UDC 575:633
DOI: 10.2298/GENSR1202419K
Original scientific paper

GRAIN WEIGHT OF GENOTYPES OF TRITICALE (X *TRITICOSECALE WITTMACK*) IN AGROECOLOGICAL CONDITIONS OF BANJA LUKA

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Kondić D., D. Knežević, and A. Paunović (2012): *Grain weight of genotypes of triticale (X Triticosecale Wittmack) in agroecological conditions of Banja Luka.* - Genetika, Vol 44, No. 2, 419 - 428.

Grain weight is a genotypic characteristic that is directly related to the realization of yield. Analysis of average grain weight was performed in ten genotypes of winter hexaploid triticale (Trimaran, Ticino, Odisej, Agrano, BLT21, BLT17, BLT10, Max 1793, Bogo and Tornado). Experiment was conducted during 2005/06, 2006/07, 2007/08. in Trapisti, region Banja Luka. During the experiment of winter triticale standard agricultural practice was applied. Microclimatic conditions during triticale

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cultivation in 2006 and 2008. were relatively similar, while in 2007. there was drought period occurrence. Statistical analysis of observed genotypes for the specified parameter was performed with method analysis of variance 10x3. Analyses of significant differences were done by using LSD test, while interactive effect was analyzed by graphical method. The average weight of triticale genotypes grain regardless of the year showed highly statistically significant differences, while in observation of years regardless of the genotype showed mutually statistically significant differences. Analysis of these relationships was observed through the interaction effects as a final evaluation of the observed genotypes. Based on the average values of the grain weight, winter triticale genotypes were evaluated. The average grain weight of triticale genotypes in the observed years showed the lowest average weight in 2007 (0.0369 g), while the highest grain weight was obtained in 2006 (0.0406 g). Statistically significant difference of the average grain weight of the observed genotypes of triticale regardless of the year showed that genotypes Bogo (0.0465 g), Odisej (0.0453 g) and BLT10 (0.0424 g) were those of the highest average grain weight without significant differences between them. These genotypes were evaluated as potentially productive genotypes under the agroecological conditions of Banja Luka.

Key words: genotypes, grain weight, interaction, triticale

INTRODUCTION

Grain weight is a genotypic characteristic that is directly related to the realization of yield. Drought (ROYO *et al*., 2000) and temperature stress (GIBSON and PAULSON, 1999) after flowering often have a damaging effect of reducing the grain weight, and thus grain yield per hectare. Triticale is characterized by the appearance of gradual physiological senescence, i.e. extension of functional activity of leaf apparatus, resulting in long-term progress of the process of formation and grain filling. Due to the gradual physiological senescence of leaf apparatus, in triticale grain are accumulated for 1-2% more proteins than in the wheat grain, or 3-5% more proteins than in the rye grain. It is essential that during the period of formation and grain filling the soil should be sufficiently supplied with water and minerals. The increasing of nitrogen dose effected on improving technological quality of triticale cultivars (ZEČEVIĆ *et al*. 2010). If the soil is not sufficiently supplied with nutrients it leads to shortening of the period of formation and grain filling, which negatively affects both the yield and quality of the grain (KOVAČEVIĆ *et al.* 2011). Quality of triticale depends on genotype, environment and their interaction and can be improved by application of nitrogen fertilizer. Fertilisation by nitrogen effected on increasing yield of grain and protein as well as crude protein content, non-protein nitrogen and true solubleprotein contents (ZEČEVIĆ *et al*. 2009; LESTINGI *et al*. 2010). The triticale varieties have very high grain weights, and values of grain weights are comparable or superior to many other cereal grains. Triticale grain is a potential source of nutritional substances in human and animal nutrition. Primarily it

refers to its high content of starch in the endosperm. Investigation of OBUCHOWSKI *et al.* (2010) showed that nitrogen fertilisation level, location and year, have a influence to the starch level in triticale grain and gluten content (ALARU *et al.*, 2003). Protein content, in average, is higher than in wheat.

The aim of this study was to examine variability of grain weight of different genotypes of triticale grown in different environmental condition.

MATERIALS AND METHODS

Examination of the grain weight of different genotypes of triticale was conducted in experiment during 2005/06, 2006/07 and 2007/08 under the ecological conditions in Banja Luka. In this study we used ten triticale genotypes originating from different countries: Trimaran, Ticino, Odisej, Agrano, BLT21, BLT17, BLT10, Mah 1793, Bogo and Tornado. Genotype BLT21 is recognized as a variety Oscar, while genotype BLT10 is recognized as a variety Viktor. All examined genotypes belong to hexaploid triticale. In all three experimental years the experiment was conducted as a randomized block design with five repetitions in the locality Trapisti. During the experiment of winter triticale standard agricultural practice was applied. In all three experimental years sowing was completed in mid-October and harvested at the stage of full maturity. Soil on which the experiments were performed is of the type of alluvial carbonate soil (fluvisol).

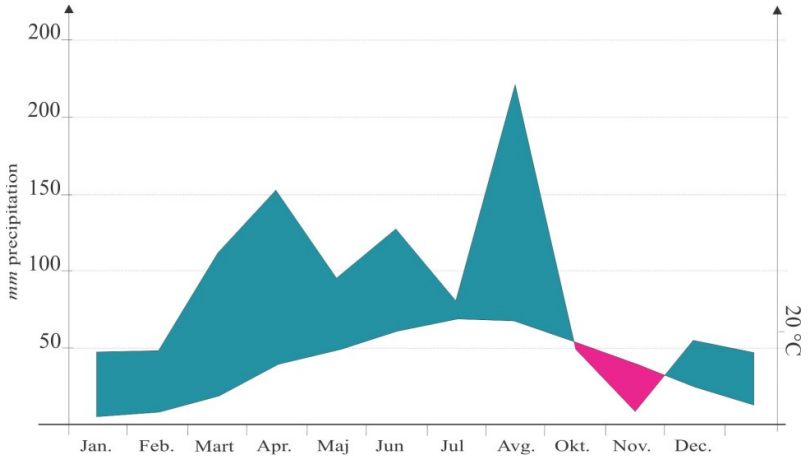

Figure 1. Climate diagram according to Walter in 2006 (WALTER, 1955)

Evaluation of microclimatic conditions for the year 2006 shows the appearance of a dry period from mid-October to early December (Figure 1). The appearance of a dry period could only have impact on the preparation of soil for the

sowing of triticale in the year 2007, as well as the germination and preparation of plants for the winter.

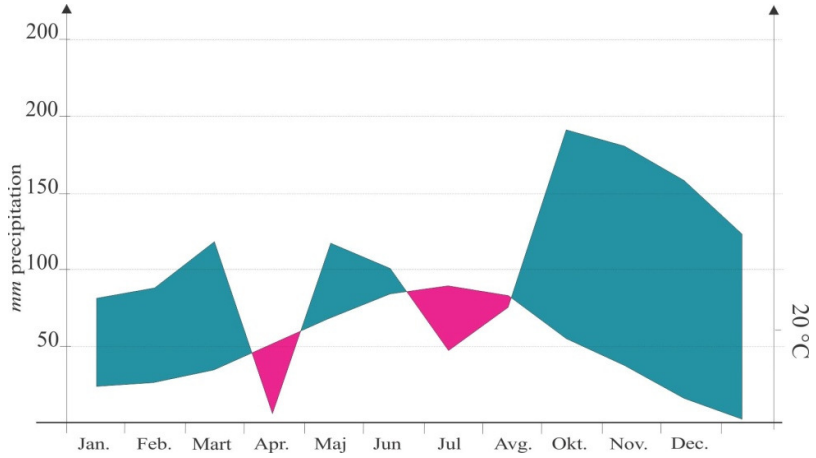

Figure 2. Climate diagram according to Walter in 2007 (WALTER, 1955)

Evaluation of microclimatic conditions for the year 2007 shows the occurrence of drought periods during the entire April and in the period from late June to mid-August (Figure 2). Given the fact that the drought period occurred during November in 2006, growing triticale in the year 2007 was potentially exposed to stress on the microclimate conditions in the region of Banja Luka.

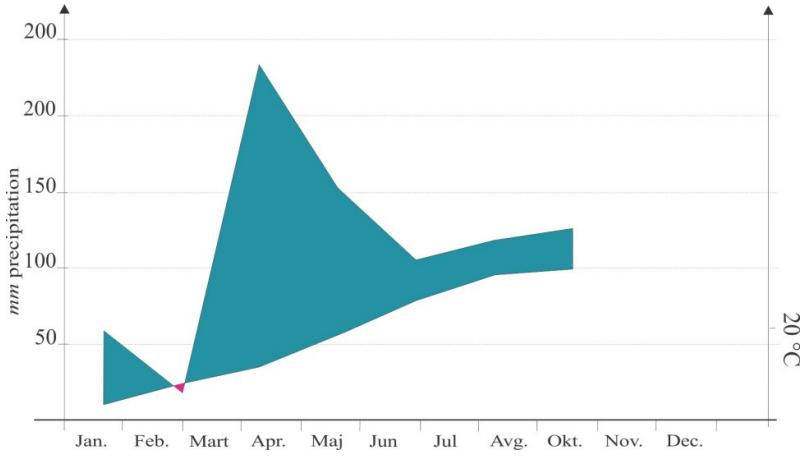

Figure 3. Climate diagram according to Walter in 2008 (WALTER, 1955)

Evaluation of microclimatic conditions for the year 2008 shows the appearance of a very short dry period in early March. During April and May there appeared wet period that may be indicative of the growth and development of triticale in the year 2008 (Figure 3). Microclimatic conditions during triticale cultivation in 2006 and 2008 were relatively similar, while in 2007 there was drought period occurrence. Statistical analysis of observed genotypes for the specified parameter was performed with method analysis of variance 10x3. The significant differences among the means were estimated according to least significant difference LSD test, while interactive effect was analyzed by graphical method (MIĆIĆ, 2011).

RESULTS AND DISCUSSION

The data of the average grain weight of examined triticale genotypes are expressed in grams and are given in Table 1.

The average grain weight of the examined genotypes of triticale regardless of the year show mutual statistically highly significant differences, and a year regardless of the genotype show mutual significant differences. Analysis of these relationships was observed through the interaction effect. Analysis of interaction in relation to the average grain weight of genotypes studied by years was performed by the graphic and is given in Fig. 4. According to data from Table 1. it is evident that the lowest average grain weight had the genotypes Ticino and Tornado in 2007 (0.031 g), and the highest average grain weight had a genotype Odisej in 2008 (0.050 g). The lowest average grain weight of the genotypes of triticale regardless of the year had a genotype Ticino (0.0300 g), while the highest average grain weight had the genotype Bogo (0.0465 g). Testing the significance of difference of the average grain weight of the examined triticale genotypes regardless of the year shows that genotypes BLT10 (0.424 g), Odisej (0.0453 g) and Bogo (0.0465 g) are genotypes with highest average grain weight and between them was no statistically significant difference.

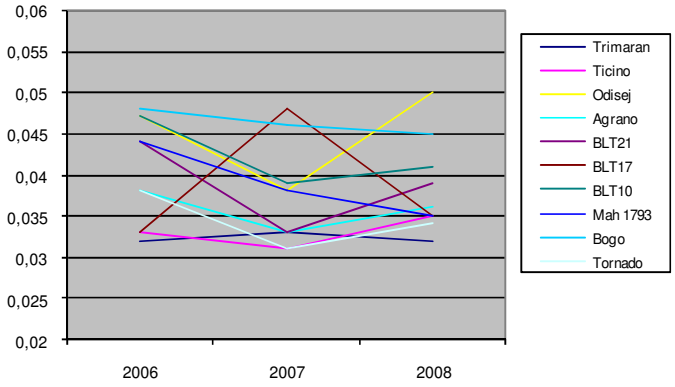

Figure 4. Interactive relation (AB) of the average grain weight of triticale genotypes tested in three years

Tab. 1. The average grain weight (g) of the examined genotypes of triticale

	Year	2006	2007	2008	
	Genotype	$\overline{X} \pm S_x$	$\overline{X} \pm S_x$	$\overline{X} \pm S_x$	$\overline{X}A$
1.	Trimaran	0,032 ± 0,002	0,033 ± 0,002	0,032 ± 0,003	0,0322
2.	Ticino	0,033 ± 0,0006	0,031 ± 0,001	0,035 ± 0,002	0,0300
3.	Odisej	0,047 ± 0,001	0,038 ± 0,003	0,050 ± 0,02	0,0453
4.	Agrano	0,038 ± 0,002	0,033 ± 0,002	0,036 ± 0,0009	0,0363
5.	BLT21	0,044 ± 0,001	0,033 ± 0,003	0,039 ± 0,001	0,0383
6.	BLT17	0,033 ± 0,002	0,048 ± 0,003	0,035 ± 0,002	0,0398
7.	BLT10	0,047 ± 0,001	0,039 ± 0,003	0,041 ± 0,002	0,0424
8.	Mah 1793	0,044 ± 0,001	0,038 ± 0,003	0,035 ± 0,002	0,0389
9.	Bogo	0,048 ± 0,003	0,046 ± 0,003	0,045 ± 0,002	0,0465
10.	Tornado	0,038 ± 0,002	0,031 ± 0,002	0,034 ± 0,002	0,0343
	$\overline{X}B$	0,0406	0,0369	0,0381	

The main factors		A	B	AB
Analysis of variance - F		15,766**	7,412*	3,621*
LSD	0,05	0,005	0,004	0,004
	0,01	0,007	0,010	0,006

Genotypes Trimaran (0.0322 g), Ticino (0.0300 g) and Tornado (0.0343 g) had the lowest average grain weight, and there was no statistically significant difference between them.

Genotypes Agrano (0.0363 g), BLT21 (0.0383 g), Mah 1793 (0.0389 g) and BLT17 (0.0398 g) according to the average grain weight are between these two groups. The average grain weight of the genotypes of triticale in the observed years, regardless of genotype indicates that the smallest average grain weight of the genotypes of triticale was in 2007 (0.0369 g) and the highest in 2006 (0.0406 g). Given that genotype BLT17 was not recognized by the Committee for Variety, a more detailed study of genotypic and ecophysiological traits may be of interest for further selection of this genotype. The average grain weight of the examined genotypes of triticale varied and established highly significant differences between

genotypes and significant differences between years of study can be viewed as a result of interaction of genotype/environment. Unfavorable environmental conditions in 2007 influenced to appear lower average grain weight in 6 genotypes (BLT10, BLT21, Agrano, Tornado, Odisej and Ticino) in relation to the remaining two years of testing. Also, genotypes Mah 1793 and Bogo manifest tendency of slight decrease in average grain weight in 2007 and in 2008 comparing it to 2006. However, genotype Trimaran exhibits a slightly higher average grain weight in 2007 comparing it to the grain weight in 2006 and 2008, while the genotype BLT17 exhibits a highly significantly increased average grain weight in 2007 comparing it to the average grain weight in 2006 and 2008 that are mutually not significantly different. Reducing of average grain weight in eight genotypes of triticale (BLT10, BLT21, Agrano, Tornado, Odisej, Ticino, Bogo and Mah1793) in 2007 comparing to the remaining two years of testing may be associated with adverse environmental conditions. However, two genotypes (Trimaran and BLT17) in 2007 had higher average grain weight, compared to the other two years of testing, which can be correlated with specific genotypic interaction and genetic differences manifested in the occurrence and duration of growth stages. Grain weight is associated with grain size and grain filling.

The expressed differences of grain weight are influenced by genetic specificity of investigated triticale genotypes and their interaction with environment. Genotype specificities are reflected in all three years of plant growth. The abiotic factors caused great variation in grain filling as well as in weight of grain. Reduced grain filling period by drought stress have influence to grain weight decreasing. Also, nitrogen plays important role in triticale nutrition and contributes to increasing of productivity (KINACI and GULMEZOGLU, 2007). However, there are differences in degrees of adaptability of plant species and cultivars to rate and mode of supplies of mineral element, as well to any other abiotic factor (KNEŽEVIĆ *et. al.* 2007). Low rainfall in October and November 2006 as well in April of 2007 (Fig. 1 and 2) stressed triticale, decreasing average grain weight in 2007 (Table 1).

Analysis of the demonstrated interaction effects indicates the following tendencies:

- genotypes BLT10, BLT21, Tornado and Agrano manifest an average decrease of grain weight in 2007 compared to 2006, and then a smaller increase in average weight in 2008, provided that it does not reach the level of average weight in 2006;
- genotypes Odisej and Ticino show a decrease in average weight in 2007 provided that they show a distinct increase in weight and it is significantly higher in 2008 than in 2006;
- genotype Trimaran showed relatively low variation, that is average grain weight with no significant difference in years of investigation;
- genotypes Bogo and Mah 1793 manifest a tendency to decrease the average grain weight in 2007 and 2008;

- genotype BLT17 manifests a completely opposite tendency compared to all genotypes, so that the average grain weight of this genotype showed a highly significant increase in 2007 compared to 2006, then a highly significant decrease in 2008 compared to 2007, provided that the average mass difference between the 2006 and 2008 is statistically random.

CONCLUSIONS

Based on the results obtained during the investigation we can conclude the following:

- The minimum average grain weight (0.0300 g) was in the genotype Ticino, while the highest observed was for genotypes of Odisej (0.0453 g) and Bogo (0.0465 g);
- Established variation in morphometric features of the same genotype in the testing years indicated the significant impact of agro-ecological factors on the manifestation of feature;
- Generally, the lowest value of studied morphometric features achieved almost all genotypes of triticale in the experimental year 2006/07 compared to the other two experimental years. This was the result of genotypic reaction to weather conditions over the year, in which during the vegetation period average temperatures of air were higher, and amount of rainfall was lower than in the remaining two years;
- Exception are genotypes Trimaran and BLT17 that in 2007 achieved higher average grain weight compared to the other two years which can be correlated with physiological activity at the stage after blossoming, larger potential for accumulation of dry matter, and favourable ecophysiological conditions at the stage of vegetative development in the climatic conditions of the year;
- Realized values of the average grain weight are connected to the photosynthetic potential of the formation and translocation of organic matter during the grain filling. Moreover, a significant impact to the value of the studied feature has also the other environmental factors (water regime, mineral nutrition, and primarily nitrogen nutrition, temperature regime of soil and air, crop density, etc.) but they were not the subject of study in this paper.

ACKNOWLEDGEMENTS

Authors gratefully acknowledge the financial support by the Ministry of Education and Science of Republic Serbia, Belgrade, Project Code TR-31092

Received June 17th, 2012
Accepted July 23rd, 2012

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MASA ZRNA GENOTIPOVA TRITIKALEA (X *TRITICOSECALE WITTMACK*) U AGROEKOLOŠKIM USLOVIMA BANJA LUKE

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Masa zrna je genotipska karakteristika koja se direktno vezuje za realizaciju prinosa. U ovom radu je izučavana masa zrna kod 10 genotipova ozimog heksaploidnog tritikalea (Trimaran, Ticino, Odisej, Agrano, BLT21, BLT17, BLT10, Max 1793, Bogo i Tornado). Eksperiment je izveden u toku 2005/06, 2006/07, 2007/08. u Trapistima, region Banja Luka, u kome je primenjena standardna agrotehnika. U toku izučavanja, klimatski uslovi u dvije eksperimentalne godine 2006. i 2008. su bili relativno slični, dok je u 2007. godini bio izražen period suše. Rezultati su pokazali statistički visoko značajne razlike u masi zrna kod izučavanih genotipova tritikalea bez obzira na godine istraživanja, dok su statistički značajne razlike konstatovane između godina bez obzira na genotip. Analiza ovih odnosa posmatrana je kroz interakcijske efekte kao zaključna ocjena posmatranih genotipova. Najmanja prosječna vrijednost mase zrna (0,0369 g) za izučavane genotipove tritikalea je dobijena u 2007. eksperimentalnoj godini, a najveća prosječna masa zrna (0,0406 g) je dobijena u 2006. godini. Genotipovi Bogo (0,0465 g), Odisej (0,0453 g) i BLT10 (0,0424 g) su imali značajno veću prosječnu masu zrna od ostalih izučavanih genotipova bez obzira na godinu. Ova tri genotipa nisu se statistički značajno razlikovali za masu zrna i pokazala su najbolju adaptivnost na agroekološke uslove Banja Luke.

Primljeno 17. VI. 2012.
Odobreno 23. VII. 2012.