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COMPARATIVE STUDY OF DIFFERENT COMMON WHEAT (*T. aestivum* L.) CULTIVARS UNDER THE AGROECOLOGICAL CONDITIONS OF SOUTH-CENTRAL BULGARIA

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Abstract

During the period of 2015-2018 in South-Central Bulgaria a field experiment was researched. The cultivars common wheat 'Ekzotik', 'Miryana', 'Avenue', 'Anapurna' and 'Neven', were studied. The experiment was applied in block design with 4 replications and 15 m^2 plot size, after pre crop sunflower. The growing of plants was performed in compliance with the standard technology. The aim of the present investigation was to carry out a comparative study of the yield and quality of some common wheat cultivars grown in South-Central Region of Bulgaria. The analysis of the results showed that the highest grain yield was obtained from 'Avenue' variety - 7400 kg/ha, followed by 'Anapurna' - 7100 kg/ha and the lowest one - from 'Neven' variety 4067 kg/ha. Among the studied common wheat cultivars, the highest values of thousand kernel (grain) weight and the test weight were reported for 'Miryana' (50.3 g and 81.0 kg, respectively) and the highest wet gluten content was established in 'Anapurna' cultivar (27.0%). The lowest value of the test weight was reported for 'Neven' cultivar (73.3 kg); of the thousand kernel (grain) weight - for 'Anapurna' cultivar (34.3 g) and of the wet gluten content - for 'Avenue' cultivar (22.0%).

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

INTRODUCTION

One of the major ways of increasing the yield and improving the wheat grain quality under the current market conditions is the establishment of new highly productive cultivars and their introduction into practice.

Establishing the proper cultivar structure depending on the concrete agroecological conditions of the region can significantly increase grain yield and quality. That requires a very good understanding of the characteristics of the different cultivars, in order to be able to make the right choice (Dallev and Ivanov, 2015; Dimitrov et al., 2016; Ilieva, 2011; Ivanova et al., 2010; Kirchev and Delibaltova, 2016; Williams et al., 2008).

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 climatic conditions of the region (Mut et al., 2017; Stoeva et al., 2006; Studnicki et al., 2018).

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 (Aktas et al., 2017; Kaya and Akcura, 2014; Yanchev & Ivanov, 2016).

The aim of the present investigation was to carry out a comparative study of the yield and quality of some common wheat cultivars grown in South Central Region of Bulgaria.

MATERIALS AND METHODS

A field experiment with common wheat was carried out on the experimental field of the village of Carimir (South Central Bulgaria) in the period 2015-2018. The test was performed by means of a block method with four replications; experimental field area - 15 m^2, after the predecessor sunflower. The following cultivars were tested; 'Ekzotik', 'Miryana', 'Avenue', 'Anapurna' and 'Neven'. 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 by $N_{120}P_{80}$ 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 super phosphate and ammonia nitrate were used. Sowing was completed within the agrotechnical term optimal for this region at sowing norm 550 germinating seeds/m^2. 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 (grain) weight (g), test weight (kg); wet gluten content (%) and were determined.

For the purpose of determining the quantity dependence between the studied indicators, the experimental data was processed by the method of dispersion and correlation analyses.

The period of the research (2015-2018) is characterized with variety of temperature and rainfall conditions which enables to evaluate the reaction of the studied varieties in accordance with their yields and quality characteristics under different climatic conditions (Figure 1).

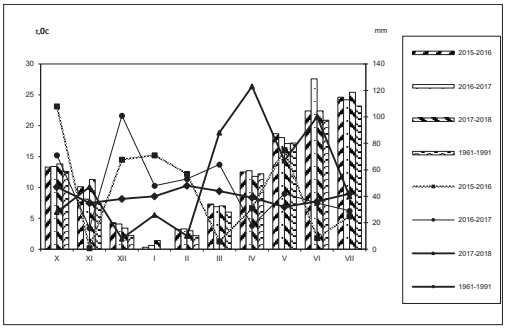

Figure 1. Temperature and rainfall distribution during the period 2015-2018

The results show that the air temperatures were close to or slightly higher than those established for a multiple-year period, with no significant deviations from the crop requirements.

The differences between the three years of the study were established in the amount of rainfall during vegetation. 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 2015-2016, 2016-2017 and 2017-2018 were higher with 61, 101 and 7 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 2016 and 2017 was lower than the mean long - term value, while in 2018 this sum was higher with 119 mm. In June and July (during grain filling-maturation) rainfalls in harvest year 2018 was higher with 62 mm, in comparison to the long - term period, while in 2016 and 2017 they were with 44.3 and 14.0 mm, respectively lower.

The most favourable for plant growth and development was the third experimental year (2017-2018), followed by the second (2016-2017), and unfavourable was the first year (2015-2016), of the experiment, having an effect on yield and grain quality of common wheat.

RESULTS AND DISCUSSIONS

Data about the grain yield (Table 1) show that 'Avenue' cultivar surpassed the other cultivars included in the experiment, when reporting the harvest by years and in average for the period of study.

In result of the better moisture provision of plants during the vegetation period and in the period of grain formation and ripening, higher yields were obtained in 2017-2018 compared to 2015-2016 and 2016-2017.

Under the conditions of that season they varied from 5000 kg/ha for 'Neven' cultivar to 8400 kg/ha for 'Avenue'. The cultivars 'Miryana', 'Ekzotik' and 'Anapurna' yielded by 2900, 2300 and 200 kg/ha less than 'Avenue' and by 500, 1100 and 3200 kg/ha more than 'Neven', respectively. All the differences were statistically significant.

The lowest grain yields during the studied period were reported in the first year of the experiment (2015-2016) and it was due to the insufficiency of moisture during the critical stages of growth and development of the wheat plants. In that season the lowest yield was obtained from 'Neven' cultivar - 3000 kg/ha, which was by 16.7% less compared to 'Miryana', by 83.3% less compared to 'Ekzotik', by 190% less compared to 'Anapurna' and by 200% less compared to "Avenue' cultivar.

Table 1. Grain yield - kg/ha

Cultivar	Years of study			Average for the period (kg/ha)
	2015-2016 (kg/ha)	2016-2017 (kg/ha)	2017-2018 (kg/ha)	
Ekzotik	5600 c	6500 c	6200 c	6100
Miryana	3600 b	4600 b	5600 b	4600
Avenue	6100 c	7600 c	8500 c	7400
Anapurna	5800 d	7200 d	8300 d	7100
Neven	3100 a	4100 a	5000 a	4067

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

In 2016-2017 the yields obtained ranged from 4000 kg/ha to 7500 kg/ha. The differences between the studied cultivars were statistically significant. The grain yield during the second experimental year was by 24.5% higher in average than in 2015-2016 and by 12.5% lower than in 2017-2018.

The highest grain yield, in average for the three years of the study, was reported for 'Avenue' cultivar - 7300 kg/ha, surpassing the cultivars 'Anapurna', 'Ekzotik', 'Miryana' and 'Neven' by 4.2; 16.7; 55.6 and 75.0%, respectively.

The results of the dispersion analysis about the effect of the factors Cultivar and Year, as well as their interaction, on the indicator grain yield, (Table 2) show a statistically significant effect of the studied factors.

Table 2. Analysis of variance ANOVA

Source of Variation	Sum of Square	df	Mean Square	F	P-value	F crit
Year**	32980870	2	16490435	386.7212	0.00	3.204317
Cultivar**	111922206	4	27980552	656.1787	0.00	2.578739
Interaction**	5429813.3	8	678726.7	15.91698	0.00	2.152133
Within	1918875	45	42641.67			

*F - test significant at P < 0.05; **F - test significant at P < 0.01; ns - non significant.

Interactions between the studied factors were also significant for the grain yield.

The thousand kernel (grain) weight is a cultivar specific trait influenced by the agroecological conditions and the growing technology.

The results show that thanks (Table 3) to the favourable climatic conditions during the wheat vegetation period in the third year, the values of that characteristic were significantly higher compared to the other experimental years.

Table 3. Thousand kernel (grain) weight, g

Variety	Years of study			Average for the period (2015-2018)
	2015-2016	2016-2017	2017-2018	
Ekzotik	46.0 d	49.0 c	48.0 c	47.6
Miryana	48.0 c	51.0 c	52.0 d	50.3
Avenue	36.0 b	39.0 b	43.0 b	39.3
Anapurna	31.0 a	33.0 a	39.0 a	34.3
Neven	41.0 c	43.0 b	44.0 b	42.7

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

In 2017-2018 'Miryana' cultivar produced the largest grains (52.0 g of 1000 grains), followed by 'Ekzotik' (48.0 g), while 'Anapurna' had the smallest grains (39.0 g). The differences between the cultivars were statistically significant. The thousand kernel (grain) weight of 'Avenue' and 'Neven' cultivars had similar values (43.0 and 44.0 g, respectively) and the difference was statistically insignificant.

Drought weather combined with high air temperatures at the stage of grain formation and ripening in 2015-2016 had an effect on grain weight.

The lowest weight of thousand kernel (grain) was reported for 'Anapurna' cultivar (31.0 g). The cultivars 'Miryana' and 'Ekzotik' surpassed in weight of thousand kernel (grain) the cultivars 'Avenue' and 'Neven' by 30.5% and 17.75%, respectively, the differences being significant.

The largest grains in average for the period 2015-2018 were reported for 'Miryana' cultivar (50.3 g), followed by the cultivars 'Ekzotik' (46.3 g), 'Neven' (41.7 g) and 'Avenue' (39.3 g). The lowest values of that characteristic were established for 'Anapurna' cultivar.

The data of the dispersion analysis about the influence of the factors and their interaction on the thousand kernel (grain), are presented in Table 4. The results show clear statistically significant variations and the interaction between the two factors was statistically insignificant.

Table 4. Analysis of variance ANOVA

Source of Variation	Sum of Square	Df	Mean Square	F	P-value	F crit
Year**	166.2333	2	83.11667	11.24887	0.00	3.204317
Cultivar**	2375.233	4	593.8083	80.36504	0.00	2.578739
Interaction^{ns}	43.76667	8	5.470833	0.740414	0.66	2.152133
Within	332.5	45	7.388889			

*F - test significant at P < 0.05; **F - test significant at P < 0.01; ns - non significant.

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 cultivars in the years of the experiment varied from 69.0 to 82.0 kg (Table 5).

Table 5. Test weight, kg

Variety	Years of study			Average for the period (2015-2018)
	2015-2016	2016-2017	2017-2018	
Ekzotik	77.0 ^{b}	79.0 ^{b}	80.0 ^{b}	78.7
Miryana	80.0 ^{c}	81.0 ^{c}	82.0 ^{c}	81.0
Avenue	78.0 ^{b}	79.0 ^{b}	80.0 ^{b}	79.0
Anapurna	72.0 ^{a}	74.0 ^{a}	79.0 ^{b}	75.0
Neven	69.0 ^{a}	73.0 ^{a}	78.0 ^{a}	73.3

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

The test weight of the cultivars 'Ekzotik', 'Avenue' and 'Miryana' had similar values in all the three years of the study, which is an evidence that for those cultivars, the characteristic is slightly influenced by the climatic conditions in the separate years and it depends more on the cultivar

In contrast to 'Ekzotik', 'Avenue' and 'Miryana', the test weight of the cultivars 'Anapurna' and 'Neven' is significantly influenced by the climatic conditions and less by the cultivar.

The highest test weight of wheat grain, in average for the period of the study, was reported for 'Miryana' cultivar (81.0 kg.), followed by 'Avenue' and 'Ekzotik' (79.0 and 78.7 kg, respectively), and the lowest values were reported for the cultivars 'Anapurna' and 'Neven' (75.0 and 73.3 kg, respectively).

The results of the dispersion analysis about the effect of the factors Cultivar and Year, as well as their interaction, on the indicator test weight, (Table 6) show a statistically significant effect of the studied factors.

Table 6. Analysis of variance ANOVA

Source of Variation	Sum of Square	df	Mean Square	F	P-value	F crit
Year**	185.4333	2	92.71667	49.81791	0.00	3.204317
Cultivar**	436.2667	4	109.0667	58.60299	0.00	2.578739
Interaction**	68.73333	8	8.591667	4.616418	0.00	2.152133
Within	83.75	45	1.861111			

*F - test significant at P < 0.05; ** F - test significant at P < 0.01; ns - non significant.

The data obtained about the wet gluten content showed that in the studied cultivars, this characteristic was greatly influenced by the production year (Table 7).

In the first year of the experiment the lowest values of that characteristic were reported for the cultivars 'Neven' (22.0%) and 'Miryana' (23.0%), while the highest values of that characteristic for the same two cultivars were established in the third experimental year (30.0 and 28.0%, respectively).

Table 7. Wet gluten, %

Variety	Years of study			Average for the period (2015-2018)
	2015-2016	2016-2017	2017-2018	
Ekzotik	22.0 ^{a}	29.0 ^{b}	26.0 ^{b}	25.6
Miryana	23.0 ^{a}	25.0 ^{a}	28.0 ^{c}	25.3
Avenue	21.0 ^{a}	25.0 ^{a}	20.0 ^{a}	22.0
Anapurna	26.0 ^{b}	30.0 ^{b}	25.0 ^{b}	27.0
Neven	22.0 ^{a}	26.0 ^{a}	30.0 ^{c}	26.0

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

In 2018 a comparatively low wet gluten content was reported for 'Avenue' cultivar (14.0%), i.e. the significant amount of rainfall at the ripening stage led to washing out of the wet gluten, while in 'Neven' cultivar, rains caused an increase of the values of that characteristic (30.0%).
In the second experimental year (2016-2017), the wet gluten content in the cultivars 'Miryana', 'Neven' and 'Avenue' varied from 25.0 to 27.0%, the differences being slight and statistically insignificant, while the cultivars 'Ekzotik' and 'Anapurna' produced grains with 11.5% higher wet gluten content.
The highest wet gluten content, in average for the whole study period 2015-2018, was established in 'Anapurna' cultivar (27.0%) and the lowest - in 'Avenue' cultivar (22.0%).
The dispersion analysis about the effect of the factors Variant and Year, as well as their interaction, on the wet gluten content, shows a significant influence of the factors on the changes of the characteristic and statistically insignificant effect of the interaction between them (Table 8).

Table 8. Analysis of variance ANOVA

Source of Variation	Sum of Square	df	Mean Square	F	P-value	F crit
Year*	217.2	2	108.6	20.92934	0.00	3.204317
Cultivar*	213.1667	4	53.29167	10.27034	0.00	2.578739
Interaction*	299.1333	8	37.39167	7.206103	0.00	2.152133
Within	233.5	45	5.188889			

*F - test significant at $P < 0.05$; **F - test significant at $P < 0.01$; ns - non significant

Table 9. Values of the coefficient of correlation

	Grain yield - kg/ha	Thousand kernel (grain) weight, g	Test weight, kg	Wet gluten, %
Grain yield - kg/ha	1.000			
Thousand kernel (grain) weight, g	-0.314	1.000		
Test weight, kg	0.360	0.614	1.000	
Wet gluten, %	0.029	0.051	0.029	1.000

As a result of the correlation analysis between the grain yield and quality indicators (Table 9), a high positive values of correlation ($r > 0.6$) were reported for thousand kernel (grain) weight and test weight.
Mean correlation was found between grain yield and test weight ($r = 0.360$). Weak correlation ($r < 0.3$) was observed between the wet gluten and all the other indicators. A negative correlation was reported for grain yield and thousand kernel (grain) weight ($r = -0.314$).

CONCLUSIONS

The highest grain yield, in average for the experimental period 2015-2018, under the climatic conditions of South Central Bulgaria, was obtained from 'Avenue' cultivar (7300 kg/ha), followed by 'Anapurna' (7000 kg/ha), and, the lowest one - from 'Neven' cultivar (4000 kg/ha).
'Avenue' cultivar produced by 300; 1300; 2800 and 3300 kg/ha higher grain yield than the cultivars 'Anapurna', 'Ekzotik', 'Miryana' and 'Neven', respectively.
Among the studied common wheat cultivars, the highest values of the thousand kernel (grain) weight and the test weight were reported for 'Miryana' (50.3 g and 81.0 kg, respectively) and the highest wet gluten content was established in 'Anapurna' cultivar (27.0%). The lowest value of the test weight was reported for 'Neven' cultivar (73.3 kg); of the thousand kernel (grain) weight - for 'Anapurna' cultivar (34.3 g) and of the wet gluten content – for 'Avenue' cultivar (22.0%).

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