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RESEARCH REGARDING MORPHOLOGICAL, BIOCHEMICAL AND PRODUCTIVITY INDICES FOR SOME BARLEY (*HORDEUM VULGARE* L.) GENOTYPES IN THE PEDO-CLIMATIC CONDITIONS OF CRIȘURILOR PLAIN AREA

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Abstract: This study focuses on the behavior of some autumn barley genotypes in the temperature, humidity, and soil conditions of the Arad area. The purpose of the study is to find solutions for expanding this crop, considering that this species represents a rich source of starch and proteins with applicability in various economic sectors, like the beer industry or animal fodder. We performed a monofactorial experiment with 5 types of autumn barley (*Hordeum vulgare* L.), in 4 repetitions, in optimal technological conditions. The experimental variants are V1 - Ametist; V2 – Belissa; V3 – Cardinal; V4 – Laverda; V5 – Lucian. Control lot is represented by the average values of the 5 types taken into study. Abiotic conditions like temperature, precipitations, nebulosity and relative humidity did not register significant differences compared to the multiannual average. The temperature in the sowing period for barley (October – June) was slightly higher than regular values but did not significantly impede the growth and development of plants. Precipitations were overall sufficient to meet the species requirements for the vegetation period, with a small deficit in October, November, and April, and a surplus in June. We evaluated the plantțs size, spike length, grains number per spike, weight of 1000 grains, hectoliter mass, seed production, protein, fat, starch, cellulose, and ash content of grains, and economic efficiency. Genotype-environment interactions generate a high level of variability of cereal plant's growth and development, especially in the case of barley (*Hordeum vulgare* L.). Our results show that the barley genotypes taken into study can be successfully cultivated in the Crișurilor Plain in optimal conditions, proving economic efficiency.

Keywords: Hordeum vulgare, genotypes, morphology, productivity, Crișurilor Plain, Romania.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest crop species that substantially contributed to the development of biological and agricultural sciences as well as the human civilization in general (Axinte et al., 2006; Mogârzan, 2012). This plant is cultivated and used worldwide, for centuries being one of the basic food resources for both humans and animals (Russu, 2015), the most important being its grains. Barley it's used in its pearl barley form and as a coffee substitute in the human diet, it's a raw material for the production of beer, glucose, and alcohol (Tarawneh et al., 2021; Gupta et al., 2010). It also represents an important source of fodder for animals that consume it in the form of grains, green fodder, straws, and hay (Badea and Wijekoon, 2021). Currently, 55-60% of the barley production is used as fodder, 30-40% for malt, 2-3% in the human diet, and approximately 5% as seed for regrowing crops (Axinte et al., 2006; Ullrigh, 2011).

Barley is spread on a large area across the globe, being the only cereal that grows at 70 degrees north latitude (in Norway and the European part of the old Soviet Union). It's cultivated in the Alps up to1700 m, in the Caucasus up to 2700 m, in Tibet up to 4700m, and in Punjab up to 5000 m. Barley is an important cereal for the extremely hot regions like the ones in North Africa and even Saharian oasis (Ifrim, 2010; Jităreanu et al., 2020; Mogârzan, 2012). The top countries that cultivate barley include Russia, China, Canada, U.S.A, France, Germany, Ukraine, Australia, Spain, Iran, and Poland (Badea Wijekoon, 2021, Issee, 2018). In Romania, between the years 2017-2019, barley was cultivated on 424-455 thousand ha, leading to a production of 1.87-1.92 million tons, with an average production of 4.4-4.5 t/ha (Isse, 2018).

MATERIALS AND METHODS

For the current study we used:

- alluvial soil with: pH = 7,0 – 7,5; humus = 3,6 – 3,93%; clay = 33-35 %; groundwater depth = 60 – 70 cm; mobile phosphorus = 12,6 – 17,7 mg/100g soil; total nitrogen= 0,16 – 0,18 mg/100g soil (Ungureanu et al., 2019; Ungureanu et al., 2020);
- plots surface of 20 m^2, 10 m long, 2 m wide, a protection space with 3 m width, 2 m space

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between repetitions, and 0,5 m paths between experimental variants (Săndoiu, 2012);
- autumn barley seeds from Ametist, Belissa, Cardinal, Laverda, and Lucian genotypes.

The soil was worked as follows:
- autumn plowing at 20-22 cm depth, leveled and kept clean or weeds until sowing;
- disking with harrow, and preparation of germinative bed with the cultivator at 4-5 cm depth;
- sowing in October, at 4-5 cm depth;
- specific maintenance work over the whole vegetation period, keeping the plots clean of weeds;
- harvesting, when the grain humidity dropped under 20%.

Fertilization was done during the preparation of the germinative bed, with complex NPK fertilizer: N = 80 kg/ha, P = 60 kg/ha, and K = 50 kg/ha.

The experiment is monofactorial, with 5 genotypes of autumn barley (*Hordeum vulgare* L.), performed under normal technological conditions, in 4 repetitions. The experimental variants are V1 - Ametist; V2 – Belissa; V3 – Cardinal; V4 – Laverda; V5 – Lucian. The control variant is represented by the average values of the 5 genotypes.

Economic efficiency was calculated using a specific methodology (Brezuleanu, 2009).

RESULTS AND DISCUSSIONS

Abiotic conditions like temperature, precipitations, nebulosity, and relative humidity didn't record any significant differences compared to the multiannual average (MeteoBlue database 2019-2020). The temperatures during the barley cultivation period, from October until June, were slightly higher than usual but didn't hold a significant influence over the growth and development of the plants. The precipitations quantities were sufficient to meet the species requirements over the vegetation season, with a small deficit during March-April, and a surplus during the end of April and May. Analyzing the climatic conditions during the years 2019-2020 when the experiment was performed, we can affirm that they were favorable for the cultivation of this species (Figures 1 and 2).

A valuable aspect about barley it's the plant size, which offers advantages regarding physical stability in harsh meteorological conditions that can intervene during the production process, like strong winds, heavy rains, storms, and whirlwinds.

For the studied genotypes, the average plant's size was 99 cm. The smallest plants are from the Lucian genotype, with a height of only 93 cm, while the tallest plants are from the Belissa genotype, with 108 cm height. Plants of Ametist type had a height of 95 cm, Cardinal plants had 97 cm height, with stem length shorter by 4 cm and 2 cm, respectively, compared to the control (Table 1).

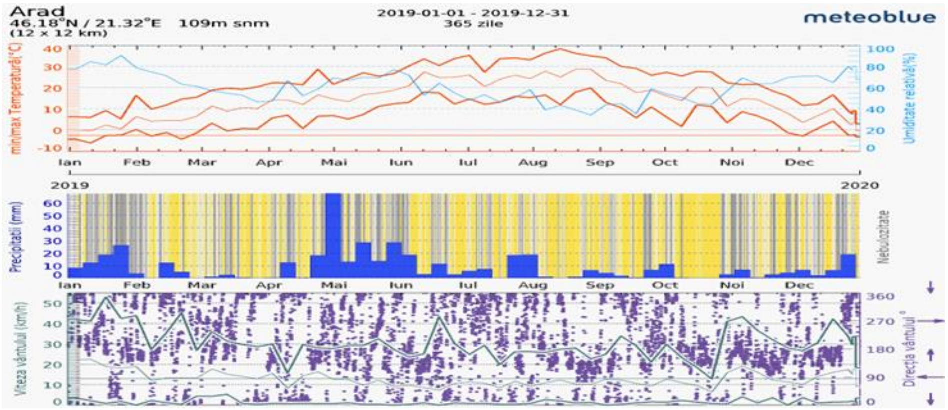

Fig. 1 Average values for temperature and precipitations during January-December 2019 in the Arad area. Source: https://www.meteoblue.com- Arhiva meteo Arad.

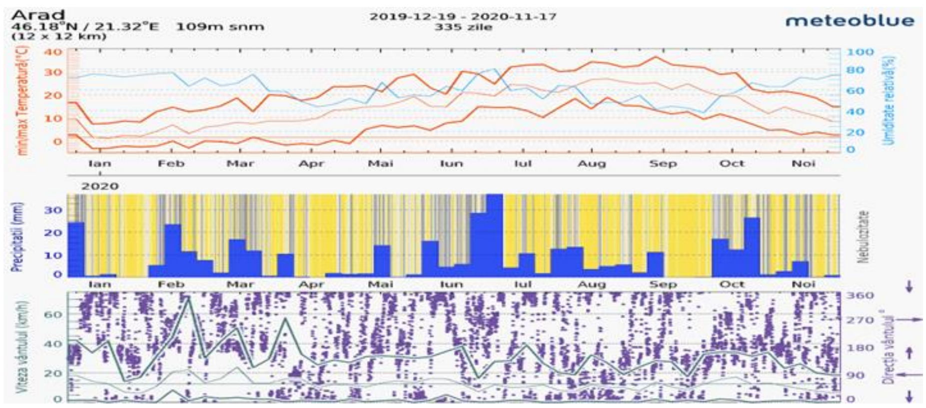

Fig. 2 Average values for temperature and precipitations during January-December 2020 in the Arad area. Source: https://www.meteoblue.com- Arhiva meteo Arad.

Table 1.

The influence of pedo-climatic conditions over the plant's size for autumn barley

No.	Genotype	Plant height (cm)	Difference (cm)
1	Ametist	95	-4
2	Belissa	108	9
3	Cardinal	97	-2
4	Laverda	102	3
5	Lucian	93	-6
6	Control	99	0

The spike length is influenced by both the cultivation methods and the environmental conditions of the crop. The spike length is tightly related to the spike density, which determines the ax's segment length. The spike length for the study's genotypes was on average 8.6 cm. The longest spikes were observed for Belissa type (9 cm), and Laverda (8.7 cm), while the shortest spikes were observed for Lucian type (8.3 cm) (Table 2).

Table 2.

The influence of the pedo-climatic conditions over the spike length for autumn barley

No.	Genotype	Spike length (cm)	Difference (cm)
1	Ametist	8,5	-0,1
2	Belissa	9,0	0,4
3	Cardinal	8,5	-0,1
4	Laverda	8,7	0,1
5	Lucian	8,3	-0,3
6	Control	8,6	0

The number of cariopses is dependent on the number of fertile plants per unit surface and the number of grains per spike. For the genotypes taken into the study we have observed over 43 cariopses on all spikes, the maximum being reached by Belissa type plants, with an average value of 51 per spike. The average value for all genotypes was 46 cariopses per spike (Table 3).

Table 3.

The influence of the pedo-climatic conditions over the number of cariopses per spike for autumn barley

No.	Genotype	No. of cariopses/spike (piece)	Difference (cm)
1	Ametist	44	-2
2	Belissa	51	5
3	Cardinal	45	-1
4	Laverda	47	1
5	Lucian	43	-3
6	Control	46	0

The weight of 1000 grains was little influenced by the traits of the genotypes taken into the study and the pedo-climatic conditions, varying between 48 g for Lucian type and 50 g for Belissa type. Overall these barley types responded well to the given conditions, having an average weight of 1000 grains of 49 g (Table 4).

Table 4.

The influence of the pedo-climatic conditions over the weight of 1000 grains (MMB) for autumn barley

No.	Genotype	MMB (g)	Difference (g)
1	Ametist	49,0	0
2	Belissa	50,0	1,0
3	Cardinal	48,5	-0,5
4	Laverda	49,5	0,5

5	Lucian	48,0	-1,0
6	Control	49,0	0

In the case of barley crops, the hectolitre mass (HM) is of utter importance as it is one of the factors that traders consider when establishing the buying price, offers details about the barley quality, directing it to be used as animal fodder or to be used in the human diet, as prime material for the production of beer if that was the intended purpose of the crop. For this study, the genotypes had a hectolitre mass between 63 kg for Cardinal type and 66 kg for Lucian type. The average value is 64,5 kg (Table 5).

Table 5.

The influence of the pedo-climatic conditions over the hectolitre mass (HM) for autumn barley

No.	Genotype	HM (kg)	Difference (kg)
1	Ametist	64,0	-0,5
2	Belissa	65,0	0,5
3	Cardinal	63,0	-1,5
4	Laverda	64,5	0,0
5	Lucian	66,0	1,5
6	Control	64,5	0

Harvesting of common barley used in the human diet or as animal fodder takes place when the plant has reached maturity, the moment when seed humidity is between 16-18%, or when the barley is completely riped (humidity 14-16%).

Barley grains used for beer production must have a low protein content and a high starch content, so the harvesting can take place only when the plant has reached full maturity, the germinative capacity, and energy have the highest values. For this study, the growth and development of the plants were between normal parameters, which led to a high grain production per unit surface, with an average value of 7130 kg/ha. The best-adapted genotypes were Laverda and Belissa, for which productions exceeded 7250 kg/ha, being 7310 kg/ha and 7260 kg/ha, respectively. Ametist and Cardinal genotypes recorded the lowest grain production values, 6930 kg/ha and 6980 kg/ha, respectively, but overall the results are satisfying (Table 6).

Table 6.

The influence of the pedo-climatic conditions over the grain production for autumn barley

No.	Genotype	Production (kg/ha)	Difference (kg/ha)
1	Ametist	6930	-200
2	Belissa	7260	130
3	Cardinal	6980	-150
4	Laverda	7310	180
5	Lucian	7170	40
6	Control	7130	0

Quality indicators of interest in improving autumn barley are the grains' protein content and quality. Given the usage, the requirements for the grains used for beer production are higher than those for animal fodder. The genotype characteristics, pedo-climatic conditions, and technological conditions during the vegetation period hold a great impact on the protein content of barley grains. The average protein content obtained in this study was between 10,3% for Lucian type and 13,2% for Belissa type. Cardinal type plants offered grains with 10,6% proteins, and the Laverda type had 12,9% (Table 7).

Table 7.

The influence of the pedo-climatic conditions over the grain's protein content for autumn barley

No.	Genotype	Proteins (%)	Difference (%)
1	Ametist	11,0	-0,6
2	Belissa	13,2	1,6
3	Cardinal	10,6	-1,0

4	Laverda	12,9	1,3
5	Lucian	10,3	-1,3
6	Control	11,6	0

Like the other cereals with straws, the oil content for barley grains is low, for the present study the values being between 1,5% and 1,7% (Table 8).

Table 8.

The influence of the pedo-climatic conditions over the grain's fat content for autumn barley

No.	Genotype	Fats (%)	Difference (%)
1	Ametist	2,4	0
2	Belissa	2,2	-0,2
3	Cardinal	2,5	0,1
4	Laverda	2,3	-0,1
5	Lucian	2,6	0,2
6	Control	2,4	0

The starch content of the grains obtained in this study met the requirements for both animal fodder and beer industry usage. The average value for analyzed genotypes was 65,1% starch. The highest value was recorded for Lucian type (66,5%), and the lowest value for Belissa type (63,5%) (Table 9).

Table 9.

The influence of the pedo-climatic conditions over the grain's starch content for autumn barley

No.	Genotype	Starch (%)	Difference (%)
1	Ametist	65,0	- 0,1
2	Belissa	63,5	- 1,6
3	Cardinal	66,0	0,9
4	Laverda	64,5	- 0,6
5	Lucian	66,5	1,4
6	Control	65,1	0

The cellulose percentage for barley grains had values with very little differences between all genotypes studied, 4,8% to 5,4%. Under 5% cellulose was recorded for Belissa and Ametist types, for which the values were 4,8% and 4,9%, respectively (Table 10).

Table 10.

The influence of the pedo-climatic conditions over the grain's cellulose content for autumn barley

No.	Genotype	Cellulose (%)	Difference (%)
1	Ametist	4.9	- 0,2
2	Belissa	4,8	- 0,3
3	Cardinal	5,3	0,2
4	Laverda	5,1	0,0
5	Lucian	5,4	0,3
6	Control	5,1	0

The ash content for autumn barley grains was on average 2,6%, slightly higher for Lucian type (92,8%), and Cardinal (2,7%), and lower for Belissa type (2,4%) and Ametist (2,5%).

Table 11.

The influence of the pedo-climatic conditions over the grain's ash content for autumn barley

No.	Genotype	Ash (%)	Difference (%)
1	Ametist	2.5	- 0,1
2	Belissa	2,4	- 0,2
3	Cardinal	2,7	0,1
4	Laverda	2,6	0
5	Lucian	2,8	0,2
6	Martor (media)	2,6	0

From an economical perspective, the results obtained can be used to recommend the 5 barley genotypes for their cultivation in the pedo-climatic area of Arad. The profits were between 3037 RON/ha for Ametist and 3379 RON/ha for Laverda type. Good results were obtained for Belissa (3334 RON/ha), and Lucian (3253 RON/ha) as well. Cardinal type offered a profit of 135 RON/ha less in comparison with Control, but can still be considered economically efficient (Table 11).

Table 12.

The influence of the pedo-climatic conditions on the economic efficiency for autumn barley

No.	Genotype	Grains production (kg/ha)	Grains production value (lei/ha)	Profit (RON/ha)	Difference (RON/ha)
1	Ametist	6930	6237	3037	-180
2	Belissa	7260	6534	3334	117
3	Cardinal	6980	6282	3082	-135
4	Laverda	7310	6579	3379	162
5	Lucian	7170	6453	3253	36
6	Control	7130	6417	3217	0

1 kg barley = 0,9 RON; Production costs = 3200 RON/ha

CONCLUSIONS

Cultivation of the 5 barley genotypes (*Hordeum vulgare* L.) in the pedo-climatic conditions of Arad resulted in optimal morphological, biochemical, and production values for all experimental variants. The average plant size was 98 cm, and the average spike length was 8,5 cm, which shows good adaptability of the plants to the environmental conditions. The number of grains per spike was between 43 and 51 pieces, confirming again that the plants were well adapted. High productions were obtained for all variants, with exceptional results for Laverda type with a grain quantity of 7310 kg/ha. With productions over 7100 kg/ha, Belissa and Lucian genotypes proved themselves viable crop variants to be cultivated in the Arad area. From a biochemical perspective, and starch content specifically, the analyzed genotypes are suited to be used as animal fodder, in the starch industry, and for beer production. The proteins content was between 10,3%-13,2%, fats content was between 2,2%-2,6%. The best economical results were obtained for the Laverda genotype, with a total production value of 7310 RON/ha, and a profit of 3379 RON/ha, followed by the Belissa type with a total production value of 7260 RON/ha, and 3334 RON/ha profits.

AUTHORS CONTRIBUTIONS

Conceptualization, U.O., and S.I.; methodology, U. O.; data collection U.O.; data validation, U.O., U.E., and T.V.; data processing U.O.; writing— original draft preparation, U.O., B.V; writing—review and editing, B.V.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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