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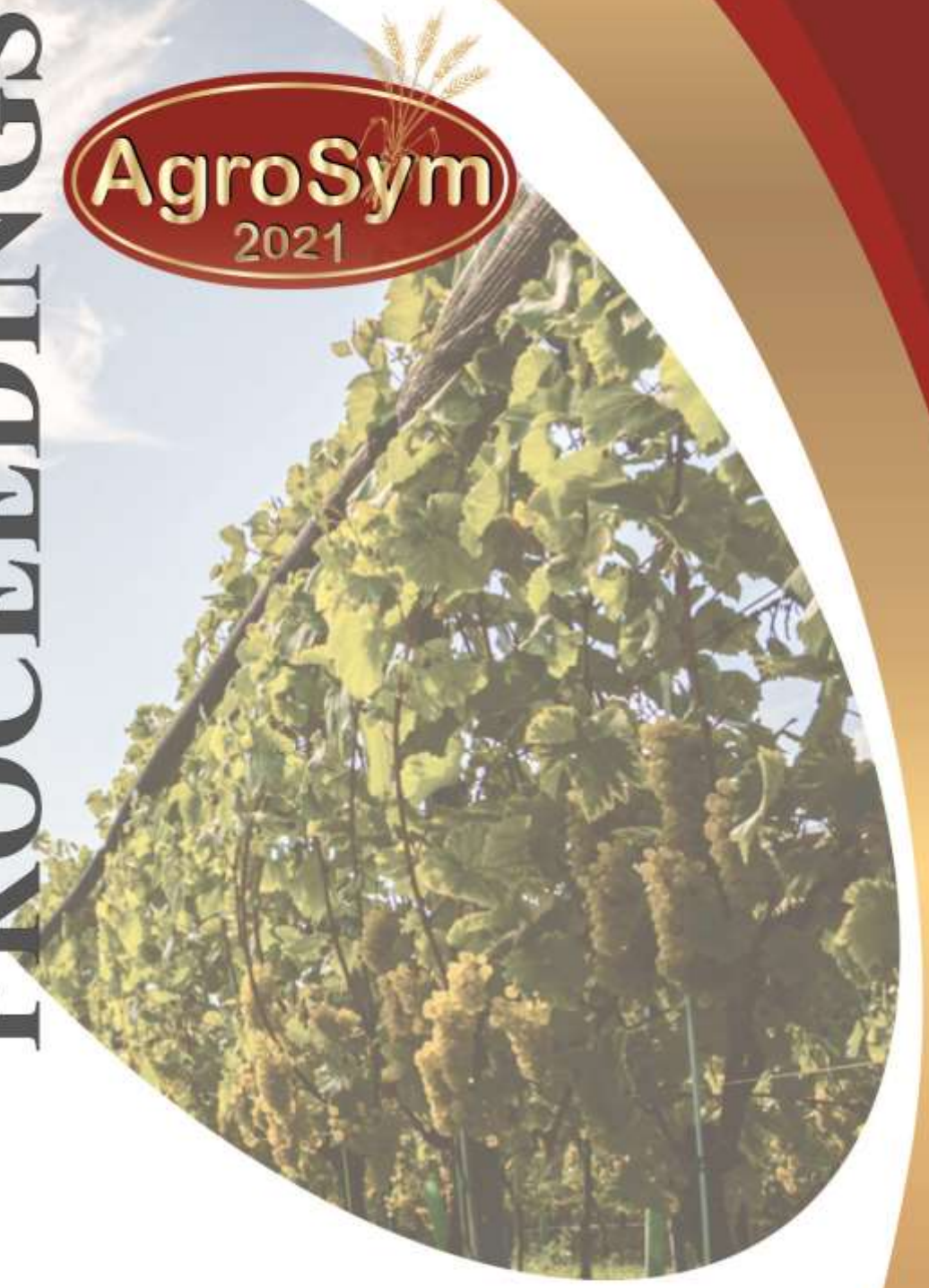

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VARIABILITY OF PLANT HEIGHT AND SPIKE CHARACTERISTICS OF DURUM WHEAT GROWING IN ORGANIC PRODUCTIONS

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Abstract

The aim of this study is to investigate phenotypic variability of yield components for seven different durum wheat genotypes (Windur, Žitka, KG Olimpik, KG-28-6, KG-3405-03, KG-43-33-1, and KG-44-3-1), which were grown during two years (2012/2013 and 2013/2014) at certified organic trial located in Mršinci, the Municipality of Čačak, Serbia. The field experiment was conducted in a randomized block design with three replications with plot of 5 m² on the soil belonging to the loamy clay type. Experiment was carried out by the organic technology of farming production of durum wheat.
For analysis of plant height and spike characteristics, 60 plants in full maturity stage were used (20 plants per replication). The primary tiller of plant was used for analyzed plant height, spike length and number of spikelets per spike.
Plant height, on average, ranged from 76.0 cm (Olimpik) to 92.1 cm (KG-3405-03), spike length from 6.9 cm (KG-44-3/1) to 8.2 cm (Windur) and number of spikelets per spike from 19.3 (Žitka) to 22.5 (Windur). Variability for plant height was similar for both of years (CV=3.6%, 3.9%, respectively), but for spike length (CV=5.5%, 6.6%, respectively) and for number of spikelets per spike (CV=5.4%, 6.2%, respectively) was lower in the first than in the second year.
Through variance analysis, a highly significant difference in mean values for all investigated components was established. Phenotypic analysis of variance indicated that ecological factors had higher impact in relations to genetic factors on expression of all three investigated traits.

Keywords*: durum wheat, organic production, plant height, spike characteristics, variability.*

Introduction

Durum wheat (*Triticum durum* Desf.) is still globally considered a minor wheat crop and typically much of the research effort on durum is often conducted in conjunction with studies of bread wheat. Only a few regions in the world are capable of producing durum that meets the high standards for end-use suitability (Beres et al., 2020). In Serbia, there are generally conditions for growing durum wheat, although climatic conditions can be limiting factors for durum production. The production of winter varieties can be risky due to low frost resistance of durum wheat, especially in years with frost without snow cover. If spring varieties are grown, it is necessary to perform earlier sowing and provide the irrigation system, because high

temperatures and drought stress can significantly reduce the grain filling period, plant height, spike characteristics, yield components and yield (Pour-Aboughadareh et al., 2020).
Genotypes under organic agriculture need a high phenotypic plasticity to adapt to different and changing climatic conditions, should be more tolerant to abiotic and biotic stresses, need a proper root system to enable efficient nutrient taking and, therefore, produce high enough yields with less/low input (Pagnota et al., 2020). Durum wheat varieties do not only differ in their agronomic traits, but also in their response to diseases and insects (DePauw and Ruan, 2018). In organic production of durum wheat, among the principles with the greatest impact on disease management are selection of a resistant variety and crop rotation (Knox, 2018). Choice of cultivar can impact grain yield, grain quality, and the type of management practices that might be needed to optimize performance and profitability for a given environment. The interest of consumers and the food industry in organic products requires work on creating cultivars suitable for cultivation in the system of organic production.
The aim of this paper is to analyze the variability of durum wheat genotypes in organic production based on their behavior in different ecological conditions during the growing seasons.

Materials and Methods

Seven genotypes of winter durum wheat [Windur (Germany), Žitka, KG Olimpik, KG-28-6, KG-3405-03, KG-43-33-1, and KG-44-3-1 (Serbia)] were grown during two growing seasons (2012/2013 and 2013/2014) at certified organic trial parcel which is located in Mršinci, in the Municipality of Čačak, Serbia (20°30' E, 43°48' N, 220 m a.s.l.).
The field experiment was conducted in a randomized block design with three replications with plot of 5 m² on the soil which belongs to the loamy clay type. Experiment was carried out by the organic technology of scientific farming production of durum wheat. Soybean in the first and potato in the second year were used as the preceding crops. Sowing was done on November 6, 2012, and in October 25, 2013 with 600 seeds per square meter. The treatment of the crops during the growing season respected the principles of the organic farming.
For analysis of plant height and spike characteristics, 60 plants were used in full maturity stage (20 plants per replication). The primary tiller was used for analyzed plant height, spike length and number of spikelets per spike. The following parameters were computed: the average value ($\bar{x}$), the standard deviation (SD), the coefficient of variation (CV), the analysis of variance (ANOVA) and components of variance (σ^2). The significant differences between the average values were estimated by LSD-test values. The ANOVA was done according to a random block system with two factors using the MSTAT-C program (Michigan State University, 1990).

Results and Discussion

Plant height on average ranged from 76.0 cm in cultivar Olimpic to 92.1 cm for KG-3405-03, which plant height differed significantly to other genotypes. Variability on average was similar for both investigated years (3.6%, 3.9%, respectively). The highest plant height in the first year had cultivar Žitka (89.43 cm), while in the second year genotype KG-3405-03 (99.27 cm) had the highest plant height. Analysis of SD and CV showed that the examined genotypes showed low variability for plant height. Genotype KG-28-6 and Windur showed the highest variability of plant height in the first year (7.1%, 5.3%, respectively) and genotypes Windur and KG-44-3/1 in the second year (5.9%, 5.4%, respectively). Analysis of variance showed highly significant

differences between genotypes and genotype-year interaction, while differences between years were significant (Table 1). In the total variance of this trait, the largest share of variance belonged to genotype-year interaction (64.18%) and genotype (25.99%). These results are in agreement with previous research (Falaki and Mohammed, 2011).

Table 1. Mean values, variability and ANOVA for plant height in durum wheat

Genotype	Year						Average
	2012/2013			2013/2014			
	$\bar{x}$ (cm)	SD	CV (%)	$\bar{x}$ (cm)	SD	CV (%)	
Olimpik	77.30gh	2.58	3.3	74.70i	2.95	3.9	76.0
Windur	84.37d	4.44	5.3	83.70d	4.92	5.9	84.0
Žitka	89.43b	3.12	3.5	78.37fg	2.28	2.9	83.9
KG-28-6	78.43fg	5.54	7.1	76.27h	2.43	3.2	77.4
KG-44-3/1	79.60ef	1.79	2.2	85.97c	4.65	5.4	82.8
KG-43-33/1	80.57e	1.16	1.4	80.47e	2.78	3.4	80.5
KG-3405-03	85.0cd	2.32	2.7	99.27a	2.72	2.7	92.1
Average	82.1	2.99	3.6	82.7	3.25	3.9	-

LSD	**Genotype (G)**	**Year (Y)**	**G×Y**
0.05	0.9665	-	1.367
0.01	1.464	-	2.071

Analysis of variance

	Genotype (G)	Year (Y)	G×Y	Error	Total
DF	6	1	6	26	41
MS	169.811	3.486	94.032	0.468	-
F	362.9268**	7.4503*	200.9691**	-	-
σ^2 (%)	25.99	8.87	64.18	0.96	100.00

Means followed by different letter (s) within the columns differ significantly at 5% level of probability using LSD.

Spike length is an important component of wheat plant yield, which along with other components, significantly affects yield. In this study, the spike length of durum wheat genotypes ranged on average from 6.9 to 8.2 cm (KG-44-3/1, Windur, respectively). Variability of this component was higher in the second (6.6%) than in the first investigated year (5.5%). On average for all genotypes, the length of spike was similar in both years, about 7 cm, which means that this trait showed homogeneity over the years (Table 2). These results are in agreement with previous research reported by Matković et al. (2015) who also established average value of spike length at observed genotypes about 7 cm in organic production of durum wheat. Analysis of variance for spike length showed highly significant differences between genotypes and years as well as its interactions. In the total variance of this trait, the largest share of variance belonged to genotype-year interaction (80.22%) and year (10.63%). These results agree with previous research in durum wheat (Gorjanović and Kraljević-Balalić, 2006) and spelt wheat (Zečević et al. 2018). The number of spikelets per spike is shown in table 3. On average, this trait varied from 19.3 (Žitka) to 22.5 (Windur). Genotype KG-44-3/1 had also 22 spikelets per spike. On average for all genotypes, the number of spikelets per spike differed by only one per year (21 and 22). Similar results obtained by Gorjanović and Kraljević-Balalić (2006) who found 21-22 spikelets per spike.

Table 2. Mean values, variability and ANOVA for spike length in durum wheat

Genotype	Year 2012/2013 $\bar{x}$ (cm)	SD	CV (%)	2013/2014 $\bar{x}$ (cm)	SD	CV (%)	Average
Olimpik	7.43f	0.36	4.8	7.87d	0.41	5.2	7.6
Windur	8.17c	0.44	5.4	8.33b	0.73	8.8	8.2
Žitka	8.40b	0.47	5.6	7.50ef	0.56	7.5	7.9
KG-28-6	7.37f	0.47	6.4	6.97g	0.58	8.3	7.2
KG-44-3/1	6.20h	0.25	4.0	7.60e	0.48	6.3	6.9
KG-43-33/1	6.90g	0.25	3.6	8.37b	0.47	5.6	7.6
KG-3405-03	8.77a	0.76	8.7	7.37f	0.34	4.6	8.1
Average	7.60	0.43	5.5	7.70	0.51	6.6	-

LSD	**Genotype (G)**	**Year (Y)**	**G×Y**
0.05	0.1094	-	0.1548
0.01	0.1658	-	0.2345

Analysis of variance

	Genotype (G)	Year (Y)	G×Y	Error	Total
DF	6	1	6	26	41
MS	1.419	0.126	1.793	0.006	-
F	256.6142**	22.7716**	324.1970**	-	-
σ² (%)	8.34	10.63	80.22	0.81	100.00

Means followed by different letter(s) within the columns differ significantly at 5% level of probability using LSD.

On average, two sterile spikelets per spike were recorded, at basal and top position of spike. Wheat yield can be increased by decreasing the sterile basal and top spikelets, which can be achieved with appropriate plant density and by supplying sufficient nutrients, mainly nitrogen (Li et al., 2016). Analysis of variance revealed highly significant differences between the analyzed genotypes, years and genotype-year interaction. In the total variance of this trait, the largest share of variance belonged to the genotype-year interaction (53.45%) and then to the genotype (13.54%), table 3.

In organic durum wheat production, productivity of plants is lower than in conventional production because of low input of fertilization and protection against diseases and insects. Weeds are one of the largest contributors to wheat yield loss. Weed control and nitrogen supply are among the most important factors for durum yield and quality, especially in years with excess precipitation and low temperature during reproductive development of durum wheat in organic production system (Campiglia et al. 2015, Zečević et al., 2019). Resistance to disease continues to be a major factor in the maintenance or improvement of durum wheat yields, especially leaf rust, yellow or stripe rust and stem rust (Eversmeyer and Kramer, 2000).

Table 3. Mean values, variability and ANOVA for number of spikelets per spike in durum wheat

Genotype	Year						Average
	2012/2013			2013/2014			
	$\bar{x}$	SD	CV (%)	$\bar{x}$	SD	CV (%)	
Olimpik	21.0bc	0.96	4.6	22.0ab	0.81	3.7	21.5
Windur	23.0a	1.29	5.6	22.0ab	2.18	9.9	22.5
Žitka	19.0d	0.76	4.0	19.67cd	1.60	8.1	19.3
KG-28-6	22.0ab	1.02	4.6	21.0bc	1.71	8.1	21.5
KG-44-3/1	22.0ab	1.29	5.9	22.0ab	0.84	3.8	22.0
KG-43-33/1	20.33cd	1.24	6.1	23.33a	1.04	4.4	21.8
KG-3405-03	20.0cd	1.44	7.2	23.0a	1.31	5.7	21.5
Average	21.0	1.14	5.4	22.0	1.36	6.2	-

LSD	**Genotype (G)**	**Year (Y)**	**G×Y**
0.05	1.107	-	1.566
0.01	1.677	-	2.372

Analysis of variance

	Genotype (G)	Year (Y)	G×Y	Error	Total
DF	6	1	6	26	41
MS	6.040	6.881	4.214	0.614	-
F	9.8438**	11.2149**	6.8687**	-	-
σ² (%)	13.54	5.66	53.45	27.35	100.00

Means followed by different letter(s) within the columns differ significantly at 5% level of probability using LSD.

Conclusion

In this study, it was found that durum wheat genotypes behave differently in organic production for the tested plant traits. Differences between genotypes were significant for plant height and spike traits. The variability was low for all examined traits. Genotype-year interaction was expressed for all three examined traits (plant height, spike length and number of spikelets per spike). The largest impact of total variance belonged to the genotype-year interaction, above 50% for all investigated traits.

The analyzed genotypes possess low variability of the examined traits in different ecological conditions, which were expressed during the two vegetation seasons. These genotypes can be used as parents in breeding durum wheat for organic and conventional production.

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