JOURNAL OF AGRICULTURE AND PLANT SCIENCES, Vol 16, No. 1, 2018

Manuscript received: 01.06.2018
Accepted: 27.06.2018

In print: ISSN 2545-4447
On line: ISSN 2545-4455
UDC: 633.16-152.61:
631.95(497.723)"2013/2014"
Original scientific paper

r

GENETIC AND ENVIRONMENTAL EFFECT ON THE GRAIN YIELD OF SPRING BARLEY VARIETIES CULTIVATED IN THE REPUBLIC OF MACEDONIA

Nenad Petkovski[1], Ljupco Mihajlov[1], Natalija Markova Ruzdik[1]

[1]Goce Delcev University, Faculty of Agriculture, Krste Misirkov. 2000 Stip, Republic of Macedonia
**Corresponding author: nenad_petkovski13@yahoo.com*

Abstract

The aim of this paper was to evaluate the genetic and environmental effect on the grain yield of spring barley varieties cultivated in the Republic of Macedonia.

Five spring barley varieties (Makedo, Xanadu, Josefin, Gladys and Scarlet) were used as an experimental material. Makedo is Macedonian variety and the other barley cultivars are imported. The field experiments were carried out during 2013 and 2014 on the field areas in Probistip, Republic of Macedonia. The experiment design was randomized complete block with three replications. The results were analyzed to synthesize the relative proportion of the influence factor (η %) such as variety or year, as well as the interaction between variety and year on the grain yield. Besides the year conditions, the impact of variety contributed significantly to the overall variability of yield (over 98 %), compared to the influence of year and the interaction between variety and year. Makedo variety showed the highest value for grain yield (6 844 kg/ha), followed by Xanadu (6 638 kg/ha). The average grain yield for all tested varieties for both years of examination was 6 544 kg/ha. Also, Makedo variety has the highest values for number of spikes per m^2 and the number of grain per spike.

Key words: *grain yield*, *barley*, *variety*, *yield components*

INTRODUCTION

After wheat, rice and maize, barley is the fourth most significant crop (Abebe, 2010). Barley is used as a livestock feed, for malt and for preparing foods. Among the cereal crops, barley is a species with the greatest adaptability to a wide range of environments. Barley is cultivated from arctic latitudes to tropical areas, grown at the highest altitudes and adapted to specific sets of agro-ecological areas (Alemayehu and Parlevliet, 1997).

In Republic of Macedonia barley and wheat are the principal cereal crops. In 2016, barley production was 144 832 t with average grain yield of 3 507 kg/ha (FAOSTAT, 2016). On the National variety list in the Republic of Macedonia, besides autumn forms of barley, only one variety (Makedo) is registered as a spring domestic variety (MAFWE, 2008).

Successful growing of spring barley depends on many factors. Productivity is the final result of the effect and interactions of several yield-related traits, which are basically polygenic, (Madić et al., 2014). The grain yield and quality traits of barley are determined by its genetic makeup and environment conditions during growth, harvest and storage. Variation of yield and major chemical components of barley grain is genetically controlled (Eagles et al., 1995), but it is also influenced by environmental factors (Helm, 1992; Paynter and Young, 2004).

Also, numerous tests have been performed which confirmed that proper and balanced cereals diet is essential to improve the yield and quality and can directly or indirectly affect the efficiency of the other agro-technical measures (Popescu et al., 1997). Basic nutrients, such as

nitrogen, potassium, sulphur and magnesium are crucial elements in many processes in the development of the plant and the formation of the yield (Randahwa and Arora, 2000), but besides this elements, microelements play a large role in the quality of final product as well. Awasti and Brahm (1994) reported that barley yield was increased by increasing the dose of nitrogen.

The yield formation can be defined as the interaction effect of soil and climatic conditions, genotype, fertilization and growing technology (Barczak and Majcherczak, 2008). Grain yield is made up of three main different yield components, the number of spikes, the number of grains per spike and the thousand-kernel weight. According to Kavitha et al., (2009), Sukram et al., (2010) productive tiller per plant, number of grains per spike and 1 000 grains weight would be more useful criteria for selecting high yield barley varieties.

The objective of this study was to determine the genetic potential and the influence of variety, environment and their interaction on grain yield in spring barley varieties, grown in Macedonia.

MATERIAL AND METHODS

Plant material and experimental design

The experiment was carried out on the field areas in Probistip, Republic of Macedonia. Probistip is an urban municipality in eastern part of the Republic of Macedonia, located at 42°00'11" N and 22°10'42" E, with an elevation above sea level of 589 m. The annual mean temperature of this city is 10°C with relative humidity around 70 % and average annual rainfall of 450 - 500 mm.

Field trials were conducted during two years (2013 and 2014). Five spring barley varieties (*Makedo*, *Xanadu*, *Josefin Variety*, *Gladys* and *Scarlet*) were used as an experimental material for this study. Only *Makedo* variety is Macedonian and the other barley cultivars are imported. The experimental material was placed by using randomized block design in three replications. The size of experimental plots was 5m^2.

In 2013 the sowing was done on 19 March and in second testing year on 17 March. The sowing was made by hand with 20 cm space within rows. The standard growing measures were applied during the vegetation. The harvest was done by hand also.

Data collection

To quantify the yield, we measured its three most important components, respectively the number of spike per m^2, the number of grain per spike and 1 000 grain weight.

Ten randomly selected plants from each repetition have been analyzed for the plant height (cm) and number of grains per spike. The number of spike per m^2 was determined by counting the plants from m^2 of each repetition. 1 000 grains weight, has been determined to measure 1 000 grains of each repetition. Grain yield obtained from the 5 m^2 was calculated in kg/ha.

Statistical analysis

For the analysis of variance (ANOVA) the statistical package SPSS (2010) was used. Least significant difference (LSD) was calculated using Statistical analysis system software JMP (2002).

RESULTS AND DISCUSSION

Due to short vegetation period extending for about 100 days and poorly developed root system, spring barley is very sensitive to drought stresses, even if they are temporary (Pecio and Wach, 2015). Increasing temperature, even without significant changes in precipitation may cause the deepening of the already negative water balance (Kozyra et al., 2009).

In our study, meteorological data do not differ for both years of testing. The average air temperature during the first year of study was 29,6° C, while for the second testing year was 29,2° C. This means that the temperature values were favourable for optimal plant development and high yield.

Figure 1 illustrates the average, lowest and the highest values of grain yield of the tested barley varieties in the period of study. Furthermore, Figure 1 presents that *Makedo* variety has the highest average value for grain yield and in the same time had the lowest rang of variation, followed by *Xanadu* and *Gladys*. The lowest grain yield was record by *Scarlet* variety.

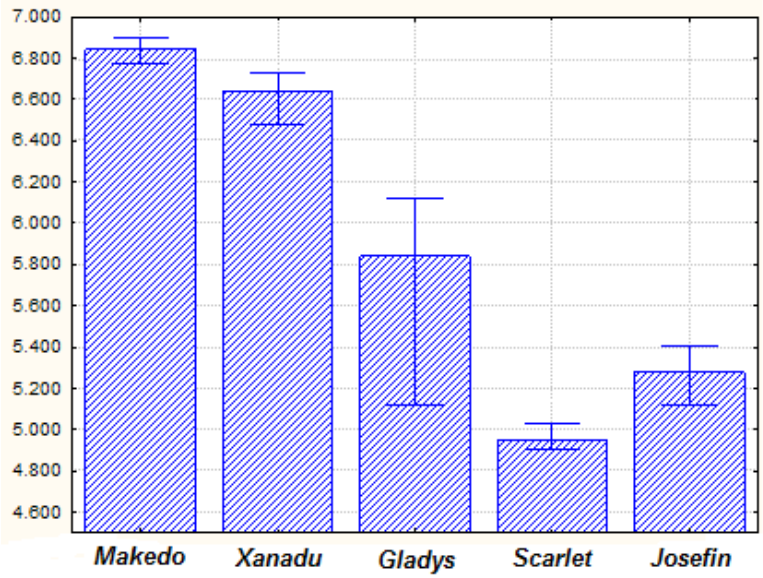

Figure 1. Average values and rang of variation for grain yield (kg/ha) at barley varieties during the period of study

Barley varieties are known to have different yield potentials which depend on many factors (Fettel, 1999; Mackenzie, 2005).

In Table 1 are given the average values for grain yield and some yield-related traits of barley varieties during the study period. LSD test showed significant difference between tested varieties and traits.

Table 1. Average values for grain yield and some yield-related traits during the period of study

Variety	Plant height (cm)	Number of spike per m^2	Number of grain per spike	1 000 grain weight (g)	Grain yield (kg/ha)
Makedo	64,8c	672a	22a	49,4a	6 844a
Xanadu	64,4c	617c	20b	43,5c	6 638a
Gladys	68,8b	576d	20b	50,1a	5 841a
Scarlet	69,8b	638b	20b	46,3b	4 949b
Josefin	76,3a	517e	20b	45,8b	5 279ab
Mean	**68,8**	**604**	**21**	**47,1**	**6 544**
$LSD_{0.05}$	**1,32**	**20,32**	**1,05**	**1,81**	**1 922,3**
CV (%)	**1,05**	**1,85**	**2,80**	**2,12**	**18,72**

Our research shows that Josefin variety has the highest value for plant height (76,3 cm), followed by Scarlet variety (69,8 cm). No significant differences were found between Makedo and Xanadu variety. Plant height has the lowest coefficient of variation (1.05 %).

Number of spike per m^2 plays important role in yield formation. LSD test show that all tested varieties significantly differ and cultivars belong to different group (Table 1). Makedo variety had the largest number of spike per m^2 (672) and the lowest was notes by Josefin cultivar. The mean value for this trait during the period of study was 604.

Number of grain per spike is one of the main yield-related components. According to LSD, there were not significant differences between tested barley varieties except for Makedo variety. This cultivar has the largest number of grain per spike (22) and the mean value for this property was 21 grains per spike for all analyzed varieties.

1 000 grain weight is a quality trait and it is indicator for the size and grain thickness. This property depends on variety genetic, but also of environmental conditions. On the other hand, 1 000 grain weight is less sensitive to climatic factors compared to grain yield. In this research

1 000 grain weight ranges from 43,5 g to 50,1 g, with average value of 47,1 g. *Gladys* variety had the highest average value (50,1 g), followed by Makedo (49,4 g). Bleidere (2008) also reported similar values for this trait.

From all tested barley varieties, the genetic potential of grain yield, mostly come to expression at Makedo variety. Macedonian variety showed 6 844 kg/ha average grain yield, followed by *Xanadu* (6 638 kg/ha). The average grain yield for all tested varieties for both years of examination was 6 544 kg/ha. According to Andrejčíková et al., (2016) the average value for grain yield during period of study (2011-2012) was 7 178 kg/ha.

In order to see how changes of environmental conditions and variety influence to the grain yield, it is necessary to assess the interaction between variety and the environmental conditions. Today, there are many papers in which the influence of variety, year conditions and their interactions on grain yield is explained (Markova Ruzdik et al., 2015). According to the results of ANOVA (Table 2), grain yield was significantly affected by the variety (98.79 %). The effect of year conditions and the interaction between variety and year had lower impact on grain yield (0.08 % and 1,13 %, successively).

Table 2. The influence of variety, year and their interaction on grain yield

Factor	Sum of Squares	df	Mean Squere	F	η
Total	17,204	30			
Factor (A) - variety	16,363	4	4,091	127,734	**98,79***
Factor (B) - year	0,013	1	0,013	0,399	0,08
A x B	0,187	4	0,047	1,462	1,13
Error	0,641	20	0,032		

CONCLUDING REMARKS

From the performed research it can be concluded that Makedo variety had the highest value for grain yield, followed by Xanadu variety. Also, Makedo cultivar had the highest number of spike per m^2 and the number of grain per spike. These results showed that Makedo variety is suitable for cultivation and should be more present in barley production. The study had proved that the variety has the strongest impact over grain yield during the period of research.

Except Makedo variety, also Xanadu and Gladys cultivars can be introduced in barley production or to be chosen as the most suitable varieties for new parents in any future breeding process, in order to get the new high yielding varieties suitable for cultivation in Republic of Macedonia.

REFERENCES

Abebe, T.D. (2010). *Genetic diversity and population differentiation analysis of Ethiopian barley (Hordeum vulgare L.) landraces using morphological traits and SSR markers*. Wellega, Ethiopia.

Alemayehu, F., & Parlevliet, J.E. (1997). Variation between and within Ethiopian barley landraces. *Euphytica*, 94, 183-189.

Andrejčíkova, M., Macàk, M., & Habàn, M. (2016). Yield potential of spring malting barley (*Hordeum vulgare* L.) varieties in the growing conditions of south-western Slovakia. *Journal of Central European Agriculture*, 17(4), 932-940.

Awasti, U.D., & Brahm, S. (1994). Physiological response of barley genotipes to nitrogen levels under moisture scarce conditions on light extrude soils of Central Utter Pardash. *Indian Journal of Plant Physiology*, 37, 32-34.

Barczak, B., & Majcherczak, E. (2008). Effect of varied fertilization with sulfur on selected spring barley yield structure components. *Journal of Central European Agriculture*, 9 (4), 777-784.

Bleidere, M. (2008). Genetic and environmental effects on the grain quality of spring barley. *Latvian Journal of Agronomy*, 11,

33-38.

Eagles, H.A., Bedggod, A.G., Panozzo, J.F., & Martin, P.J. (1995). Cultivar and environmental effects on malting quality in barley. *Australian Journal of Agricultural Research*, 46, 831-844.

FAOSTAT (2016). World crop production. Published online ahttp://www.faostat.fao.org.

Fettell, N.A., Moody, D.B., Long, N., & Flood. (1999). Determinants of grain size in malting barley. In ''9th Australian Barley Technical Symposium". Melbourne, Victoria. (Eds. D. B. Moody, R. G. Flood) (The Regional Institute Ltd).

Helm, J.H. (1992). Cultivar and growing location effects on composition of barley grains, Barley for food and malt. Proceedings of International symposium, September 7-10, Sweden, 308-312.

JMP (2002). Version 5.0 1a, A Business Unit of SAS 1989 - 2002 SAS Institute Inc.

Kavitha, G., Dhindsa, G.S., Singh, S., & Singh, J. (2009). Stability analysis of yield and its components in malt barley (*Hordeum vulgare* L.) genotypes. *Journal of Crop Improvement,* 36(1), 29 – 34.

Kozyra, J., Doroszewski, A., & Nieróbca, A. (2009). Climate change and its expected impact on agriculture in Poland. *Studia i Raporty IUNG-PIB*, 14, 243-257.

Madić, M.R., Djurović, D.S., Knezević, D.S., Paunović, A.S., & Tanasković, S.T. (2014). Combining abilities for spike traits in a diallel cross of barley. *Journal of Central European Agriculture*, 15 (1), 108-116.

MAFWE (2008). *National variety list of Republic of Macedonia*. RI Grafica, Skopje, Republic of Macedonia.

Markova Ruzdik, N., Vulcheva, D., Mihajlov, Lj., Mitrev, S., Karov, I., & Ilieva, V. (2015). The influence of environment on yield and yield components in two row winter barley varieties. *Bulgarian Journal of Agricultural Science*, 21, (4), 863-871.

Mckenzie, R., Middleton, H.A.B., & Brener, E. (2005). Fertilization, seeding rate and seeding date of malting barley yield and quality in southern Alberta. *Canadian Journal of Plant Science*, 85, (3), 603-614.

Paynter, B.H., & Young, K.J. (2004). Grain and malting quality in two-row spring barley are influenced by grain filling moisture. *Australian Journal Agricultural Research*, 55, 539-550.

Pecio, A., & Wach, D. (2015). Grain yield and yield components of spring barley genotypes as the indicators of their tolerance to temporal drought stress. *Polish Journal of Agronomy*, 21, 19-27.

Popescu, S., Idriceanu, A., Stan, S., Mihãilã, V., Negrilã, M., Povarnã, F.I., & Ionescu, F. (1997). Implicaþii ale dezechilibrelor nutritive in sintenza proteinei la grau. An. I.C.C.P.T Fundulea.

Randahwa, P.S., & Arora, C.L. (2000). P and S interaction effect on dry matter yield and nutrient uptake by wheat. *Journal of Indian society of soil science*, 48, (3), 536-540.

SPSS Statistics 19 (2010). SPSS Inc., an IBM Company.

Sukram, P., Tejveer, S., & Ramesh, B. (2010). Estimation of genetic parameters in barley (*Hordeum vulgare* L.). *Journal of Crop Improvement* (Abs.) 37, (1), 52 – 56.

ГЕНЕТСКИОТ ПОТЕНЦИЈАЛ И ВЛИЈАНИЕТО НА НАДВОРЕШНАТА СРЕДИНА ВРЗ ПРИНОСОТ КАЈ ПРОЛЕТНИ ФОРМИ НА ЈАЧМЕН ОДГЛЕДУВАНИ ВО РЕПУБЛИКА МАКЕДОНИЈА

Ненад Петковски[1*], Љупчо Михајлов[1], Наталија Маркова Руждиќ[1]

Универзитет „Гоце Делчев", Земјоделски факултет, „Крсте Мисирков" бб, 2000 Штип, Република Македонија

*Контакт автор: nenad_petkovski13@yahoo.com

Резиме

Целта на овој труд е да се одредат генетскиот потенцијал и влијанието на надворешната средина врз приносот кај пролетни форми на јачмен одгледувани во Република Македонија. Како експериментален материјал се користени пет пролетни форми на јачмен (*македо*, *ханаду*, *јозефин, гладус* и *скарлет*). *Македо* е македонска сорта, а останатите сорти на јачмен имаат странско потекло. Полските експерименти беа реализирани во текот на 2013 и 2014 година на површините во Пробиштип, Република Македонија. Опитот беше поставен во рандомизиран блок-систем во три повторувања. Истражувањата беа направени со цел да се утврди дали сортата, надворешните услови или нивната интеракција е главниот фактор на влијание (η) врз приносот на зрно. И покрај значајноста на климатските фактори врз приносот на зрно, во овие истражувања се покажа дека главен фактор кој има силно влијание врз приносот е сортата. Влијанието на сортата врз формирањето на приносот е над 98%. Највисок принос беше добиен од сортата *македо* (6844 kg/ha), а веднаш по неа следуваше ханаду со 6638 kg/ha. Просечниот принос на зрно од двете години на испитување беше 6544 kg/ha. Сортата *македо,* исто така, имаше и најголем број на класови на m^2 и најголем број на зрна во клас.

Клучни зборови: *принос на зрно*, *јачмен*, *сорта*, *компоненти на принос*