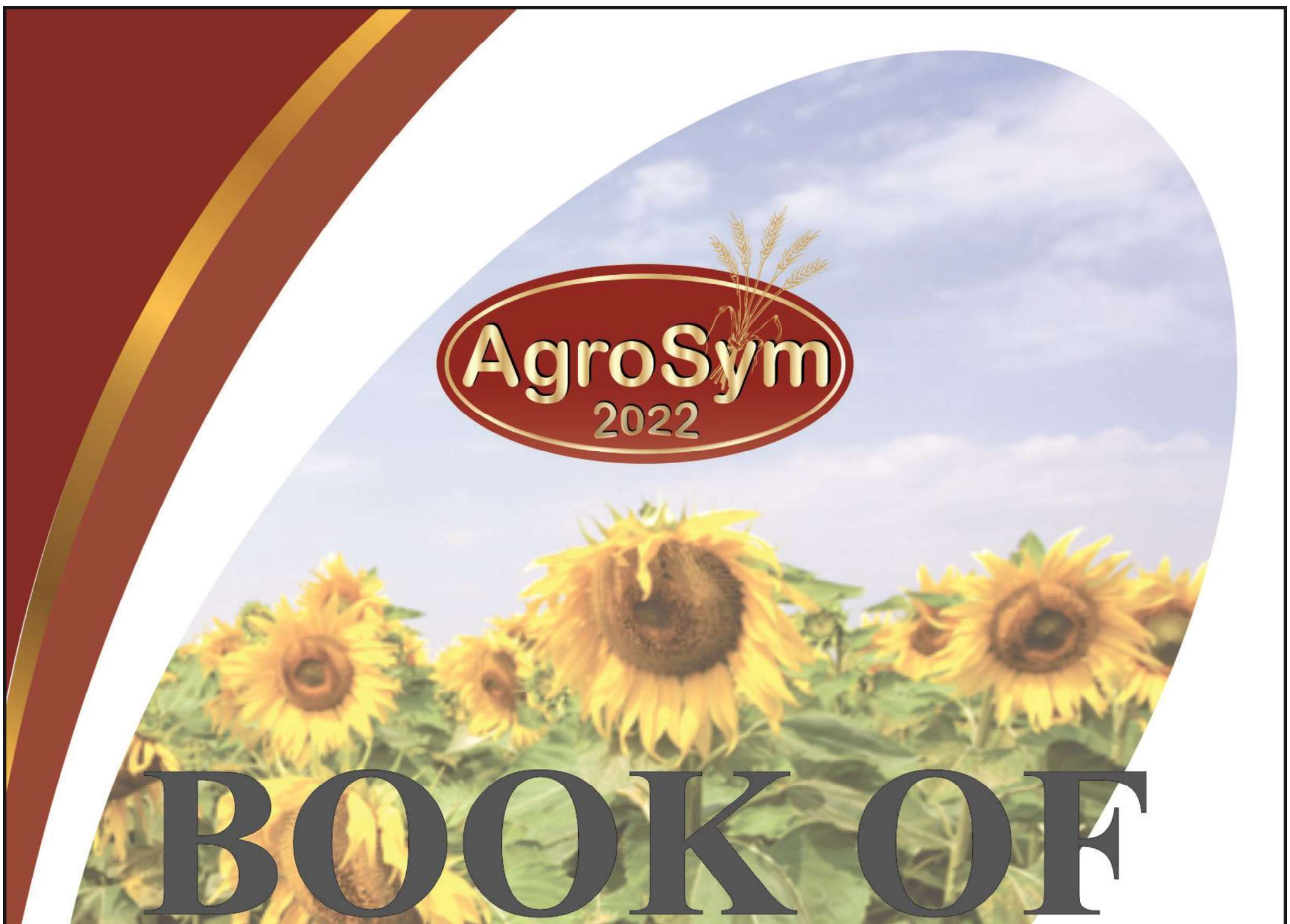

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PHENOTYPIC VARIABILITY AND SIMILARITY OF NUMBER OF PRODUCTIVE TILLERS IN WHEAT VARIETIES (*TRITICUM AESTIVUM* L.)

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Abstract

Number of productive stem tillers influence on crop density, number of fertile spikes which is directly related to grain yield. Aim of this study is estimation variability of productive tillering of wheat varieties grown under different environmental condition. The 50 wheat varieties are included for investigation, during two years (2015-2017) in experiment which was set up as a randomized block design in three replications on the field in Kraljevo, Serbia. Sparse sowing was performed in order to enable the examined plants to fully manifest their traits. Sixty plants at the full maturity stage (20 replication^{-1}) were used for analysis of number of tillers. The analysis of variance was performed by MSTAT C (5.0 version). Similarity among wheat was analyzed by hierarchical method of Euclidean distance. The results showed significant differences in number of tillers among varieties in both years, estimated by F-test. In average in the first year the smallest number of tillers 7.57 had Evropa 90 while the highest number of tillers (10.15) had Pobeda variety. In second year, the number of tillers varied from the lowest 8.42 in Evropa 90 to the highest 10.33 in Partizanka and Zastava. The similarity with Euclidean distance illustrated on dendogram contained five clusters in first year and six cluster of varieties in second year. The prominent cluster contains different number and composition of varieties with the highest degree of similarity. The differences in average number of productive tillers were determined by genetic and environmental factor as well as by interaction genotype/environment.

Key words: *wheat, variety, tillers, similarity, environment*

Introduction

Considering that the resources of arable land are limited, there is intensive work on the creation of genotypes with higher genetic potential for yield. For improving the genetic potential for yield, breeders need includes work on engineering the architecture of the plant's vegetative (root, stem, leaf) and generative (ear, seed) organs, which will have a greater capacity for increasing seed yield and better quality (Knežević et al., 2018; 2021). In order to achieve this, it is necessary to know the genetic control of traits, components of yield and quality, their mutual

connection in order to obtain the desired combination in the newly created variety ((Branković et al., 2015; Knežević et al., 2006; 2015). Tillering is directly influence to population structure in wheat crop, primarly crop density number of spike m^{-2}, number of grains $plant^{-1}$ (Madić et al., 2006; Xu et al., 2015), the number of fertile spikes, which is a critical component of grain yield (Wang et al., 2019). Among the three stages of tiller development: 1) axillary meristem initiation, 2) axillary bud development, and 3) axillary bud outgrowth. The first stage is determined mainly by genetic factors (Hyles et al., 2017), whereas the third is regulated mainly by environmental factors and management practices (Assuero and Tognetti, 2010; Assuero et al., 2012). Wheat which carry of reduced tillering (e.g., *tin*) genes have shown that inhibition of tillering stimulate the development of deeper roots, increases the tiller number, and increases the formation of large spikes under drought environments (Houshmandfar et al. 2019; 2020).
The number of productive tillers, as well as the total number of tillers, depends on environmental conditions, vegetation area, i.e. density of sowing or crops, mineral nutrition, moisture, light, temperature (Elhani et al., 2007; Kondić et al., 2016; Tilley et al., 2019). Abiotic stress factors at the time of shoot growth can inhibit their formation, and at a later stage their extinction can occur (Xie et al. 2016). Lack of nutrition can have a direct impact on the development and appearance of shoots, as well as the balance of auxin and cytokinin, which can also affect the termination of dormancy of the side buds (Valerio et al., 2009). In the conditions of a larger vegetation area, optimal mineral nutrition and soil moisture, the plants have greater general tillering (Paunovic et al., 2007). Under conditions of water deficit and drought, tillering is reduced, which can be used as a selection criterion, especially in a drought breeding program (Mitchell et al., 2006).
The aim of the work is to determine the potential of productive tillering of the stem plant in divergent genotypes of winter wheat varieties grown in different agro-ecological conditions.

Materials and Methods

In this study of productive tillering in wheat were included 50 varieties. Selected wheat genotypes were sown in experiment which was set up as a randomized block design in three replications, on plots size 1 m^2 on the field in Kraljevo, Serbia in two growing seasons (2015/16 and 2016/17). The seeds of varieties were sown at the distance of 0.10 m in rows of 1.0 m length among which was the distance of 0.2 m. For analysis of number of tillers, were used 60 plants in full maturity stage (20 plants per replication). Using the program MSTAT C 5.0 version the analysis of variance was performed according to a random block system with one factor and significant differences were estimated by F-test values and tested by test value of $LSD_{0.05}$ and $LSD_{0.01}$. Similarity among wheat analyzed by hierarchical method of Euclidean distance.

Weather conditions

The average temperature was 9.96 °C and total amount of precipitation was 651mm in first year was higher than in the second year 2016/17 in which average temperature was 8.74 °C and total amount of precipitation was 523 mm, and than in ten year periods recorded temperature 8.50 °C and precipitation 417.8 mm (Table 1). For plants growth in the second year was more favorable regime of temperature and precipitation. In the two months (October-November) the amount of precipitation and average temperature values were similar in both year of experiment favorable for seed germination and development of plants. During the February-April amount of precipitation in the first year (250.5 mm) was higher than in the second (174.0 mm), although the distribution of rainfall was more favorable in the second year experiment (Table 1).

Table 1. Average monthly temperature and total monthly precipitation in Kraljevo

	Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Xm	Total
Temperature ºC	2015/16	11.6	7.3	3.3	-0.1	8.8	7.8	14.1	15.5	21.3	**9.96**	
Temperature ºC	2016/17	10.6	6.8	0.0	-4.7	5.2	10.8	11.1	16.8	22.1	**8.74**	
2000-2010		11.8	6.4	1.7	-0.1	2.6	5.9	11.6	16.4	20.4	**8.50**	
Precipitatin (mm)	2015/16	56.8	64.0	9.0	86.2	52.7	157.9	39.9	135.9	48.6	72.3	**651.0**
Precipitatin (mm)	2016/17	84.1	77.6	9.4	22.0	35.0	57.0	82.0	100.0	56.0	41.1	**523.1**
2000-2010		61.0	44.3	44.6	30.0	29.9	33.2	52.9	52.6	69.3	46.4	**417.8**

Results and Discussion

The number of productive tillers in the first year of experiment varied in range of 7.57 (Evropa 90) to 10.15 (Pobeda) with average value 8.91 for all 50 varieties, while in second year varied from 8.42 (Evropa 90) to 10.33 (Partizanka and Zastava) with average value 9.48 for 50 varieties (table 2).

Table 2. Variability of number of tillers in wheat varieties

	Cultivars	First year	Second year	Average			First year	Second year	Average
1	Evropa 90	7,57±0,10	8,42±0,18	7,99±0,14	26	Jarebica	9,10±0,17	9,45±0,18	9,28±0,18
2	Dejana	7,92±0,10	8,68±0,14	8,30±0,12	27	Fortuna	8,88±0,16	9,17±0,17	9,03±0,17
3	Sila	8,48±0,13	10,18±0,24	9,33±0,19	28	Sasanka	8,80±0,17	9,47±0,17	9,14±0,17
4	Omega	8,77±0,17	9,20±0,18	8,99±0,18	29	Danica	8,85±0,17	9,55±0,15	9,20±0,16
5	Lasta	8,05±0,12	9,15±0,14	8,60±0,13	30	Somborka	9,27±0,15	9,45±0,16	9,36±0,16
6	Milica	8,42±0,17	9,93±0,27	9,18±0,22	31	Kremna	8,82±0,15	9,00±0,17	8,91±0,16
7	Parizanka	8,37±0,17	10,33±0,25	9,35±0,21	32	KG-75	8,90±0,17	9,78±0,19	9,34±0,18
8	Pobeda	10,15±0,27	10,18±0,26	9,35±0,27	33	Šumadija	8,80±0,20	9,22±0,18	9,01±0,19
9	Dična	9,10±0,20	9,28±0,21	9,19±0,21	34	Levčanka	9,20±0,17	9,15±0,16	9,18±0,17
10	NS Rana 5	9,23±0,24	9,25±0,24	9,24±0,24	35	Oplenka	9,13±0,15	9,28±0,23	9,21±0,19
11	Alfa	10,10±0,27	9,28±0,21	9,70±0,24	36	Gruža	8,63±0,21	9,53±0,23	9,08±0,22
12	Rodna	8,12±0,24	9,30±0,30	8,71±0,27	37	Gružanka	8,70±0,18	9,77±0,23	9,24±0,21

13	Balkan	8,60±0,20	9,32±0,21	8,96±0,21	38	KG-58	8,70±0,18	9,82±0,20	9,26±0,19
14	Rana Niska	9,20±0,27	8,83±0,23	9,02±0,25	39	KG-56	8,95±0,21	9,32±0,20	9,14±0,21
15	Proteinka	9,15±0,23	9,15±0,17	9,15±0,20	40	Orašanka	9,33±0,20	9,63±0,19	9,48±0,20
16	Stepa	9,37±0,23	9,15±0,25	9,26±0,24	41	KG-78	9,12±0,25	9,93±0,25	9,53±0,25
17	NSR-2	9,85±0,31	9,78±0,26	9,86±0,29	42	Ravanica	8,92±0,19	9,47±0,17	9,20±0,18
18	Prima	8,45±0,21	9,58±0,23	9,02±0,22	43	Lepenica	8,93±0,24	9,97±0,23	9,45±0,27
19	Sloga	9,08±0,20	9,28±0,24	9,18±0,23	44	Jasenica	9,62±0,26	9,72±0,27	9,67±0,27
20	Agrounija	9,28±0,27	10,17±0,23	9,73±0,25	45	Zastava	9,23±0,26	10,33±0,29	9,78±0,28
21	Zadruga	9,05±0,17	10,23±0,24	9,64±0,21	46	Kosmajka	8,15±0,14	8,28±0,14	8,22±0,14
22	Tera	8,85±0,17	9,27±0,23	9.06±0,20	47	Šumadija	8,62±0,20	8,05±0,15	8,34±0,18
23	Kompas	9,53±0,15	9,82±0,21	9,68±0,18	48	Morava	8,12±0,12	9,63±0,20	8,88±0,16
24	Tanjugovka	8,70±0,17	9,85±0,26	9,28±0,22	49	KG 56 S	8,60±0,19	9,63±0,20	9,12±0,20
25	Jugoslavija	9,60±0,18	9,70±0,15	9,65±0,17	50	Ljubičevka	9,35±0,28	9,85±0,28	9,60±0,28
	Average						8,91±0,12	9,48±0,21	
	V						17.1	17.1	17.1

The average value of productive tillering in the first year was lower than in the second year of the experiment and 8.91 shoots, while in the second year the average value for all varieties was 9.48 shoots (table 2).

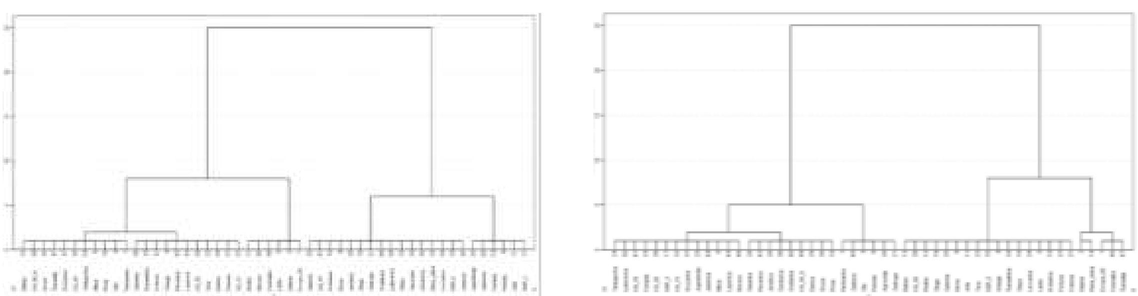
The number of tillers in previous investigation of Serbian wheat was less (Zečević *et al.*, 2005; Knežević et al., 2009; Branković et al., 2015) as well as for Italian and Spanish wheat cultivars (Álvaro *et al.*, 2008).

The analysis of variance established that the differences between the varieties for the trait productive tillering were significant and highly significant. Differences between years for productive tillering in varieties indicate that there is an influence of external environmental factors on the manifestation of productive tillering. The established significant differences in the average values of number of tillers plant^{-1}, indicating genetic divergence of varieties (table 3).

Table 3. Analysis of variance for productive tillering in wheat in two vegetation season

Source of variance		Vegetation season 2015/16							Vegetation season 2016/17						
	df	*SS*	*MS*	*F*	*F crit*	σ^2	$Lsd_{0,05}$	$Lsd_{0,01}$	*SS*	*MS*	*F*	*F crit*	σ^2	$Lsd_{0,05}$	$Lsd_{0,01}$
Genotypes (G)	49	40.613	0.829	86.388	1.4829	0,273	0.040	0.054	36.608	0.747	44.993	1.482944	0,243	0.053	0.071
Repetitions (R)	2	0.046	0.023	2.419	3.0892				0.009	0.005	0.283	3.089203			
Error	98	0.940	0.010			0,010			1.627	0.017			0,017		
Total	149	41.599	149			0,283			38.245				0,260		

Based on the obtained values for productive tillering, five clusters of mutually similar genotypes are distinguished in the first vegetation season (2015/16). The first cluster contain 11 varieties, second-11 varieties, third-six varieties, fourth-16 and fifth cluster contain six mutually similar varieties. Among those five cluster, the highest similarity was between first and second cluster, with which the third cluster is the most similar. The less degree of similarity showed cluster forth with fifth cluster, and this formed cluster manifested the least similarity with cluster formed from first, second with third cluster (Figure 1).



1) 2)

Figure 1. Similarity of wheat genotypes according to productive tillering in two vegetation season: 1) 2015/16 and 2) 2016/17

In second year (2016/17). the six cluster mutually similar varieties were established. The first cluster contain 13 varieties, second-9 varieties, third-six varieties, fourth-17, fifth-2 and sixth cluster contain three mutually similar varieties. Among those six cluster, the highest similarity was between first and second as well between fifth and sixth cluster. Less degree of similarity, but the highest showed third with formed cluster from first and second, and than less but the highest similarity showed fourth cluster with formed cluster from fifth and sixth cluster. The least similarity manifested the between formed cluster from first, second and third and cluster formed from fourth with fifth and sixth cluster (Figure 2).

In these studies, the examined wheat genotypes showed a high potential for productive tillering, which on average varies between 7.99 and 9.76 shoots in two years. In the study of other wheat genotypes, similar values of variation in productive tillering were found (Zečević et al., 1995), and slightly higher values of tillering were found in the study of Dimitrijević et al. (1996). The obtained high values of the number of productive shoots indicate the potential of tillering, which

was manifested in the plants grown under well supplied mineral elements of nutrition, the plants had a large vegetation area due to sowing seed with large distance in row and between the raw, and the distribution of precipitation was favorable.
The crop nutrition with nitrogen and phosphorus fertilizers has a high impact on wheat yield (Takahashi and Anwar, 2007; Knežević et al., 2016; Jelic et al., 2017), while phosphorus deficit results in a lower number of tillers (Valle and Calderini, 2010; Fioreze et al. 2012). The greatest contribution to the increase in the number of productive tillers have soil moisture, mineral nutrition and accessibility of mineral elements for absorption, temperature, light and process of photosynthesis and reutilization and translocation of organic matter (Elhani et al., 2007)).

Conclusions

Based on the obtained results, it was established that the number of productive tillers varied in the analyzed wheat genotypes that were grown in two vegetation season which characterized different weather conditions. The variation of tillering in the same variety in two years shows the genotype's response to different environmental conditions. The average value of productive tillering for all genotypes in the second year was 9.48 tillers , which was higher than in the first year, 8.91 tillers. The Zastava varitey had the highest average value of productive budding for both years with 9.78 tillers, although in the second year Zastava and Partizanka had the highest number 10.22 of productive tillers. The differences between genotypes were significant and highly significant for productive tillering. Genetic factors, environmental factors and genotype/environment interaction had an influence on the manifestation of the studied traits.

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