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PERFORMANCE OF ROMANIAN BARLEY VARIETIES FOR GRAIN YIELD AND SOME QUALITY TRAITS UNDER RAINFED CONDITIONS

Ioana Claudia DUNĂREANU[1], Dorina BONEA[2], Valeriu Lucian RADU[1]

[1]Agricultural Research and Development Station Şimnic – Craiova, Bălcești Road, no. 54, Dolj County, Romania, Emails: claudia.borleanu@yahoo.com; raduvaleriu17@yahoo.com
[2]University of Craiova, Faculty of Agronomy, 19 Libertății Street, Dolj County, Romania, Email: dbonea88@gmail.com

Corresponding author: dbonea88@gmail.com

Abstract

The present study aimed to identify barley varieties with high grain yield and quality for rain-fed conditions. The trials were conducted in the experimental field of the ARDS Şimnic during two growing seasons (2018/2019 and 2019/2020). The analysis of the results from the two years of study showed that the Simbol variety (5,842 kg/ha) performed the best for grain yield, while the Ametist variety (4,662 kg/ha) had the lowest grain yield. The highest average value of test weight was found in the Univers variety (61.5 kg/hl) and the lowest in the Ametist variety (55.5 kg/hl). The average protein content values ranged between 9.9% (Simbol) and 11.5% (Dana). The years (precipitation and air temperature) were the predominant source of variation in yields and test weight, representing 87.3% and 78.8%, respectively of the total sum of squares, thus indicating the relative importance of the climatic conditions in achieving of high yields and quality. Therefore, the Simbol variety is recommended for increasing barley yield and improving farmers' incomes in the central part of the Oltenia region and in areas with similar agro-ecologies.

Key words**:** *barley, protein content, test weight, yield*

INTRODUCTION

Cultivated barley (*Hordeum vulgare* L.) belongs to the genus *Hordeum*, the *Poaceae (Gramineae)* family is of major importance as an annual cereal that is mainly used as animal fodder, as a raw material for malting in beer and whiskey production and for human consumption. It is a self-pollinating diploid crop (2n = 2x = 14).

Barley contains essential minerals and vitamins, especially beta glucans therefore it is indicated as a good source of food for people suffering from type II diabetes or prediabetes and for a healthy lifestyle [1].

In Romania, the total area covered by this crop is about 422 thousand hectares with a total production of 1,870 million tons and an average yield per hectare of 4,432 kg. In the world, barley ranked fourth in production of cereal crop after maize, rice and wheat [9].

In Europe, two-row barley varieties are predominantly used for malting, but lately, six-row barley varieties are used for malt production in some regions of the United States [18].

The agronomic value of a variety depends not only on its genetic potential, but also on its ability to reach the genetic potential under different environmental conditions [8].

In the Oltenia region, lack of rainfall and associated droughts are the main causes of low crop productivity [2, 3, 4, 5, 17].

According to [13], the genotypic characters of a cultivar and agro-climatic conditions during the growing season are the two key factors influencing grain yield and quality, therefore the choice of suitable cultivar is the first step to success in the growing systems of barley.

The yield performance and yield stability are the important features in choosing cultivars for different areas.

Because barley has a significant role in food security, we believe that is important to evaluate and recommend the best performing varieties for the Oltenia region.

MATERIALS AND METHODS

During the 2018/2019 and 2019/2020 growing seasons, 6 six-row barley varieties created at NARDI Fundulea (Dana, Cardinal FD, Univers, Ametist, Smarald and Simbol) cultivated at the Agricultural Research and Development Station (ARDS) Șimnic, were evaluated.

The trials were conducted in a randomized block design (in three repetitions), with a plot size of 9 m^2. The usual agricultural practices for the conventional cropping system were applied. The complex fertilizers were administered before sowing with 200 kg/ha NPK 20.20.0. Ammonium nitrate (NH_4NO_3) was also administered in February (200 kg/ha) and in April (150 kg/ha).

The sowing took place on 8 and 18 October in 2018 and 2019, respectively.

The test weight (kg/hl) was analyzed by specific apparatus and the protein content (%) by spectrometric method using NIR analyzer INFRAMATIC 9200.

Analysis of variance (ANOVA) was used to comparison varieties and to determine the effects of genotype, year, and genotype x year interaction for the studied parameters.

The Duncan's multiple comparison test (at $p \leq 0.05\%$) was used to demonstrate the differences between the studied varieties.

The climatic conditions of the two experimental years showed a great variability for precipitation and air temperature.

The amount of precipitation in both years of study was lower than the multiannual average and with a very uneven distribution per months (Figures 1 and 2).

In most months of the 2018/2019 growing season (October, December, February, March, April, May, July) there was a deficit of precipitation which negatively affected the barley crop.

The largest precipitation deficiencies (-44.5 mm and -34.9 mm, respectively) compared to the multiannual average, have been registered during the sowing period (October) and the flowering period (May).

In the 2019/2020 growing season, the distribution and amount of precipitation were considerably more favourable, which led to increased yields in that year.

The average air temperature in 2018/2019 was higher by 1.5°C and in 2019/2020 was higher by 2.15°C, which confirms the heating trend for this area.

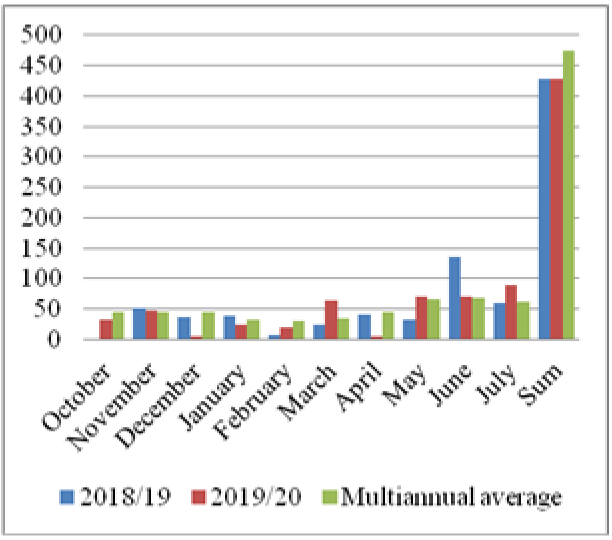

Fig. 1. Total monthly precipitation (mm) at ARDS Şimnic
Source: own processing based on data from Meteorological Station Şimnic, Craiova.

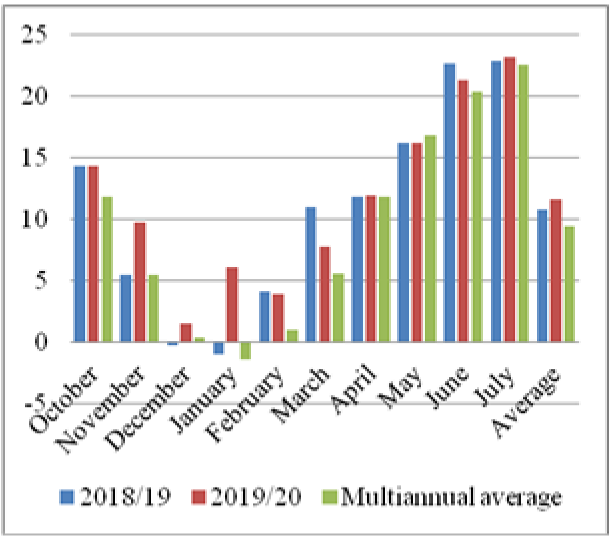

Fig. 2. Mean monthly air temperature (°C) at ARDS Şimnic
Source: own processing based on data from Meteorological Station Şimnic, Craiova.

RESULTS AND DISCUSSIONS

Grain yield

The analysis of the variance for grain yield in 2018/2019 did not show significant differences ($p \leq 0.05$) between the barley

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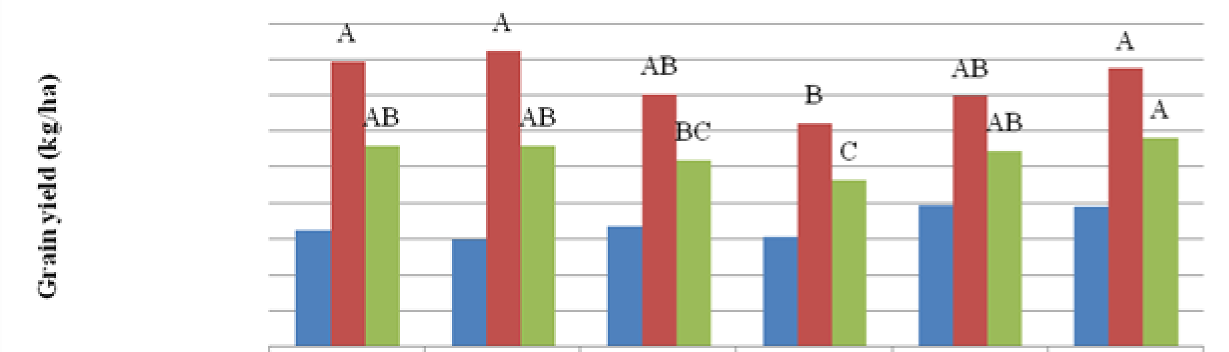
varieties. The level of grain yield of the studied varieties ranged from 2,972 kg/ha for the Cardinal variety to 3,958 kg/ha for the Smarald variety (Figure 3). This year, the yields were lower than in 2019/2020, probably due to the deficit of precipitation during the periods of flowering, pollination and grain-filling (May and July), periods considered critical for barley yield [15, 16]. According to [6], due to heat stress during the grain-filling stage, pollen infertility and seed abortion occur, which ultimately lead to reduced in grain yield.



	DANA	CARDINAL	UNIVERS	AMETIST	SMARALD	SIMBOL
2018/2019	3,239	2,972	3,341	3,074	3,958	3,912
2019/2020	7,982	8,267	7,061	6,249	6,992	7,772
average two years	5,611	5,619	5,201	4,662	5,475	5,842

Fig, 3. The grain yield values of barley varieties cultivated under rain-fed climate conditions at ARDS Simnic
Source: Own calculation.

For the year 2019/2020, which was more favourable for barley cultivation, the analysis of variance for grain yield showed significant differences between the barley varieties ($p \leq 0.05$).

The Cardinal (8,267 kg/ha), Dana (7,982 kg/ha) and Simbol (7,772 kg/ha) varieties were significantly superior compared only to the Ametist variety (6,249 kg/ha).

In average for two-years, the barley variety Simbol gave maximum value for grain yield (5,842 kg/ha) followed by Cardinal (5,619 kg/ha), Dana (5,611 kg/ha) and Smarald (5,475 kg/ha) varieties which were statistically at par with each other. The Simbol variety was significantly superior compared only to the Ametist (4,662 kg/ha) and Univers (5,201 kg/ha) varieties.

Similar results have been reported in other studies. [19], following research conducted during 2013-2015 at ARDS Marculesti, reported that the best yields were obtained by Symbol (6,641 kg/ha), Smarald (6,627 kg/ha) and Ametist (6,497 kg/ha) varieties and the lowest yield by Dana variety (5,709 kg/ha). Following the research conducted in 2016 and 2017 at ARDS Turda, [10] also reported a very good behaviour of the varieties Smarald (5,093 kg/ha), Simbol (4,819 kg/ha) and Cardinal (4,813 kg/ha).

Test weight

The value of test weight in the 2018/2019 growing season ranged from 50.6 kg/hl (Ametist) to 57.5 kg/hl (Univers), the differences between the varieties being statistically non-significant.

During the 2019/2020 growing season values of the varieties was higher than in the first year because of more favourable conditions. The Univers variety (65.4 kg/hl) had the highest test weight, while Ametist variety (60.7 kg/hl) had the lowest ($p \leq 0.05$).

The average of test weight over the two-years was also higher ($p \leq 0.05$) at Univers variety (61.5 kg/hl) followed by Cardinal variety (59.2 kg/hl), while Ametist variety had the lowest value (55.5 kg/hl).

Our results were similar with those reported by [11], but were less values than those of some research [8, 12, 18].

According to the Grading Manual from 2017 [7], barley grain should have a test weight from 63 kg/hl (Class I) to 67 kg/hl (Class III) for malting production and from 60 kg/hl (Class I) to 62 kg/hl (Class II) for animal feed.

Protein content

According to [11], protein content is one of the most important selection criteria for the quality of malt. It should be in the range of 9.5-11.5% [18].

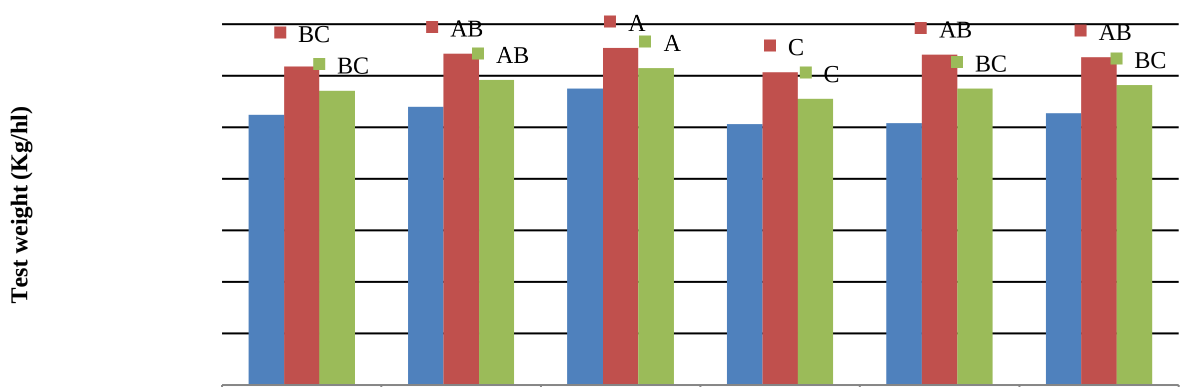
The protein content of grain barley during the 2018/2019 ranged from 10.2% (Smarald) to 11.3% (Ametist), but the differences between the varieties being statistically non-significant.

During the 2019/2020 growing season the Dana variety (12.7%) had the highest protein content followed by Ametist variety (11.1%), while Simbol variety had the lowest value (9.2%).

The average protein content over two-years varied between 9.9% (Simbol) and 11.5% (Dana), the differences between the varieties being statistically non-significant.

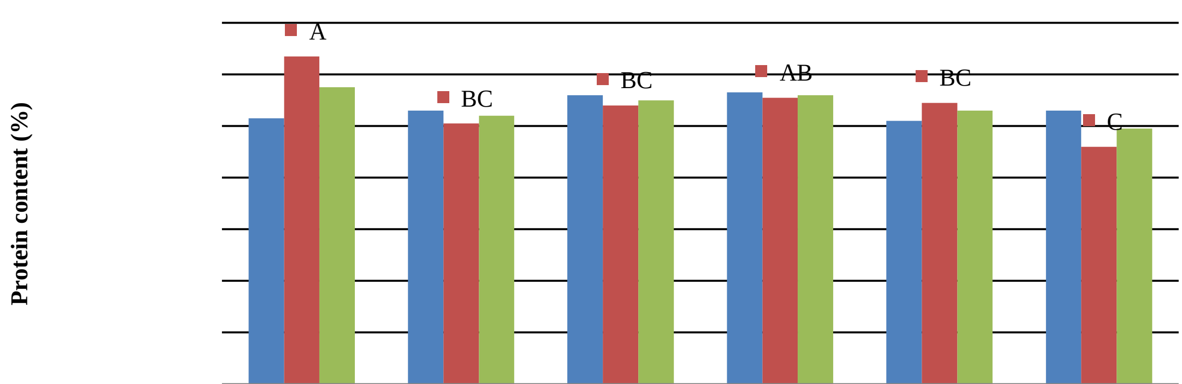
Similar to our results for protein content, researchers such as [18] also obtained at NARDI Fundulea during 2012-2015.

On the other hand, these values were less than those of some research [12, 13].



	DANA	CARDINAL	UNIVERS	AMETIST	SMARALD	SIMBOL
2018/2019	52.4	54	57.5	50.6	50.8	52.7
2019/2020	61.8	64.3	65.4	60.7	64.1	63.6
average two years	57.1	59.2	61.5	55.5	57.5	58.2

Fig. 4. The test weight values of barley varieties cultivated under rain-fed climate conditions at ARDS Simnic
Source: Own calculation.



	DANA	CARDINAL	UNIVERS	AMETIST	SMARALD	SIMBOL
2018/019	10.3	10.6	11.2	11.3	10.2	10.6
2019/2020	12.7	10.1	10.8	11.1	10.9	9.2
average two years	11.5	10.4	11	11.2	10.6	9.9

Fig. 5. The protein content values of barley varieties cultivated under rain-fed climate conditions at ARDS Simnic
Source: Own calculation.

In terms of the impact of genotype, year and genotype x year interaction on yield, test weight and protein content, it is presented in Table 1.

The results for grain yield showed significant effects in the case of genotype (G) ($p \le 0.05$), the year (Y) ($p \le 0.01$), as well as in the case of the G x Y interaction ($p \le 0.05$).

The sum of square for genotype effect explained 3.2% of the total variation, the differences between years explained 87.3% of the grain yield total variation, while the effects of G x Y interaction explained 3.6% of total variation. The great effect of Y (year) on grain yield was due to the contrasting growing conditions (distribution and amount of precipitation, air temperature) in which the experiments were set up.

Our results are in agreement with [14], who stated that year (Y) explained the highest percent of yield variation (81%) in Rimski Šančevi experimental field near Novi Sad, while the influence of G and G × E interaction is usually smaller effect.

Test weight of the barley varieties was significantly ($p \le 0.01$) influenced by genotype and year, but not significantly by genotype x year interaction.

The sum of square for genotypes effect explained 9.7% of the total variation; the year explained 78.8% of the test weight variation, and the effects of G x Y interaction explained 2% of total variation.

[8] reported only highly significant effects of the genotype of test weight.

The protein content was significantly ($p \le 0.01$) influenced by genotype and G x Y interaction ($p \le 0.05$), but not significantly by year (Table 4). Similar results have been reported by [13].

In contrast, [12] reported a significant effect of year on protein content due to drought during grain-filling stage which increased protein content.

Table 1. ANOVA of tested parameters and F test for two-years

Source	Sum squares	DF	Mean squares	F test	Total variation explained (%)
Grain yield					
Genotype (G)	5,269,099	5	1,053,820	2.68*	3.2
Year (Y)	141,939,425	1	1,419,239,425	362.18**	87.3
Genotype x Year (G x Y)	5,906,994	5	1,181,399	3.01*	3.6
Error	9,405,470	24	391,895		
Total	162,520,988	35			
Protein content					
Genotype (G)	11.02	5	2.20	2.65*	25.0
Year (Y)	0.07	1	0.07	0.08	0.16
Genotype x Year (G x Y)	12.99	5	2.60	3.12*	29.5
Error	19.97	24	0.83		
Total	44.05	35			
Test weight					
Genotype (G)	117.09	5	23.42	4.86**	9.7
Year (Y)	953.78	1	953.78	197.90**	78.8
Genotype x Year (G x Y)	23.86	5	4.77	0.99	2.0
Error	115.67	24	4.81		
Total	1,210.40	35			

* Significant at the 5% probability level; ** Significant at the 1% probability level
Source: Own calculation.

CONCLUSIONS

The results for two years of study indicated that yield performance and test weight of studied barley varieties were highly influenced by year effect.

The Simbol variety (5,842 kg/ha) followed by Cardinal FD (5,619 kg/ha), Dana (5,611 kg/ha) and Smarald (5,475 kg/ha) varieties

showed the best performances among varieties tested, while the Ametist variety (4,662 kg/ha) had a low grain yield and adaptability. So, variety Simbol was recommended for the central part of the Oltenia region and areas with similar agro-ecologies for sustainable barley production and for improving farmers' incomes.
The Univers variety was noted by the high value of test weight (61.5 kg/hl) and by good protein content (11%), but had a low yield.

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