Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 20, Issue 1, 2020
PRINT ISSN 2284-7995, E-ISSN 2285-3952

VARIABILITY OF YIELD TRAITS IN A GERMOPLASM OF BARLEY CULTIVARS, STUDIED AT TURDA AGRICULTURAL RESEARCH AND DEVELOPMENT STATION, CLUJ COUNTY, ROMANIA

Emilia-Ancuța BOANTA[1], Leon MUNTEAN[1], Florin RUSSU[2], Ioana PORUMB[2], Raluca-Maria PARLICI[1], Andreea-Daniela ONA[1]

[1]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania, 3-5 Manastur, Cluj-Napoca, 400372, Romania, Emails: ancuta.boanta@usamvcluj.ro, lmuntean@usamvcluj.ro, andreea.ona@usamvcluj.ro
[2]Turda Agricultural Research and Development Station, 27 Agriculture Street, Cluj County, Romania, Phone: +40 0264 311 680, Emails: florin.russu@scdaturda.ro, ioanaporumb18@yahoo.com

Corresponding author: andreea.ona@usamvcluj.ro

Abstract

Barley (Hordeum vulgare) is one of the essential cereal crops for humankind, the harvested area with barley ranks the 3rd place regarding grains cereals, after wheat and rice. The yield potential of barley, trait with complex genetic determinism, represents the maximum level of biomass which a genotype can realize under optimal conditions of growth and development as well as in an environment free of diseases, pests and weeds. The inheritance of quantitative traits involves a large number of genes which act additively in determining the character. To increase the yield potential of barley varieties, the present paper studied three traits which are involved in yield: spike length, grain weight/spike and grain number/spike that on 22 cultivars of barley, in ecological condition of ARDS Turda. Significance of the sample F for the genetic factor and interaction between the year and the genotype, for all three studied traits, reflects the fact that between those the 22 distinct genotypes there are very significant differences, which can be used in breeding programmes. As genitors for breeding programmes we can use cultivars Daciana, Romaniţa and To 2170/01 for spike lenght, cultivars Turdeana, Aura, Daciana and Xanadou for grain weight/spike and cultivars Turdeana and Adina for grain number/spike. The correlations between the three studied traits, which influence the barley yield, were positive, statistically assured, allowing their simultaneous improvement in the breeding programs.

Key words**:** *barley, yield traits, cultivars, spike, correlations, variance, genotype, interaction genotype year*

INTRODUCTION

Among the oldest cultivated plants [2], [9], [15], barley (*Hordeum vulgare*) is one of the essential cereal crops for humankind [5], [12]. Worldwide, the harvested area with barley ranks the 3rd place regarding grains cereals, after wheat and rice, reaching 47 million hectares. In Europe, barley is the 2nd most widespread cereal crop following wheat, exceeding 2 million hectares. Barley in Romania is the 2nd most cultivated grain cereal after wheat, with a harvested area of 455 thousand hectares and total grain production of 1.9 million tonnes [4].

Barley has wider uses in animal feed and beer industry, but also in human nutrition where it can be consumed in the form of crumps, flour, and malt [16]. In addition to these achievements, another important use of this crop is in agriculture, because it liberates the field early, it contributes to the reduction of the weeds, allows the sowing of successive crops and is a good precursor for most spring crops [2]. Winter barley is superior yielding than spring barley, but the latest is better for malting and brewing quality. Nevertheless lately, also the winter barley crops are encouraged to be use for brewing industry because of their yield stability under the global warming effects [3], [7].

On the global scale, the average yield for barley crops was 3,136 kg ha-1 [4], but the world record of 13,800 kg ha-1 was set by a New Zealand farmer in 2015 [8]. The yield potential, trait with complex genetic determinism, represents the maximum level of biomass which a genotype can realize under optimal conditions of growth and development as well as in an environment free of diseases, pests and weeds [14]. The inheritance of quantitative traits involves a

large number of genes which act additively in determining the character. Quoting [10], the main aims in barley's breeding are represented both by the increase of the quality assumptions concomitant with the high production of grains, as well as of other qualities related to the variety [1].

In major barley-growing countries like Germany, grain yield of winter barley has been increased in the last decades by ca. 70 kg ha^{-1} each year. This progress recorded due to the use of haploid method in lines breeding. Besides this, more recently, the marker-assisted selection allows an efficient association of genes or loci for improving varieties quality and enhancing resistance to different pathogens. Nowadays, the exploitation of the heterosis phenomenon using hybrid breeding, leads to a higher yield potential in barley hybrid varieties [6]. Together, breeding and crops technologies are able to fulfil the requirements of barley growers and beer industry [11].

The present paper presents some of the yield components that can be improved by breeding techniques to increase the yield potential of varieties.

MATERIALS AND METHODS

In plant breeding programs, both variability and stability of morpho-productive traits are important requirements in choosing the most accurate genitors. In order to identify barley parents, useful for the future breeding programs, in this study we proposed the evaluation of some agronomic traits of the yield in a series of Romanian and foreign barley genotypes, in two experimental years 2017 and 2018. The experience was placed at ARDS Turda, according to the randomized blocks method in three repetitions, each experimental plot had an area of 14 m^2 and the harvestable area of 10 m^2. For this experience we have chosen 22 cultivars, and the main biometric features were the length of the spike, the weight and the number of grains per spike. Polifact and Excel were used for the processing of the experimental data, and the standard formulas for statistical calculation were used for the variability parameters.

RESULTS AND DISCUSSIONS

The length of the spike is an important feature of a barley yield, which is less affected by the climatic factors, as is proved by F sample, not statistically assured for this factor. Significance of the sample F for the genetic factor reflects the fact that between those the 22 distinct genotypes there are very significant differences, which can be used in breeding programmes. Also, the interaction between the two years of culture and genotypes are very important, as evidenced by the significance of the sample F for the interaction between the two factors (Table 1).

Table 1. Analysis of variance for spike length, grain weight/spike (g) and grain number/spike (Turda 2017 - 2018)

No.	Source of variability	SS	DF	s^2	F	SS	DF	s^2	F	SS	DF	s^2	F
	Trait	Spike length (cm)				Grain weight/spike (g)				Grain number/spike			
1	Total	75.44	129			5.61	131			1,859.24	131		
2	Years (Y)	17.45	1	17.45	10.11	1.97	1	1.97	24.99*	400.75	1	400.75	45.76 *
3	Genotype (G)	27.85	21	1.33	6.76***	1.74	21	0.08	8.62***	664.57	21	31.64	5.02 ***
4	Y x G	10.21	21	0.49	2.48***	0.91	21	0.04	4.51***	241.24	21	11.48	1.82 *
5	Error (A)	3.45	2	1.73		0.15	2	0.07		17.51	2	8.75	
6	Error (G)	16.48	84	0.20		0.80	84	0.00		529.09	84	6.29	

Source:original, obtained through the statistical program.

Earlier, we mentioned that the climatic factors show a less eloquent influence on the spike length, but if we analyse the data presented in Table 2, it can be observed that almost all genotypes recorded higher values of this trait in 2018 compared to 2019, excepting Capriana cultivar. In fact, in 2017, the only genotype that registered statistically assured differences was the Romanian cultivar Daciana. This cultivar is also distinguished by a high stability of this trait, recording the same values in both experimental years, the

values being above the average of the years. The Romanian Romaniţa cultivar, can be considered a good genitor for improving this trait, because it has registered the highest average value for this trait. Alongside this cultivar, the To 2170/01 line is noted, which ranks second on the average of this trait. From the values of the coefficients of variation for this trait it is noted that between the analysed variants there is a small to medium variability, the useful part of this variability lies between the values medium and maximum (Table 2).

Table 2. Behaviour of genotypes in the two experimental years and indicators of variability for spike length

Genotype	Spike length (cm)		Spike length (cm)		Variability indicators
	2017	2018	2017	2018	
Control	8.03	8.76	0.00	0.00	Year 2017 The coefficient of variation = 5.5% Minimum = 7.33 Maximum = 9 Sample variance = 0.20
Turdeana	8.33	9.33	0.30	0.58	
Aura	8.00	9.00	-0.03	0.24	
Daciana	9.00	9.00	0.97**	0.24	
Romaniţa	8.67	10.00	0.64	1.24***	
Capriana	8.67	8.33	0.64	-0.42	
Jubileu	8.33	9.00	0.30	0.24	
To 2027/10	8.00	9.00	-0.03	0.24	
To 2172/01	7.33	8.00	-0.70	-0.76^{0}	
To 2170/01	8.33	10.00	0.30	1.24***	
Marthe	7.33	7.67	-0.70	-1.09^{00}	
Vienna	7.67	9.00	-0.36	0.24	Year 2018 The coefficient of variation = 7.25% Minimum = 7.67 Maximum = 10 Sample variance = 0.40
Sulilly	7.67	8.67	-0.36	-0.09	
Tatum	8.00	9.33	-0.03	0.58	
Odyssey	7.67	9.00	-0.36	0.24	
Chronicle	7.67	8.00	-0.36	-0.76^{0}	
Concerto	8.00	8.67	-0.03	-0.09	
Sidney	7.67	8.00	-0.36	-0.76^{0}	
Steward	8.00	9.00	-0.03	-0.24	
Belgravia	8.00	8.00	-0.03	0.76^{0}	
Xanadou	8.67	8.67	0.64	-0.09	
Armada	8.00	8.00	-0.03	-0.76^{0}	
Salome	7.67	9.00	-0.36	0.24	
LSD (5%)0.72 LSD (1%) 0.95 LSD (0.1%) 1.23					

Source:original, obtained through the statistical program.

Along with the number of spike per unit area, the weight of the grains/spike is a trait that greatly determines the level of yield. By the fact that the process of formation and filling of the grains lasts a considerable period of time, respectively from a few days from the anthesis to the physiological maturity, it is very much influenced by the climatic conditions. Also, the expression of this trait is closely related to the technological factors (fertilization, sowing times and density, respecting the phytosanitary protection measures etc.). The many factors involved in controlling this trait greatly reduce the contribution of heredity to phenotypic expression. Moreover, the values of the variance corresponding to the factor year (s2 = 1.97), support the previously stated regarding the involvement of the environment in the phenotypic expression of this trait. The values of the sample F suggest that between the 22 variants analysed there are very significant differences and in interaction with the year they have manifested very differently (Table 1).

The fluctuations of the individual values of the genotypes from the two experimental years together with the parameters of the annual variability (mean, minimum and maximum, the coefficient of variation and variance), stand out the major role of the environment in the phenotype of the grain weight/spike (Table 3). The highest values of this trait belong to the Romanians cultivars Turdeana and Daciana and the western European cultivar Xanadou in 2017, and in 2018 the first three places belong to the three ARDS Turda cultivars: Turdeana, Aura and Daciana. Of the tested genotypes, the cultivar Turdeana is particularly noteworthy, that in both experimental years recorded values beyond control, in 2018 the differences from the average being very significant positive. In a quite similar trend is registered the Aura cultivar, with the mention that it behaved above average only in 2018, the differences

being very significant. Turdeana and Aura cultivars are the first two genotypes created at ARDS Turda being obtained from a biological material from very different areas with a high ecological plasticity. The two varieties have a high plant height and are prone to fall under very favourable conditions but under less favourable conditions they react quite positively. We could recommend that these two crops be destined or used by those farmers who practice organic farming.

Table 3. Behaviour of genotypes in the two experimental years and indicators of variability for grain weight/spike

Genotype	Grain weight/spike (g)		Difference		Variability indicators
	2017	2018	2017	2018	
Control	1.29	1.04	0.00	0.00	Year = 2017 The coefficient of variation = 6.8% Minimum = 1.14 Maximum = 1.42 Sample variance = 0.00
Turdeana	1.41	1.67	0.13	0.63***	
Aura	1.22	1.38	-0.06	0.34***	
Daciana	1.42	1.12	0.14	0.08	
Romanița	1.37	1.11	0.08	0.07	
Capriana	1.32	0.94	0.04	-0.10	
Jubileu	1.41	0.90	0.13	-0.14	
To 2027/10	1.31	1.08	0.02	0.04	
To 2172/01	1.20	0.96	-0.09	-0.08	
To 2170/01	1.33	1.07	0.05	0.03	
Marthe	1.15	1.08	-0.14	-0.25^{00}	
Vienna	1.19	0.86	-0.10	0.04	Year 2018 The coefficient of variation = 17.34 % Minimum = 0.86 Maximum = 1.67 Sample variance = 0.03
Sulilly	1.16	1.09	-0.12	-0.18^{0}	
Tatum	1.28	0.97	-0.01	0.05	
Odyssey	1.14	1.00	-0.15	-0.07	
Chronicle	1.26	1.01	-0.03	-0.04	
Concerto	1.27	0.96	-0.01	-0.03	
Sidney	1.26	1.00	-0.03	-0.08	
Steward	1.29	1.01	0.00	-0.04	
Belgravia	1.33	0.88	0.04	-0.16^{0}	
Xanadou	1.41	1.06	0.12	0.02	
Armada	1.35	1.07	0.06	0.03	
Salome	1.19	0.92	-0.10	-0.12	
LSD (5%) 0.16 LSD (1%) 0.21 LSD (0.1%) 0.27					

Source:original, obtained through the statistical program.

Table 4. Behaviour of genotypes in the two experimental years and indicators of variability for grain number/spike

Genotype	Grain number/spike		Difference		Variability indicators
	2017	2018	2017	2018	
Control	25	21	0.00	0.00	Year 2017 The coefficient of variation = 6.64% Minimum = 22 Maximum = 27 Sample variance = 2.80
Turdeana	27	27	2.67	6.15**	
Aura	25	28	0.33	6.82**	
Daciana	27	24	2.67	2.48	
Romanița	27	23	2.33	2.15	
Capriana	25	21	0.33	0.15	
Jubileu	24	19	-0.33	-2.52	
To 2027/10	26	23	1.67	1.48	
To 2172/01	24	22	-0.67	0.82	
To 2170/01	27	21	2.33	-0.18	
Marthe	23	14	-1.67	-7.52 ^{000}	
Vienna	25	21	0.00	-0.52	Year 2018 The coefficient of variation = 15.25 % Minimum = 14 Maximum = 28 Sample variance = 10.91
Sulilly	22	18	-2.33	-3.18	
Tatum	25	21	0.00	0.15	
Odyssey	22	19	-2.33	-2.18	
Chronicle	24	20	-0.33	-0.85	
Concerto	24	22	-0.67	1.15	
Sidney	23	18	-2.00	-2.85	
Steward	24	16	-0.67	-5.52^{00}	
Belgravia	25	20	0.67	-1.18	
Xanadou	27	24	2.00	2.48	
Armada	24	25	-1.00	3.82	
Salome	22	20	-3.00	-1.18	
LSD (5%) 4.08 LSD (1%) 5.40 LSD (0.1%) 6.98					

Source:original, obtained through the statistical program.

The number of grains/spike is one of the important trait of the production, being closely related to the number of rows, the length and the density of the spike. The values

of the F sample reflect the important contribution of the genotype factor in the expression of this trait, being followed by the year factor but also by the double interaction between the year and the genotype (Table 1).
The number of grains/spike were higher in 2018 than in 2019. The coefficient of variation of 6.64 indicates a small variability for the analysed genotypes, but there are differences between minimum (22) and maximum (27), which can allows selection for genotypes with a large number of grains (table 4). The data are also underlined by another study conducted by Russu et al. [13], carried out in two experimental years (2016, 2017) on 185 genotypes of spring barley, number of grains/spike presented a coefficient of variation of 8%, with minimum and maximum values between 20 and 31 grains/spike. At the level of 2018, the value of coefficient of variation is 15% indicated moderately variability and the values between the smallest minimum (14) and maximum (28) makes possible identification of genitors for this trait breeding. The Turdeana and Adina cultivars show the highest values for these traits in both experimental years, with significant difference compare to control.
As it is known, in any breeding programme are studied morphological and physiological traits of the plant, easily observable, which influence the yield as well as its quality. Identifying the correlations between these elements is very important in breeding work, to facilitate the selection process of the most valuable genotypes and reduce the time of obtaining the new cultivation. From a theoretical point of view, the study of correlations is noted by the possibility to combine in a modern mathematical methodology, biometric aspects of plants, moving from subjective observations to exact quantitative expression.

Table 5. Phenotypic correlation between yield traits of barley

Trait	grain weight/speak	speak length
grain number/speak	0.86***	0.57**
grain weight/speak	-	0.60**

Source:original, obtained through the statistical program.

CONCLUSIONS

For barley cultivars studied at ARDS Turda, the environment had an important influence on the weight and the number of grains per spike. Significance of the sample F for the genetic factor and interaction between the year and the genotype, for all three studied traits, reflects the fact that between those the 22 distinct genotypes there are very significant differences, which can be used in breeding programmes.
As genitors for breeding programmes we can use cultivars Daciana, Romaniţa and To 2170/01 for spike lenght, cultivars Turdeana, Aura, Daciana and Xanadou for grain weight/spike and cultivars Turdeana and Adina for grain number/spike.
The correlations between the three studied traits, which influence the barley yield, were positive, statistically assured, allowing their simultaneous improvement in the breeding programs.

REFERENCES

[1]Boantă, E.A., Porumb, I., Russu, F., Filip, E., Muntean, L., Ona, A.D., 2019, Variability Of Some Productive Traits Of Two-Row Spring Barley In The Conditions Of ARDS Turda, Agricultura, 109(1-2):8-13.
[2]Capettini, F., Grando, S., Ceccarelli, S., 2010, Barley Breeding History, Progress, Objectives, and Technology, pp.158-218.
[3]Deudon, O., Treut H., Janovici, J.M., Pararnoud, V., Calvet, J.Ch., Rosenzweig, C., Dellecoll, R., 2001, Changements Climatiques, Quelles Consequences pour l'Agriculture, Persp. Agric., 266:44-61.
[4]Faostat, http://www.fao.org/faostat/en/, Accessed in February 10, 2020.
[5]Friedt, W., 2010, Barley: Production, Improvement, and Uses, 158-218.
[6]Friedt, W., Ordon F., 2013, Barley Production and Breeding in Europe: Modern Cultivars Combine Disease Resistance, Malting Quality and High Yield, In book: Advance in Barley Sciences, pp. 389-400.
[7]Lalic, A., Simic ,G., Kovacevic, J., Novoselovic, D., Horvat, D., Abicic, I., Lenart, L., Mijakovic, R., Ugarcic-Hardy, Z., 2010, Analysis of Grain Yield and Cytolytic Degradation of Winter and Spring Barley Cultivars, Not. Bot. Hort. Agrobot, Cluj, 38(1):88-91.
[8]Muntean, L., Ona, A., 2019, Ameliorarea plantelor: Partea specială, Editura AcademicPres (Plant Improvement: Special Part, AcademicPres Publishing House), Cluj-Napoca, pp.46-54.

[9]Porumb, I., Rusu, F., Boantă, A., Filip, E., Tritean N., Stancă-Moise C., Muntean L., 2019, Choosing The Genitors - An Important Measure In Making The Breeding Works Better At The Spring Barley, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 19(1): 471-476.
[10]Potlog, A.S., Nedelea, G., Cărăuș, V., 1980, Genetica și ameliorarea calității plantelor agricole, Editura ştiinţifică şi enciclopedică, Bucureşti (Genetics and quality improvement of agricultural plants, Scientific and Encyclopedic Publishing House, Bucharest), pp.45-66.
[11]Pržulj, N., Momčilovi, V., 2006, Barley breeding for yield and quality, Glasnik Zaštite Bilja, 29(1):57.
[12]Russu, F., 2015, Studiul unor cultivare de orz de primăvară cu două rânduri în sistem concurențial și neconcurențial, Teză de doctorat (The study of spring barley cultivation with two lines in the competitive and non-competitive system, PhD thesis), University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania.
[13]Russu, F., Porumb, I., Mureșanu, F., Tritean, N., 2019, Estimation of the Variability and Inheritance af Some Quantitative Traits in Two Rows Spring Barley in the Conditions of ARDS Turda, Romanian Agricultural Research, No. 36, Pp 67-77.
[14]Savatti, M., Ardelean, M., Nedelea, G., 2004, Tratat de ameliorarea plantelor, Editura Marineasa, Timișoara (Treatise on plant improvement, Marineasa Publishing House, Timișoara), pp.249-252.
[15]Tiwari, V., 2010, Growth and Production of Barley, In: W.H. Verheye (ed.). Soils, Plant Growth and Crop Production, Encyclopedia of Life Support Systems (EOLSS), 1:1-31.
[16]Zhou, M.X., 2009, Barley Production and Consumption, In: Zhang G., Li C. (eds) Genetics and Improvement of Barley Malt Quality, Advanced Topics in Science and Technology in China, Springer, Berlin, Heidelberg, pp. 1-17.