BOOK OF PROCEEDINGS

VII International Scientific Agriculture Symposium
Jahorina, October 06-09, 2016

agro 2016 sym

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VII International Scientific Agriculture Symposium
"Agrosym 2016"

AGROSYM 2016

Jahorina, October 06 - 09, 2016

Impressum
VII International Scientific Agriculture Symposium „Agrosym 2016“

Book of Proceedings
Published by
University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia
University of Belgrade, Faculty of Agriculture, Serbia
Mediterranean Agronomic Institute of Bari (CIHEAM - IAMB) Italy
International Society of Environment and Rural Development, Japan
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CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

631(082)(0.034.2)

INTERNATIONAL Scientific Agricultural Symposium "Agrosym 2016" (7 ; Jahorina)
Book of Proceedings [Elektronski izvor] / VII International Scientific Agriculture Symposium "Agrosym 2016", Jahorina, October 06 - 09, 2016 ; [editor in chief Dušan Kovačević]. - East Sarajevo =Istočno Sarajevo : Faculty of Agriculture =Poljoprivredni fakultet, 2016. - 1 elektronski optički disk (CD-ROM) : tekst, slika ; 12 cm

CD ROM čitač. - Nasl. sa nasl. ekrana. - Registar.

ISBN 978-99976-632-7-6

COBISS.RS-ID 6216984

10.7251/AGRENG1607196

VARIABILITY OF GRAIN MASS PER SPIKE IN CULTIVARS OF TRITICALE (X TRITICOSECALE WITTM.)

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Abstract

Triticale is a cereal species created by crossing the wheat and rye species. It is characterized by good quality and high yielding capacity which is specific for wheat and high tolerance to abiotic and biotic stress factors which is specific for rye. The high yield potential of triticale is determined by genetics and influenced by environmental factors. The aim of the paper is to present the results obtained at different triticale varieties under different climatic conditions regarding the grain mass spike^{-1}. Five triticale (*xTriticosecale* Wittm.) cultivars (KG 20, Bolero, Rtanj, Odisej and Bogo) were investigated in field experiment which was conducted as a randomised block design in five replications on 5m^2 size of unit plot, during three years period (2010-2013). In full stage of maturity 100 plants (20 plants per replication) were used for analysis of grain mass spike^{-1}. Obtained results for grain mass spike^{-1} showed significant differences among studied triticale cultivars, years of experiment and interaction genotype/year. The average value of grain mass spike^{-1} for all three years and all five tested cultivar of triticale was 2.28g. The cultivar Bolero had the lowest average value (2.15g) and Odisej the highest value (2.52g) of grain mass spike^{-1} in average for three years period.

Keywords: *grain mass, spike, triticale, cultivars*

Introduction

Triticale is highly productive cereal species which use for planting as alternative to other cereals in region where growing conditions are unfavorable or in low-input systems (Erekul and Köln, 2006; Jelić et al., 2007). Triticale is, in general, more tolerant to environmental stresses than wheat and barley. Breeding for marginal areas (acidic or alkali soils), phosphorus deficiency, micro-elements deficiencies (Cu, Zn, Mg) or toxicity (boron) and drought stress in the arid and semi-arid zones is the important task of breeding programs in the world (Oettler, 2005; Knezevic et al., 2010). By breeding was increased grain yield, improved resistance to disease and optimized morphological traits and grain protein composition (Hernández, 2001). Triticale can be used for different purpose as animal and human food (Zečević et al., 2007; Martinek et al., 2008). Flour of triticale very often use to replace soft wheat flour in mixtures for breads, cakes or cookies (Bagcı, 2005; Zecevic et al. 2005). The grain mass spike^{-1} is important factor for grain yield which have positive association with grain number spike^{-1} and with yield (Yanbeyi et al., 2006). Except, grain mass spike^{-1}, the numerous morphometric components (plant height, tillering, grain number spike^{-1}, thousand grain mass, hectoliter mass, etc.) have contribute to total grain yield. Response of genotypes on different environmental conditions is a good way for estimation which genotypes is more adaptive to specific area for growing (Kirchev et. al., 2014). The formation of grain yield varied under the influence of environmental factors (temperature, precipitation). Grain yield depends of variations of precipitation in critical months. Triticale breeding programs are focused on increasing grain yield, biomass yield, earliness, grain filling percentage as well nutritional quality (Grabovets and Popova, 2015; Moskalets et al., 2016). The strong interaction between genotype/environment require the creation of varieties with specific adaptability to climatic conditions both favorable and unfavorable (Zečević et al., 2010). For improvement of spike traits, grain yield and yield components depends on the amount of nitrogen nutrition (Kirchev et at., 2006; Madic et al., 2015) and that require study to optimize measure of technology growing (Jelić et al., 2007) in different area of triticale production, considering the climate change. The changes of environmental conditions as well climate in recent years emphasized the extreme variations, with consequences on the agricultural production (Zečević et al., 2010).

The aim of this paper is study of variability of grain mass spike-1, in five genetically divergent winter triticale cultivars influenced by different environmental conditions.

Material and Methods

The five cultivars of triticale (KG 20, Bolero, Rtanj, Odisej and Bogo) were included for investigation variability of grain mass spike^{-1}. Field experiment was set up as a randomised block design in five replications on 5m^{-2} size of unit plot, which carried out in three growing season (2010/11, 2011/2012 and 2012/2013). The experiment conducted on the soil type pseudogley which characterized acidic pH (pH$_{H2O}$ = 4.1) and the following content: humus 2.36%, readily available phosphorus 7.8 mg 100^{-1} g soil and potassium 14.3 mg 100^{-1} g soil. In full stage of maturity of 100 plants (20 plants per replication) were used for analysis of grain mass spike^{-1}. The analysis of variance was computed according to randomize complete block design with two factors: A (cultivars), B (year) and using ANOVA (MSTAT-C program, 1989). The significant differences among the means were estimated by least significant difference (LSD) test (Hadživukovic, 1991). Components of variance (genetic, interaction and environment) were computed by Falconer (1981).

Climatic conditions during growing seasons

In the years of experiment the values of temperature and precipitation were different. Also, those values in comparison with computed average values for 10 previous years were different (tab. 1). In the first year the average temperatures (8.74^{o}C) were similar to average of ten years period (9.08^{o}C) and in second (8.13^{o}C) were in average slightly lower than in first year and ten year period, while in third year of experiment (2012/13) average value of temperature (9.73^{o}C) was higher than in other year of experiment and average temperature for ten years period. In the first year 2010/11 the amount of precipitation (520.5mm) was higher than in second 2011/12 (474.7mm) year, while in the third year 2012/13 was the highest amount of precipitation (611.5mm). The average value of precipitation in the first and second year of experiment was lower, while in the third year was higher than average value of precipitation for ten year period (2000-2010). Amounts of precipitation in the first and third years was higher and suitable up to the June in the stage of ripening plant. The precipitation in the second year in the period of emerging (November) was extremely low, while from December to June distribution of precipitation was suitable at each stage of development, while the low amount of precipitation in June (17.8mm) at the stage of grain filling. This precipitation was suitable for seed maturity phase, and was lower for 52.9mm than in first year, 136.85mm than in the third year and for 74.4mm lower than in ten years average values.

Table 1. Monthly and mean temperatures and monthly and cumulative precipitation

Month	Temperature °C				Precipitation (mm)			
	2010/11	2011/12	2012/13	2001-2010	2010/11	2011/12	2012/13	2001-2010
October	9.2	10.4	13.7	12.2	93.6	30.4	56.7	64.3
November	11.1	3.2	9.1	7.0	34.1	1.7	11.1	57.4
December	2.7	3.3	0.4	2.0	64.9	63.7	97.6	48.5
January	0.3	-0.1	2.9	0.9	28.1	107.1	62.4	42.8
February	0.6	-4.2	4.0	2.4	59.2	54.9	84.3	44.7
March	6.6	8.8	6.4	7.6	48.9	24.5	102.0	52.5
April	12.2	12.7	13.3	12.0	37.1	69.1	41.2	66.6
May	15.6	16.0	18.0	17.2	82.9	105.5	70.8	74.9
June	20.4	23.1	19.8	20.4	71.7	17.8	85.4	92.2
Average	**8.74**	**8.13**	**9.73**	**9.08**	57.8	52.7	67.94	60.4
Total	78.7	73.2	87.6	81.7	**520.5**	**474.7**	**611.5**	**543.8**

Results and discussion

The analysis of gran mass spike-1 showed differences among cultivars as well for the same cultivars depends of year. Under specific environmental conditions of experimental season 2010/11 the gran mass spike-1 varied between 2.12g (KG 20) and 2.49g (Odisej) with an average value for five investigated cultivars of 2.29g. The values for grain mass spike-1 in 2011/12 varied between 2.08g (Bolero) and 2.26g (Odisej and KG20) with average value for all five cultivars of 2.20g. In the climatic year conditions of 2012/13 grain mass spike-1 varied between 2.13g (KG20) and 2.81g (Odisej) with an average value for five investigated cultivars of 2.34g. The average value of grain mass spike-1 for all three years and all five tested cultivar of triticale was 2.28g and variation value of grain mass spike-1 was between 2.15g (Bolero) and 2.52g (Odisej) table 2.

The results for grain mass spike-1 in this research were similar to obtained value of grain weight (ranged from 1.94 to 2.58g) for triticale lines, reported by Dogan et al., (2009) and similar to research (Giunta et al., 2004; Kociuba et al., 2010). However, values of grain mass spike-1 in this study is higher to obtained values in investigation (Pochişcanu, et al., 2013; Gerdzikova, 2014). Also, different values of grain mass spike-1 in comparison to our investigation were found in other studies Atak et al. (2006), Yanbeyi et al. (2006) and Akgun et al. (2007). These differences may arise from different ecological conditions in which different researcher were conducted.

The better climatic conditions of 2012/13 compared to 2011/12, especially concerning the much better water supply from precipitation, determined a significant increase in the grain mass spike-1 at analyzed triticale cultivars. Except of genotype specificity, higher amount of precipitation in first (520.5mm) and third (611.5mm) year in relation to second year of experiment (474.7mm) have influence to efficient grain filling as well higher grain mass spike-1.

The investigation (Hernández, 2001) showed that under good rainfed condition (~ 700mm) triticale has 15% higher grain yield than wheat, or approximately three fold higher than under low (~300mm) rainfed condition. This advantage is much larger under dry and marginal conditions. Also, physiological-genetic variable have influence on the variations of yield among crop plant genotypes and has been linked to stomatal conductance and assimilation. Productive genotypes which also sustain growth and yield under variable moisture and temperature conditions express higher stomatal conductance and gas exchange (Horie et al. 2006; Blum 2011; Reynolds et al., 2012; Blum, 2013; Wang et al., 2014).

Table 2. Mean values for grain mass spike^{-1} of triticale cultivars in different growing seasons

Genotype	grains mass spike^{-1} (g)			
	Year			Average
	2010/11	2011/12	2012/13	
KG 20	2.12gh	2.26cde	2.13fgh	2.17c
Bolero	2.19efgh	2.08h	2.20defg	2.15c
Rtanj	2.34c	2.20defg	2.24cdef	2.26b
Odisej	2.49b	2.26cde	2.81a	2.52a
Bogo	2.31cd	2.20defg	2.34c	2.28b
Average	2.29	2.20	2.34	2.28

Distinct letters in the row indicate significant differences according to LSD test ($P \leq 0.05$).

Through the analasys of variance highly significant differences were detemined among grains mass spike^{-1} of different genotypes (F=59.017**), then among years of research (F=23,523**), and their interactions as well (F=16.406**), table 3. Differences among cultivars of triticale according to grin mass spike^{-1} influenced with genetic specificity and different regime of temperature and precipitation during vegetative period in experimental years. It means that grain mass spike^{-1} is highly depended on genetic and interaction genetic/environmental factors.

Table 3. Analysis of variance for grain mass spike^{-1} (g)

Source of variance	*Degree of freedom* (DF)	*Mean square* (MS)	F-test	*LSD*		*Components of variance*	
				0.05	0.01	σ^2	%
Repetitions (R)	4	0.002	0.401^{ns}	-	-	-	-
Genotypes (G)	4	0.326	59.017**	0.0785	0.1302	0.016	39.03
Year (Y)	2	0.130	23.523**	0.0943	0.2174	0.002	4.88
Interaction (GxY)	8	0.091	16.406**	0.1130	0.1644	0.017	41.46
Error	56	0.006	-	-	-	0.006	14.63
Total	74	-	-	-	-	0.041	100.00

* Significant at P = 0.05 level; ** significant at P = 0.01 level

The investigated genotypes of triticale expressed significant differences for the average values of grain mass spike^{-1} in different year of growing that indicates on diversity of examined genotypes. Variability of grain mass spike^{-1} depended on investigated genotypes and year as well what is in agreement of investigation. These findings are in agreement with previous study (Knezevic et al., 2010; Kondić et al., 2012; Madic et al., 2015). For increasing grain mass spike^{-1} the important role have morphological and anatomical structure of plants and their organs (Kondić et al., 2012).

Conclusion

The analyzed triticale cultivars showed differences in average values of grain mass spike^{-1} what indicates that these genotypes are specific. The cultivars examined in this study had different values of grain mass spike^{-1} in the years of examination what indicates different reaction of a investigated cultivars to different conditions during its development. The expression of variability of grain mass spike^{-1} were influenced by genetic and environmental factor. The effect of genetic factor and interaction of genetic/environmental was highly significant. The largest impact of environmental factor (annual and monthly average value of temperature, precipitation) with 41.46% and the genotypes with 39.03% of variance. Promising genotypes for use in the breeding process are those that have expressed the stability of mass of spike in different climate with high average values, and among them are the cultivar Odisej and Bogo. The grain mass spike^{-1} was different for the analyzed triticale cultivars and play important role in forming of grain yield. However, increasing of genetic potential of grain yield is achievable through improvement of other quantitative characteristics, as well as increase of the size and capacity of spike as well as improvement of anatomical structure of spike. The phenotypic variability is possible to identify which genotype could be involved in future triticale breeding programs.

Acknowledgements

This investigation supported by Ministry of Education, Science and Technology Development of Republic of Serbia, Project TR 31092.

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