in Bulgaria, grown using 11,182,401 decare of the area and producing 5,662,721 tons and 474.8 kg per decare⁻¹ grain yield in 2016. Compared with other cereals, it provides food humans with more calories and proteins in their daily diet, a considerable amount of trade throughout the world, and a lot of other products.

The development of high grain yields potential for good quality and resistance to biotic and abiotic stress factors. In addition, it responds to improved agricultural practices which are the main achievements for bread wheat breeding programmes (Delibaltova, 2016; Delibaltova, Kirchev, 2016).

In the last few decades, efforts taken by wheat breeders have resulted in successful development of bread wheat varieties possessing higher grain yielding potential, improved resistance to pest and diseases and better quality parameters.

The gluten content of wheat is a critical factor in bread making and high gluten content of wheat is associated with good bread making characteristics. It is genetically controlled but it may vary widely on the variety, location, climatic conditions, soil fertility and the complex interactions between these factors. In general, high gluten flours generate better results since they have a high loaf volume potential with higher water absorption. Genotype-by-environment interactions and the negative correlation between grain yield and grain gluten content of wheat had been established in different studies (Williams et al., 2008).

If a genotype has a high stability and shows low interactions with the environment are the desirable conditions in plant breeding.

Studies of a number of authors show that the amount of grain yield is closely related to the cultivar, the use of farming machinery and the soil and climate of the region (Dallev, Ivanov, 2015; Dimitrov et al., 2016; Ivanova et al., 2010). Therefore, in order to use the full productive potential of the cultivar, the proper choice of suitable cultivars for each

agroecological region is a decisive factor for obtaining high yields. That necessitates systemic studies of the cultivars in the different regions of the country (Ilieva, 2011; Yanchev, Ivanov, 2012).

The aim of the study was to establish the grain yield and quality of some common wheat cultivars grown in Central Bulgaria.

MATERIALS AND METHODS

A field experiment with common wheat was carried out on an experimental field in Slatina, Bulgaria during the period 2012 - 2015. The test was performed by means of a block method with four replications; the experimental field area was 15 m², with sunflower predecessor. The following varieties were tested: Enola, Kristal, Pirineo, Bononia and Kapo. All the stages of the established technology for wheat growing were followed.

Soil tillage included single disking (10-12 cm) after harvesting of the previous crop, and double disking after the main fertilization. The area was treated with N120P80 and the whole quantity of the phosphorous fertilizer and 1/3 of the nitrogenous fertilizer were applied before main soil tillage.

The remaining amount from the nitrogen norm was applied before the beginning of permanent spring vegetation. Triple superphosphate and ammonia nitrate were used. Sowing was completed within the agrotechnical term optimal for this region at sowing norm 550 germinating seeds/m².

Control of weeds, diseases and pests was done with suitable pesticides when necessary. Harvesting was done at full maturity. The grain yield is determined with standard grain moisture of 13%.

The indices grain yield (kg ha⁻¹); thousand kernel weight (g), test weight (kg), wet gluten content (%) were determined.

For the purpose of determining the quantity dependence between the studied indicators, the experimental data was processed according to the Anova Method of dispersion analysis, and the differences between the variants were determined by means of the Duncan's Multiple Range Test (Duncan, 1995).

The period of the research (2012-2015) is characterized with variety of temperatures and rainfall conditions which enables to evaluate the reaction of the studied varieties in accordance with their yields and quality characteristics under different climate conditions.

Rainfalls in autumn and during the critical spring period are decisive for the development of the wheat plants. The mean annual precipitation sums during October - March, which formed the autumn-and-winter moisture reserves in soil during the experimental years 2012-2013, 2013-2014 and 2014-2015 were higher with 77.7, 64.2 and 119.5 mm, respectively, than the mean sums of the long - term period. During April-May when plants were at stages booting and heading, the mean annual precipitation sum in 2013 and 2014 was higher, while in 2015 this sum was lower than the mean long - term value.

In June and July (during grain filling-maturation) rainfalls in harvest years 2013, 2014 and 2015 were higher with 61.6, 45.6 and 47.2 mm, respectively, than the mean sums of the long - term period.

The most favourable for plant growth and development was the first experimental year (2012-2013), followed by the second (2013-2014), while the third year (2014-2015) of the experiment was unfavourable, having an effect on yield and grain quality of common wheat.

RESULTS AND DISCUSSIONS

The results obtained were presented in Table 1 and they show that for both, by years and in average, for the experimental period variety Pirineo surpassed in grain yield all the other varieties included in the study.

The highest grain yields were obtained in the favourable for wheat year 2013 when the temperature values and the precipitation sum fully met the plant requirements for warmth and moisture throughout the whole vegetation period. The yields obtained reached up to 8500 kg/ha in variety Pirineo. Referring to grain yield that variety surpassed the varieties Enola, Bononia, Kristal and Kapo by 1.2%, 3.7%, 7.6% and 21.4%, respectively, the differences being statistically significant.

Table 1. Grain yield, kg/ha

Variety	Years of study			Average for the period kg/ha
	2012-2013 kg/ha	2013-2014 kg/ha	2014-2015 kg/ha	
Enola	8400 ^d	7300 ^c	7000 ^c	7567
Kristal	7900 ^b	6800 ^b	6700 ^b	7133
Pirineo	8500 ^c	7500 ^c	7100 ^d	7700
Bononia	8200 ^c	7400 ^d	7000 ^c	7533
Kapo	7000 ^a	6450 ^a	6200 ^a	6550
Mean values for Years	8000 ^c	7090 ^b	6800 ^a	

*Means within columns followed by different lowercase letters are significantly different ($P < 0.05$) according to the LSD test.

In the second experimental year (2014) the grain yields obtained varied between 6450 kg/ha and 7500 kg/ha, i.e. they were by 11.4% lower in average in comparison to 2013. Mathematical processing of data showed that varieties Bononia, Enola and Kristal significantly fell behind Pirineo by 100, 200 and 700 kg/ha, respectively. The lowest yields were realized by variety Kapo - 6450 kg/ha.

In the third experimental year of the study the meteorological conditions during the variety vegetation were unfavourable and the plants were not able to attain their biological potential.

The grain yields obtained were within the limits of 6200 to 7100 kg/ha. Statistically proven, the lowest ones were those of variety Kapo and the highest - Pirineo.

During the period of study (2012-2015) Pirineo variety realized the yield of 7700 kg/ha in average and it surpassed the varieties Enola, Bononia, Kristal and Kapo by 1.7%, 2.2%, 7.9% and 17.6%, respectively.

The results from the multifactor analysis of variances showed the independent effect of the investigated factors, as well as their interaction (Table 2). Years with their climate conditions had highest statistic influence on the seeds yield - η 98, followed by variety - η 88.

Table 2. Analysis of variance for grain yield for the period 2012-2015

Source of Variation	Sum of Square	DF	Mean Square	Sig of F	η^2
Variety	10087099.90	4	2521775	.000	88
Years	15596239.90	2	7798119.89	.000	98
2- Way Interactions	999200.60	8	124900.07	.000	74
Residual	242331.25	45	5385.14		

Interaction - Years x Variety - η 74 was also significant for grain yield.

The results of the quality characteristics of the studied varieties are presented in Table 3. The thousand kernel weight is a cultivar specific trait influenced by the agroecological conditions and the growing technology.

The results show that thanks to the favourable climatic conditions during the wheat vegetation period in the third year, the values of that characteristic was significantly higher compared to the other experimental years.

In 2012-2013 Pirineo variety produced the largest grains (53.0 g of 1000 grains), followed by Enola and Kristal (48.0 g), while Kapo had

the smallest grains (45.0 g). The differences between the varieties were statistically significant. The thousand kernel weight of Enola and Kristal variety had similar values and the difference was statistically insignificant.

Drought weather combined with high air temperatures at the stage of grain formation and ripening in 2014-2015 had an effect on grain weight. The lowest weight of thousand kernel (grain) was reported for Kapo variety (42.0 g). The varieties Pirineo and Bononia surpassed in weight of thousand kernel (grain) the varieties Kristal and Enola by 20.9% and 4.6%, respectively, the differences being significant.

The largest grains in average for the period 2012-2015 were reported for Pirineo variety (51.7 g), followed by the varieties Bononia

(46.0 g), Kristal and Enola (45.3 and 45.0 g). The lowest values of that characteristic were established for Kapo variety.

Table 3. The results of the quality characteristics of the studied varieties

Index	Variety	Years of study			Average for the period (2012-2015)
		2012-2013	2013-2014	2014-2015	
Thousand kernel (grain) weight, g	Enola	48.0 ^c	44.0 ^b	43.0 ^b	45.0
	Kristal	48.0 ^c	45.0 ^b	43.0 ^b	45.3
	Pirineo	53.0 ^d	50.0 ^d	52.0 ^d	51.7
	Bononia	47.0 ^b	46.0 ^c	45.0 ^c	46.0
	Kapo	45.0 ^a	43.0 ^a	41.0 ^a	43.0
	Mean values for Years	48.2 ^c	45.6 ^b	43.8 ^a	
Test weight, kg	Enola	80.0 ^c	81.0 ^b	82.0 ^b	81.0
	Kristal	78.0 ^a	78.0 ^a	80.0 ^a	78.7
	Pirineo	81.4 ^c	82.5 ^c	83.0 ^b	82.3
	Bononia	85.0 ^d	84.0 ^d	85.0 ^c	84.7
	Kapo	79.0 ^b	82.0 ^c	82.1 ^b	81.0
	Mean values for Years	80.7 ^a	81.5 ^a	83.4 ^b	
Wet gluten, %	Enola	26.0 ^b	28.5 ^b	28.4 ^b	27.6
	Kristal	25.0 ^a	26.0 ^a	27.0 ^a	26.1
	Pirineo	34.0 ^c	33.0 ^d	34.0 ^c	33.3
	Bononia	33.0 ^d	32.0 ^c	30.0 ^c	32.0
	Kapo	32.0 ^c	33.5 ^d	31.4 ^d	32.3
	Mean values for Years	30.0 ^a	30.6 ^a	30.2 ^a	

* Means within columns followed by different lowercase letters are significantly different (P<0.05) according to the LSD test

Test weight is a commercial indicator showing grain quality and it plays an important role in determining the market price. That characteristic of the studied varieties in the years of the experiment varied between 78.0 and 85.0 kg.

The highest test weight of wheat grain, in average for the period of the study, was reported for Bononia variety (84.7 kg.), followed by Pirineo, Kapo and Enola (82.3 kg, and 81.0 kg, respectively), while the lowest values were reported for the variety Kristal (78.7 kg).

In the experimental years the wet gluten content of the studied varieties obtained varied from 25.0% to 34.0%. It showed that the grain of these varieties is considered to be good for flour producing.

The highest wet gluten content, in average for the whole study period 2012-2015, was established in Pirineo variety (33.3%) and the lowest - in Kristal (26.1%).

CONCLUSIONS

Under the conditions of Central Bulgaria the highest yield, in average for the experimental period 2012-2015, was obtained from Pirineo variety - 7700 kg/ha, followed by Enola - 7567 kg/ha and the lowest one - from Kapo variety 6550 kg/ha. Pirineo variety produced by 133, 167, 567 and 1150 kg/ha higher grain yield than the variety Enola, Bononia, Kristal and Kapo, respectively.

Among the studied common wheat variety, the highest values of thousand kernel weight and the wet gluten content were reported for Pirineo (51.7 g and 33.3% respectively) and the highest values of test weight were reported for Bononia (84.7 kg)

The lowest value of the thousand kernel (grain) weight - for Kapo variety (43.0 g); of the test weight and of the wet gluten content was reported for Kristal variety (78.7 kg and 26.1%, respectively).

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