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THE PERFORMANCE OF SOME BARLEY GENOTYPES UNDER ORGANIC AND DIFFERENT PEDOCLIMATIC CONDITIONS

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Abstract

Barley is an important food and industrial crop in Romania and the choice of varieties is one of the most important decisions in the barley crop management because it greatly improves the production obtained in the ecological farming system and not only that. The aim of this study was to compare how some barley varieties differ in physiological traits and yield under organic farming conditions. This study was conducted in three different area from Romania throughout 2023-2024 winter wheat season. In one of the three localities the soil is acidic so another goal was to highlight the genetic variability among barley genotypes, to identify barley genotypes tolerant to acid soils using stress indices and to assess the association among stress indices as well as grain yield. The results showed that in the three location, the chlorophyl content, the height of plants, leaf area index and dry matter were highly variable. The grain yields were positively correlated with chlorophyll content and biomass, at a significance level of 0.01. Assessment of acid soil stress indices was also found to be promising in identifying tolerant genotypes with good yield potential. Based on these results, high-yield barley varieties may be choise to be cultivated under organic agriculture under climate change conditions from Romania.

Key words: *barley, organic agriculture, height of plant, chlorophyll content, leaf area index, index of aluminium tolerance, yield.*

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the basic crops in European agriculture (Acharya et al., 2021). Currently, most barley production is for animal feed and malt (Vasilescu et al., 2022) and Romania achieved a total barley production of 2.001 million tons in 2023, an increase of 294,000 tons compared to 2022.

Organic farming relies on diverse crop rotation systems for maintaining soil health and breaking up disease, pest, and weed cycles, and winter barley can help of these challenges. Barley has a fibrous root system that contributes to increase the soil organic matter (Snapp et al., 2005), can escape by drought due to short period of vegetation (Vasilescu et al., 2019; Voica L., 2021) and rotating small grain crops can break up disease and weed cycles while increasing the biodiversity of the system (Voica and Lazar, 2021).

Growth analysis is the most simple and precise method to evaluate the contribution of different physiological processes in plant development. The physiological indices such as leaf area index (LAI), total dry matter (TDM) are influenced by genotypes, plant population, climate and soil fertility (Petcu et al., 2003). Chlorophyll content is an important physiological parameter that is frequently measured as an indicator of chloroplast development, photosynthetic capacity, leaf nitrogen content or general plant health (Ling et al., 2011; Guidi et al., 2019). Barley production is affected by biotic and abiotic constraints among which soil acidity is a serious threat in some area of Romania where barley production is very important.

The aim of this study was to evaluation of yield and the some of physiological indices of barley (*Hordeum vulgare* L.) genotypes under ecologycal farm conditions in three locations from Romania and to highlight which genotypes show tolerance to soil acidity.

MATERIALS AND METHODS

Twenty barley genotypes including 19 barley cultivar obtained by NARDI Fundulea and one standard check were studied.

The barley genotypes were grown for growing season 2023-2024 in ecological fields certified at three locations. These three locations includes the National Agricultural Research and Development Institute from Fundulea (44°26`N latitude and 26°31`E longitude) on the cambic chernozem soil, at Agricultural Research and Development Station Valu lui Traian (44°16`N - 28°48`E) on typical chernozem soil and at Agricultural Research and Development Station Albota (44°65`N - 24°50`E) on the albic luvisol soil with a 25-25.2% clay content (acid soil, soil pH is 5.02).

The plot for each cultivars was by 12 m^2 in three replications. Each barleyt variety was sown on 15 October 2023, the sowing depth was approximately 5 cm, the row spacing was 12 cm, and the sowing density was the same, at approximately 200 kg ha^{-1}.

The total area of leaves/plant was measured by a leaf area meter (Li-COR Inc., Lincoln, NE, USA), height of plants was measured by a ruler.

For each cultivars at maturity, three 1-m^2 areas were harvested randomly to measure the grain yield, 20 wheat plants were chosen to determine the grain number per spike, and 10 repeated samples were chosen to measure the weight of 1000 and weight of seeds per plant.

The analysis of variance (ANOVA) and coefficient of correlation (r) for traits under study were statistically analyzed using Microsoft Excel program. The aluminium adaptation index (AAI) was calculated using method of Howeler (1991), AAI = (Yns)*(Yst)/(AYns)*(AYst), where Yns and Yst are yields of a given genotype under non-stress (Fundulea and Valu lui Traian) and stressed soil conditions (Albota); the Yns and Yst are average yields of all genotypes under non-stress and stressed soil conditions.

RESULTS AND DISCUSSIONS

The years of experimentation were totally different from the viewpoint of quantity and monthly repartitions of rainfall in studied areas. In Fundulea, the cumulated rainfall from sowing to harvested stage was 308.8 mm, below multi annual average with 103,1 mm (Table 1). In location Albota the cumulated rainfall during winter wheat growing seazon were below the normal of the zone with 209.9 mm, with two drought periods, one of them in the autumn-winter and the other one in the spring starting with April. In Valu lui Traian the cumulated rainfall during winter wheat growing seazon exced the normal of the zone with 46.9 mm, but with hydric deficit in January, February and June. Thus, October, May and June registered a moisture deficits in all studied areas, while November was rainier with 44.4 mm in Fundulea, 17.2 mm in Albota and with 94.5 mm in Valu lui Traian vs. multi-annual average (Table 1).

Table 1. Monthly distribution of rainfall (mm) during the winter wheat vegetation period compared with multiannual average

Month	Fundulea		Valu lui Traian		Albota	
	Rainfall	MMA	Rainfall	MMA	Rainfall	MMA
Oct	29	*42.4*	13.6	*37.7*	6.8	47.9
Nov	85.6	*41.2*	136.2	*41.7*	66.5	49.3
Dec	24.4	*44.2*	42.2	*35.4*	17.6	45
Jan	17.6	*34.8*	17.2	*29.7*	70	41.5
Feb	1.4	*31*	1.4	*24.6*	13	37.7
Mar	38.6	*37.2*	28	*29.3*	41.5	38
Apr	62.4	*44.4*	85	*34.2*	45.1	55.9
May	34.2	*61.8*	35	*41.8*	15	88.5
June	15.6	*74.9*	25.8	*63.1*	12	93.6
Sum	308.8	*411.9*	384.4	337.5	287.5	497.4

According to the analysis of variance for height of plants, the magnitude of variance due to locations and genotypes was larger compared to their interaction (Table 2).

Table 2. The analysis of variance of height of plants for barley genotypes during 2023-2024 growing season in three locations (Fundulea, Valu lui Traian, Albota)

Source of variance	Df	Mean squares	Factor F and significance
Location	2	16354.2	2665.5***
Genotype	19	418.90	24.11***
Location x Genotype	38	287.76	16.56***

*** significant at 0.001 level of probability; Df, degrees of freedom

The heigh of plants at maturity stage varied over the locations and genotype (Figure 1). Thus, the genotypes that presented the highest height were Iulian and H 417-12. It is obvious that under the conditions from Albota, on acidic soil, the barley genotypes studied had a lower height (average of 69 cm) compared to the performances achieved by same barley genotypes on the cambic chernozem soil from Fundulea (101 cm) and the typical chernozem from Valul lui Traian (93 cm) (Figure 1).

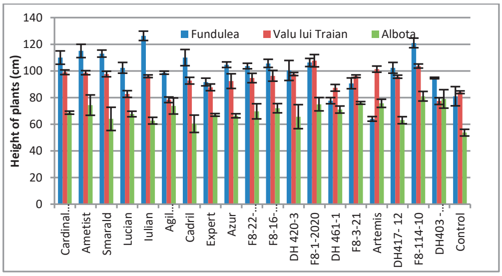

Figure 1. The height of studied barley genotypes in three locations

The analyses of variance showed than the variability for leaf area index (LAI) were the result of both the zone of cultivation, cultivars as well as of interactions of these (Table 3).

Table 3. The analysis of variance of leaf area index for barley genotypes during 2023-2024 growing season in three locations (Fundulea, Valu lui Traian, Albota) and two date of analyses

Source of variance	Df	Mean squares	Factor F and significance	Mean squares	Factor F and significance
Location	2	20.75	501.28***	139.28	191.06***
Genotype	19	1.91	36.3***	0.92	1276***
Location x Genotype	38	1.17	22.29***	0.90	12.50***

***significant at 0.001 level of probability; Df, degrees of freedom

The leaf area index (LAI) of barley in the BBCH 35 stage was significantly higher in Fundulea and Valu lui Traian locations than in Albota location. In Albota, the values of this index did not exceed 2.8. The highest values were achieved by the Cadril and Ileana genotypes under Fundulea conditions. On the other hand, the lowest LAI was found with genotype Iulian (0.9) in Albota location (Figure 2). Kizilgeci et al. (2017) reported that leaf area index at heading stage of barley varied within the range of 1.44-6.00

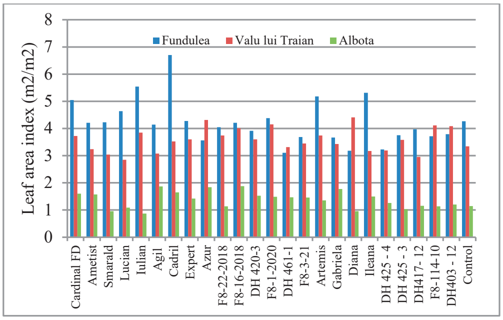

Figure 2. The leaf area index in the fully earing stage (BBCH 55) of studied barley genotypes in three locations

The results showed that both the genotypes and the environmental conditions significantly ($p < 0.01$) influenced the yield performance of barley genotypes (Table 4). The variation of 1000 grain weight (TGW) was significantly ($p < 0.01$) influenced by both main factors (G and E). The main effect of variation was due to genotype (88%) (Table 4).

Table 4. The analysis of variance of yield and 1000 grain weight (TGW) for barley genotypes during 2023-2024 growing season in three locations (Fundulea, Valu lui Traian, Albota)

Source of variance	Df	The yield		TGW	
		Mean squares	Factor F and significance	Mean squares	Factor F and significance
Location	2	6.13	31.86***	95.74	25.97***
Genotype	19	1.09	5.64***	209.10	856.7***
Location x Genotype	38		1.78**	21.59	88.4***

***significant at 0.001 level of probability; Df, degrees of freedom

The average grain yield varied between 1.53 g/pl in Fundulea, 1.93 and 1.10 g/pl in Valu lui Traian and Albota (Table 5). The varieties Cardinal, Smarald, Lucian, Iulian, Expert and FD 8-16-2018 genotypes performed very well in locations witout acidic stress. Lower yields, below the experience average, were achieved by the Artemis and Ametist genotypes in soil acidic comditions from Albota, (Table 5)
Highest values of AAI designate stress tolerant genotype. In this context Cardinal, Smarald, F 8 -22 -2018 and F8-16-2018 (with values of this index over 1.6) could be more tolerant to acidic soil as compared with Artemis (with lower values of this index) (Table 5).

Table 5. The grain yield and aluminium adaptation index for studied barley genotypes

Genotype	The grain yield (g/pl)			AAI
	Fundulea	Valu lui Traian	Albota	
Cardinal FD	2.91	2.77	1.48	2.20
Ametist	1.30	2.42	0.69	0.67
Smarald	2.23	2.20	1.40	1.63
Lucian	1.68	2.21	1.20	1.22
Iulian	1.83	2.25	0.85	0.91
Agil	1.60	1.78	1.20	1.07
Cadril	1.51	2.13	0.85	0.81
Expert	1.64	2.08	1.33	1.30
Azur	1.54	1.56	1.20	0.98
F8-22-2018	1.85	2.36	1.50	1.66
F8-16-2018	1.86	2.34	1.45	1.60
DH 420-3	1.40	2.06	1.15	1.04
F8-1-2020	1.03	2.16	1.29	1.08
DH 461-1	1.46	2.09	1.35	1.26
F8-3-21	1.32	1.69	0.96	0.76
Artemis	0.78	1.42	0.63	0.36
DH 417- 12	1.28	1.18	0.95	0.61
F8-114-10	1.18	1.24	1.04	0.66
DH 403 - 12	1.00	1.32	0.76	0.46
Control	1.13	1.42	0.75	0.50
Average	**1.53**	**1.93**	**1.10**	**1.04**

Leaf chlorophyll content is one of the important indicators of the health and potential physiological performance of a plant (Petcu et al., 2011; Collalti et al., 2020). The chlorophyll concentration in the leaf is essential for crop growth and development (Kummer et al., 2002) hence quantifying it makes available vital information about the effects of environment on plant growth (Schlemmer et al., 2005; Kalaji et al., 2017). Results show that there was strongly positive (r = 65***, 0.62***, 0.54***) correlation between the chlorophyl content and grain yield, (table 6). Significant and positive correlations was found between yield and biomass (r =0.53***, 0.59***, 0.47**) (Table 6).

Table 6. Relationship between yield and analized traits

Variable x	Variable Y	Coefficients of correlation (r)		
		Fundulea	Valu lui Traian	Albota
The yield	Biomass	0.53***	0.59***	0.47**
	Height of plant	0.44	0.19	0.1
	LAI	0.20	-0.08	0.2
	Chlorophyl content	0.65**	0.62***	0.54***

Acording to Farshadfar et al. (2001) most suitable indices for selecting stress-tolerant cultivars is an index that has are relatively strong correlation with the grain yield under stress and non-stress conditions (with coefficient of correlation over 80).

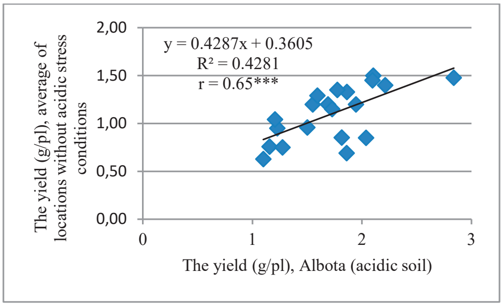

Figure 3. Relationships between the yield under acidic stress and non stress conditions

In our case, the association of grain yield under stress versus non-stress environments showed a significant positive (r = 0.65***) correlation indicating that genotypes that performed well under non-stress also performed well under stress conditions.

Generally, the strong positive correlation between grain yield under stress and non-stress environment implied the possibility of direct selection for stress conditions based on performance under non-stress conditions (Negarestani et al., 2019).

However, Drikvand et al. (2012) reported a lack of association between yield under stress and non-stressenvironment suggesting the feasibility of an independent breeding approach. The second approach would probably be more efficient in our case if we take into account the fact that in our case the correlation in question was not so strong (r = 0.65, Figure 3).

CONCLUSIONS

The present study aimed to evaluate the performances of different barley genotypes grown in three locations in ecological agricultural farming system. One of the three locations being with acid soil. The results showed that the barley genotypes presented variability for the studied physiological characters and for production.

The current study confirmed the severity of acid soils in barley development with negative repercussions on production. The percentage of yield loss under acid soil stress as compared to non-stress experiments being over 35%. Moreover, this study also revealed the existence of adequate levels of genetic variation in Romanian barley provided from NARDI Fundulea under both acid soil stress and non-stress conditions in ecological farming system indicating the potential for future barley genetic improvement. Accordingly, the currently identified high-yielding and tolerant barley genotypes need to be used for further adaptation studies and simultaneous breeding line extraction for subsequent crossing works and variety development.

At the same time, the study provides useful information regarding the production performance of some barley varieties necessary for farmers practicing organic agriculture

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