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YIELD AND YIELD COMPONENTS ON SOME WHEAT VARIETIES GROWN IN ALEKSINAC REGION

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Abstract
Yield and yield components of 5 wheat varieties (Kruna, Toplica, Zvezdana, Etida, Angelina) in Aleksinac region (Serbia) were analysed. The experiment was performed in randomized block design in 3 replications on the experimental field in area of Aleksinac city. The results showed relatively high yields in all varieties. The general average yield was 6140 kg ha^{-1}. The highest average yield varied from 6858 kg ha^{-1} in cultivar Zvezdana to 5050 kg ha^{-1} in Toplica. The cultivar Kruna showed lowest number of productive stems per square meter – 572, and largest number in Zvezdana and Angelina, with an average of 658 and 641, respectively. Average longest spike was found in variety Angelina 12.4 cm, and shortest in Toplica (9.8 cm). The average number of spikelets per spike for all cultivars was 19.4. Cultivar Angelina showed biggest number (21.1), and Kruna smallest number (17.9). The biggest number of grains per spike was obtained in cultivar Etida(54.8), and lowest in Zvezdana (51.4). During the examination, the highest average value for hectoliter weight is obtained in variety Zvezdana (78.3 kg hl^{-1}), and lowest in Toplica (75.4 kg hl^{-1}). From the data on yield and yield components, it can be concluded that all tested varieties can be grown in the region of Aleksinac, with preference to varieties Zvezdana and Etida.
Key words: wheat, yield, yield components.

Introduction

Wheat is grown on about 600000 ha in Serbia (http://webrzs.stat.gov.rs/WebSite/repository/documents/). About 52 % of this area is on the territory of Vojvodina, and 48 % in the other regions of Serbia. Average yield at the State level is around 3.4 t ha^{-1} (Malesevic et al., 2011). In terms of assortment, most national varieties are developedin the Institute of Field and Vegetable Crops in Novi Sad and Institute for cereals in Kragujevac, and the rest are imported varieties.However, although there are many varieties, in Serbia is noticeable appearance of greater variation of the area under wheat, tending to their slight decline last years (http://webrzs.stat.gov.rs/WebSite/repository/documents/). Introduction of new varieties in production for all different microclimatic areas is one of the measures that can achieve a stop to this trend, because, achieving the genetic potential for yield and quality largely depends on environment conditions in micro areas (Hristov et al., 2010). Proper classification of level of microclimate conditions may be the key factor, which will used maximum genetic potential of variety in a separate area, and will get stable yields and good quality.

Based on these findings, the aim of this study was to investigate the potential of some new national wheat varieties in the region of Aleksinac. The goal was to investigate the possibilities for breeding through field trials and to obtain data on yield and quality. The research is aimed at studying the productive components for each genotype individually, as well as the mutual comparison of the genotypes tested in order to make recommendations for growing varieties in similar microclimate conditions.

Material and methods

Field trials were conducted during two years (2009/10 and 2010/11), on the fields of JSC "Selekcija" in Aleksinac - Serbia. Five national soft wheat varieties such: Kruna and Toplica developed in the Institute of cereals in Kragujevac, and Zvezdana, Etida and

Angelina from the Institute of Field and Vegetable Crops in Novi Sad were used as plant material.

Experiments were setup in a randomized block system, in three replications of 5 m^2, and the planting is carried out with 550 seeds per m^2. The basic soil preparation was made with the autumn plowing at a depth of 25 cm.Complex fertilizer of 300 kg ha^{-1} of $15N_2$-$15P_2O_5$-$15K_2O$ was applied before seeding and 150 kg ha^{-1} of KAN (27 % N_2) was used as top-dressing fertilizer in both years. Inspring at the end of the tillering stage, plants were treated against weeds with herbicide Monosan Herba, at a doseof 2 l ha^{-1}. The plant-based measurement of the number of productive stems per m^2, were made during the vegetation season. During the research, also were measured: length of spike, number of spikelets per spike, number of grains per spike, grain yield per hectare and hectoliter weight of grain. The results of the test were statistically processed by ANOVA method of analysis of variance and compared with LSD test.

Results and discussion

Climatic and soil conditions

It is extremely important to know the climatic conditions in a certain area as a essential factor for successful production of certain wheat varieties in a region (Vasilevski *et al*., 1992). Each region is characterized by specific conditions, which directly affect the yield and quality of wheat (Hristov et al., 2011; Yanchev et al., 2014).

Moderate continental climate dominates in the area of Aleksinac. The springs are usually cold and humid, summers are hot and dry, and winters are often cold, with insufficient quantities of snow.

According to the data on average monthly air temperatures in the investigated years (Table 1), it may be noted that the warmest months are July and August, with average temperatures of 21.1 or 21.2 °C. The lowest average monthly temperatures are registered in January and February, with amount of 0.7 - 0.9 for the first, as well 1.1 °C for the second year. The average annual temperature in the first testing year was 10.6 °C and 11.7 °C in the second year. Annual fluctuations in the average monthly temperatures, suggest existence of temperate continental climate in the region.

Table 1. Average monthly and annual air temperatures (°C)

	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	Av.
2009/10	21	16.8	11.2	6.9	1.5	0.7	0.9	4.7	10.4	14.8	18	20.8	10.6
2010/11	21.4	18	12.6	7.5	2.1	1.1	1.1	6.1	12	16	20.4	21.5	11.7
Average	21.2	17.4	11.9	7.2	1.8	0.9	1	5.4	11.2	15.4	19.2	21.1	11.1

Table 2. Monthly and annual amount of precipitation (mm)

	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	Sum
2009/10	48	45	51	60	43	18	27	28	38	27	30	53	468
2010/11	36	39	57	54	58	41	52	49	56	61	55	47	605

Table 2 shows the values of precipitation per month as well annual amount of rainfall. According to the results of the first year, highest amount of precipitation was recorded in November (60 mm), and the lowest in February and May (27 mm). In the second year, the largest amount of rainfall was registered in May (61 mm), and lowest in August (36 mm). The total rainfall amount in the second year is 605 mm which is higher than the precipitation amount in the first year (468 mm) for 137 mm. Also, it is noticeable that, during the spring months (III, IV, V, and VI) in the second year, there is more precipitation in contrast to the first. Generally, 2010/11 has higher amounts of precipitation, the schedule is good in both years of the research, and there is a sufficient amount of rainfalls in both years.

Table 3. Mechanical compositionofthesoil (%)

Horizon	Depth (cm)	Skeleton (<2)	Sand (0,2 – 0,02)	Dust (0,02 – 0,002)	Cley (> 0,002)
I	0 – 30	9.5	31.6	35	23.9

Although wheat can be grown on different soil types, she has positive reaction of rich soil with good physical properties and pH of 6.8 to 7.2. The best soil types for wheat are humus, alluvial and diluvia deposits (Filipovski, 1993). The soil where were placed experimental plots, were alluvial sediments, with first-class creditworthiness. The layout of the mechanical structure to a depth of 30 cm is equal, but below this depth, sharply growing share of the soil skeleton (Table 3).

Grain yield

Wheat yield is quite variable and depends of the capacity of the yield elements (Yanchev et al., 2013). According to the analysis of Jestorovic (1998), 97.9% of the total impact on the yield belongs to external factors, while only 2.1% of the genotype. Confirmation of strong dependence of this property from external influences, also attached Jevtic (1992), which concluded that, the lack of sufficient water in the period after the fertilization of grains, results in reduced yield, absolute and hectoliter mass of grain. Tsenov et al., (2001) concluded that the yield and quality of wheat depends on both the variety and the agro-technique, which should be correlated with climatic conditions. Hristov et al,. (2012) examined 8 NS wheat varieties in different agro-ecological conditions of Vojvodina, in the period from 2005 to 2011. They found that varieties Zvezdana and Etida are characterized by high genetic potential for yield than standard variety Pobeda, but yield of these varieties is strongly influenced by external conditions. On the other hand, the variety Angelina showed slightly lower yield, but higher yield stability.

Table 4. Grain yield ($kgha^{-1}$)

Cultivar	Year		Average of cultivar
	2009/10	2010/11	
Kruna	5610	6100	5855
Toplica	4860	5240	5050
Zvezdana	6810	6907	6858
Etida	6650	6740	6695
Angelina	6187	6306	6246
Average of year	6023	6258	6140

Cultivar	Year	Interaction cultivar x year
$LSD_{0,05}$ = 206	$LSD_{0,05}$ = 130	$LSD_{0,05}$ = 291
$LSD_{0,01}$ = 282	$LSD_{0,01}$ = 178	$LSD_{0,01}$ = 399

All varieties exhibited relatively high yields per hectare, regardless of the year (Table 4). The general average yield was 6140 kg and the average highest yield for both years had variety Zvezdana (6858 kg) and lowest Toplica (5050 kg). Variety Toplica had the lowest yield in both years, in the first year it was 4860 kg, and in the second 5240 kg. On the other hand, the variety Zvezdana showed the highest values in both years, which in 2010 stood at 6810 kg and in 2011, 6907 kg. Higher amount of rain in the second year has noticeably greater impact on some varieties. Thus, varieties Zvezdana, Etida and Angelina, exhibit no statistically significant differences. Regarding this, it can be concluded that these varieties are easily adaptable and have greater tolerance to periods of less rainfall, unlike varieties Kruna and Toplica. The data shows strong and significant impact of the rainier year on high statistical significant level at 99 %.

Analyzing the differences between varieties, which includes the impact of the year, the variety Zvezdana showed statistically significant differences in yield on level of 99 % compared to Angelina, Toplica and Kruna, while there are not significantly differences from the variety Etida. Second positioned variety in terms of yield, the variety Etida, also shows statistically significant difference in the yield level of 99 % significance compared to

Angelina, Toplica and Kruna. The yield of Angelina showed differences at the level of 99 % significance compared to the yield of Toplica, at level of 95 % compared to Kruna. Kruna proved reliable statistical significant difference at the level of 99 %, compared with Toplica.

Number of productive stems

The number of productive stems is one of the indicators of yield, because it is the number of all stems with formed spike (Bokan and Malesevic, 2004). In determination of the optimal crop density, it is necessary to know the potential of the variety for tillering and accordingly to plant optimal agrotechnics (Nedic, 1989). For high potential of wheat varieties,t he number of productive stems should be between 600 and 700 per m^2, which is accomplished by sowing 500-550 seeds per m^2 (Mastilovic, 1998).

Table 5. Number of productive stems (spikes per m^2)

Cultivar	Year		Average of cultivar
	2009/10	2010/11	
Kruna	571	573	572
Toplica	612	600	606
Zvezdana	680	637	658
Etida	598	566	582
Angelina	609	674	641
Average of year	614	610	612

Cultivar	Year	Interaction cultivar x year
$LSD_{0,05}$ = 23	$LSD_{0,05}$ = 14	$LSD_{0,05}$ = 32
$LSD_{0,01}$ = 31	$LSD_{0,01}$ = 20	$LSD_{0,01}$ = 44

According to thedata, variety Kruna has smallest amount of productive stems – 572, and Angelina and Zvezdana higher, with an average of 658 and 641, respectively. Yearly average of all varieties showed that there were not major differences, in both years considering productive stems per m^2 (Table 5). Statistical analysis of interaction variety x year,showed thegreatest coefficient of differences, followed the differences between the varieties and the impact of the year.

Spike length

The spike length varies depending of the agrotechnique, rainfall in the region and amounts of fertilizers, especially during the formation of the spikes (tillering stage). Roncevic (1998) studied the morphological and productive characteristics of several foreign varieties of wheat and received major differences between varieties for this property. Vasilevski (1980), in experiments with different doses of fertilization, observed differences in the length of the spikes for certain varieties of winter wheat, regardless of the method of fertilization, indicating that this trait is inherited strictly under the same growing conditions.

Table 6. Spike length (cm)

Cultivar	Year		Average of cultivar
	2009/10	2010/11	
Kruna	10.3	11	10.6
Toplica	10.1	9.5	9.8
Zvezdana	10.5	11.5	11
Etida	11.1	11.2	11.1
Angelina	11.9	12.9	12.4
Average of year	10.8	11.2	11

Cultivar	Year	Interaction cultivar x year
$LSD_{0,05}$ = 0.5	$LSD_{0,05}$ = 0.3	$LSD_{0,05}$ = 0.7
$LSD_{0,01}$ = 0.7	$LSD_{0,01}$ = 0.4	$LSD_{0,01}$ = 0.9

Average value of this feature was 11 cm regardless of year and cultivar (Table 6). The average of the first year was 10.8 cm, and the second was higher by 0.4 cm, respectively

accounted for 11.2 cm. Statistical significance compared to the year has been observed in all cultivars, except for Etida, indicating that this variety has good stability in terms of cultivation. In individual analysis of the varieties, the longest average length was recorded for the variety Angelina (12.4 cm), and the shortest in Toplica (9.8 cm). Angelina showed statistically reliable differences at the level of 99 % compared with other varieties in both years. In the Etida variety, in the first year is certainly received statistical deviation level of 95 % compared with all other varieties, while in the second year, only at variety Toplica.

Number of spikelets per spike

The number of spikelets per spike is a direct indicator of fertility of a particular variety, in certain growing conditions. This component depends on both the characteristics of the variety and conditions of cultivation (Jevtic, 1986). According to Jestorovic (1998), the number of spikelet in 83.5 % depends on the influence of external factors, and in 16.5 % of genotype variability. Vasilevski (1980) concluded that the impact on the schedule of precipitation is an important determinant of the total amount of rainfall for the number of spikelet per spike.

According to the results of our research, the values correspond to previous studies (Table 7). The average number of spikelets per spike for all varieties for both years was 19.4. Angelina showed the highest (21.1) and Kruna the lowest (17.9) value. Analyze of the impact of interaction variety x year there are evident statistical differences among all varieties except between Zvezdana and Toplica. Among the variety Kruna, the number was the lowest in both years of the survey, while Angelina and Etida had the highest number in the first year (20.4) and Etida (21.8) in the second. Differences due to the impact of the year as well as the differences between varieties were highly statistically significant at the level of 99 %.

Table 7. Number of spikelets per spike

Cultivar	Year		Average of cultivar
	2009/10	2010/11	
Kruna	17.3	18.4	17.9
Toplica	18.2	19.1	18.6
Zvezdana	18	19.6	18.8
Etida	20.4	20.9	20.6
Angelina	20.4	21.8	21.1
Average of year	18.9	20	19.4

Cultivar	Year	Interaction cultivar x year
$LSD_{0,05}$ = 0.4	$LSD_{0,05}$ = 0.2	$LSD_{0,05}$ = 0.5
$LSD_{0,01}$ = 0.5	$LSD_{0,01}$ = 0.3	$LSD_{0,01}$ = 0.7

Number of grains per spike

The number of wheat grains in the spike largely depends on the genetic characteristics of the variety, but also, extremely important are climatic conditions during the formation of spikelet.

Jestorovic (1998) finds that external factors have affected 66.1 % of this capacity, and 33.9 % was due to the impact of genotype. In other research, Vasilevski (1980) concluded that the impact of the year on the average number of grains is great. Nedic (1989) concluded no influence of sowing density, to average number of grains per spike varies in different years of investigation.

Table 8. Number of grains per spike

Cultivar	Year		Average of cultivar
	2009/10	2010/11	
Kruna	50.6	56.1	53.3
Toplica	51.4	58.1	54.7
Zvezdana	48.5	54.4	51.4
Etida	59	50.7	54.8
Angelina	53.6	50	51.8
Average of year	52.6	53.9	53.2

Cultivar	Year	Interaction cultivar x year
$LSD_{0,05}$ = 1.3	$LSD_{0,05}$ = 0.8	$LSD_{0,05}$ = 1.8
$LSD_{0,01}$ = 1.7	$LSD_{0,01}$ = 1.1	$LSD_{0,01}$ = 2.4

The results in our research (Table 8), shows that all varieties have well-developed spikes with big number of grains per spike. The highest average value for this property from two years of research was obtained in cultivar Etida (54.8), and lowest among the Zvezdana (51.4). Seen by year, the lowest number of grains in the first year of studies had variety Zvezdana (48.5) and second year Angelina (50). The largest number of grains in the first year was found in variety Etida (59) and second year in cultivar Toplica (58.1). A comparison of average values for all varieties of two years showed that in the second year, varieties had larger number of grains in spike (53.9) than in the first year (52.6). Statistically significant differences in the number of grains in spike exist between varieties and between conditions of the year, which coincides with previous similar studies.

Hectolitre grain weight

Hectolitre grain weight is one of the most important parameters in assessing of milled quality of the wheat. It is an indicator of two thirds of the required qualitative-quantitative properties of the grain, and parameter for necessary capacity and equipment of storage (Miric et al., 2007). In addition, hectoliter grain weight is an indicator of biological plasticity and adaptability of the variety in different climate conditions, especially in high temperatures and air drought. Mladenov and Milosevic (2011) concluded that the environmental conditions greatly affect hectolitregrain weight. Mastilovic (1998), determining the quality of wheat in Serbia from 1995 to 1998, found differences of hectoliter grain weight in the same variety in different years.

In our investigations, hectolitre weight of grain varied depending of the year and variety (Table 9). Highest value is obtained in variety Zvezdana (78.3 kg hl^{-1}), and lowest in Toplica (75.4 kg hl^{-1}). The highest average weight in the two years of the examination was obtained in Zvezdana, which in 2010 amounted to 77.3 kg hl^{-1}, and in 2011 to 79.3 kg hl^{-1}. The average for all varieties in the first year was 76.3 kg hl^{-1}, in the second year 77.4 kg hl^{-1}, and the general average was 76.8 kg hl^{-1}.

Table 9. Hectolitre grain weight (kg hl^{-1})

Cultivar	Year		Average of cultivar
	2009/10	2010/11	
Kruna	75.5	77.8	76.6
Toplica	76	74.9	75.4
Zvezdana	77.3	79.3	78.3
Etida	76.8	76.5	76.6
Angelina	76	78.4	77.2
Average of year	76.3	77.4	76.8

Cultivar	Year	Interaction cultivar x year
$LSD_{0,05}$ = 1.5	$LSD_{0,05}$ = 0.9	$LSD_{0,05}$ = 2.1
$LSD_{0,01}$ = 2	$LSD_{0,01}$ = 1.3	$LSD_{0,01}$ = 2.9

Conclusions

Based on the research results of five wheat varieties in the region of Aleksinac we can extract several conclusions.

Climate and soil conditions in the investigated area are favorable for growing these varieties, since without irrigation it was obtained relatively high yields. Grain yield is the highest among the variety Zvezdana, which occurs as a result of the large number of grains productive per unit area and number of grains per spike. Variety Zvezdana has average yield of 6858 kg ha^{-1}. The variety Etida, also proved very high yield, with an average of 6695 kg ha^{-1}. These results coincide with the results of previous studies of these two varieties on the territory of Vojvodina. The lowest average yield was obtained in the variety Kruna, with 4902 kg ha^{-1}. Number of productive stems is confirmed as a cultivar trait. Highest number was in the variety Zvezdana (658), and lowest in Kruna (572). The longest spike is obtained in Angelina (12.4 cm), and the shortest in Toplica (9.8 cm). The highest number of spikelet has Angelina (21.1) and lowest Kruna (17.9), but the number of fertilized and shaped grains showed the highest values among the variety Etida (54.8), and lowest among Zvezdana (51.4). Highest value for hectoliter grain weight was obtained for varieties Zvezdana (78.3 kg hl^{-1}) and Angelina (77.2 kg hl^{-1}). As a final conclusion, it was found that, although all tested varieties can be grown in the region of Aleksinac, preference may be given to varieties Zvezdana and Etida.

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