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EFFECT OF SOWING DENSITY ON QUANTITY AND QUALITY OF PRODUCTION IN WINTER BARLEY (*Hordeum vulgare* L.)

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Abstract

Winter barley (Hordeum vulgare L.) is an important crop in Romania grown under different pedoclimatic conditions over whole country. The aim of this study was to establish the influence of four different sowing densities (300, 400, 500 and 600 seeds/m^2) of Lucian variety and of Jallon hybrid (200, 250, 300 and 350 seeds/m^2), under pedoclimatic conditions of Giurgiu county during 2021-2022. Assessments were conducted in order to evaluate production elements and the quality indexes (number of tillers, plants height, number of ears, number of grains/ears, the 1,000-grains weight, protein content and starch content). The results obtained showed that yield was obviously influnced by sowing density and by variety grown. Hybrid Jallon has provided the highest yield (7,875 kg/ha) when sown at 350 seeds on square meter. An yield of 6,487 kg/ha has been recorded when Lucian variety was sown at 600 seeds on square meter. Productivity elements and quality indicators of barley yield were strongly influenced more by sowing density than variety sown.

Key words*: winter barley, density, quality indexes, varieties, genotypes.*

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest crop in the world and one of the most important cereal with many uses in livestock fodder, human nutrition and industry, being the fourth grown cereal in the world after wheat, corn and rice. Barley is grown under different pedoclimatic conditions that affect the overall performance, especially the grain yield and quality. Barley has been an excellent solution for farmers in recent years due to its many advantages, including the diversification of sown grass crops and the reduction of risks generated by drought or frost. In order to obtain a high quality barley, in addition to perform the technological links, choosing the right variety is the main factor that mostly influences profitability.

For barley crop, the cultivar has an important role in obtaining safe and stable yield, and its agronomic characteristics such as, tillers per plant and grain physical quality ensure better constancy and stability for yield (Friedt et al., 2011; Pérez-Ruiz et al., 2016). To achieve barley high yield for grain or green mass, stable and qualitatively superior, growing of several valuable genotypes, with high production capacity, is required with superior qualitative features, resistant to diseases and adapted to different environmental conditions (Bolandi et al., 2012; Vasilescu et al., 2020; Costantea et al., 2022).

Sowing density is an important factor which influence yield and quality of barley. Optimum densities vary greatly between areas, climatic conditions, soil, sowing time and cultivars. As cultivars differ genetically in yield components, individual cultivars must be tested at a wide range of seeding rates to determine the optimal seeding rate (Wiersma, 2002; Spasova; Dragica et al., 2013). For this reason, in scientific investigations, it is constantly investigated optimization of plant number per unit area (Zecevic et al., 2014).

Taking into account these aspects, the aim of our investigations was to assess the impact of two different genotypes and the sowing rate on the yield and some quality characteristics of winter barley under pedoclimatic conditions from the Giurgiu area.

MATERIALS AND METHODS

Research was carried out in field at the Oinacu village, Giurgiu county (43˚58'452" N and 026˚ 05'164" E) and was performed under the influnce of the rainfall ammount of the area on a calcareous alluvial type of soil, moderately gleized, sandy texture (pH 7.3-7.5). The experiment used the method of subdivided plots into 3 replications, with the experimental plot area of 36 m^2 (3.6 x 10).

Two winter barley genotypes were sown in the field: the hybrid Jallon and the cultivar Lucian. Hybrid Jallon was sown at four different densities: 200, 250, 300 and 350 seeds/m^2 and the variety Lucian at: 300, 400, 500 and 600 seeds/m^2. Sunflower was the previous crop. Fertilization consisted on NPK fertilizer 20:20:0 application splitted in two stages: in the autumn at seedbed tillage (60 kg/ha) and after hibernation at the tillering stage in early spring (30 kg/ha). Seedbed was done before sowing by two soil harrowings. The sowing was performed mechanized in 08.10.2021. Distance between rows was 12.5 cm and sowing depth was 2-4 cm. Lucian variety has mid early maturity, medium height, good tillering capacity and long yellow awns. It proves good wintering resistance and damping-off resistance and tolerance to foliar diseases.

Jallon is a mid-early hybrid with an average height of 85-90 cm, with good damping-off resistance and drought tolerance, fast spring growth and excellent vigour, adapted to Romanian climatic conditions. It has a very well-developed root system, good tillering capacity, resulting in a greater number of fertile spikes and better disease tolerance.

Within the trial, several assessments were carried out during the growing season to observe how genotypes performed under the influence of other factors contributing to the growth and development of the winter barley crop.

In the field, observations and determinations were carried out regarding the percentage of emergence, number of tillers, plants height, number of spikes, number of kernels on spike.

The average percent of emergence was determined one month after sowing by counting the number of emerged plants per linear meter in each repetition, being reported on square metre. In the spring, tillering capacity was assessed by numbering the tillerings on linear meter in every repetition, on square meter reported.

Plant height was assessed by measuring with a graduated ruler before harvesting, from the soil surface to the top of the spike, excluding the awns. Measurements were made at three different places for each repetition.

Laboratory activity consisted on assessing the number of grans on spike, grains weight of spike (g), yield estimation (kg/ha) for field area under optimal moisture content of 14%, 1000 grains weight (g), protein content (%) and content of starch in barley grains (%). All the spikes were manually processed.

The total number of grains was divided by the number of spikes resulting in the number of kernels per spike. For the determination of TGW (1000 seed weight, g), samples of 1,000 grains each were counted from the spikes harvested from each experimental variant. The samples were weighed with an analytical balance and the weight was noted in grams.

Quality parameters (protein%, starch%) were determined by NARDI Fundulea (Barley Breeding Laboratory) with the help of Infratec 1241 grain analyzer.

All data were subjected to statistical analysis (ANOVA) provided by ARM-9 (P = .05, Student-Newman-Keuls) software. P-value was always inserted below every table to prove statistical differences between samples.

RESULTS AND DISCUSSIONS

From point of view of weather conditions, the year 2021-2022 was dried year compared to multiannual average recorded in Romania as shown by Weather station Giurgiu (Figure 1). The entire amount of rainfall recorded during December 2021 - June 2022 in barley crop resumed to only 154.7 mm. In October and November the rainfall amount was extremely low (in fact 8.7 and respectively 2.1 mm), but in December reached 91.5 mm to assure normal plant development in spring. During spring rainfall was extremely poor. Highest temperature degree was recorded on July (average 32.9˚C) since the precipitation was also poor (4.9 mm).

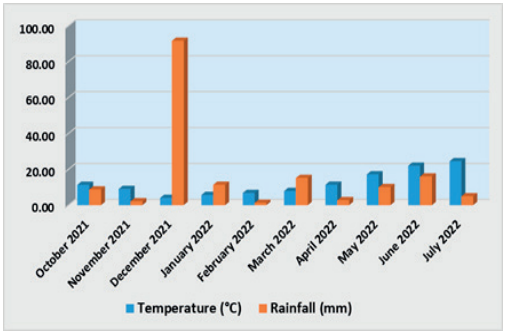

Figure 1. Precipitation and temperature evolution at Giurgiu, 2021-2022

It is well-known that in Romania winter barley gets to maturity stage with 7-10 days sooner than wheat because of its lower requirements for humidity (Panaitescu et al., 2011; Rizza et al., 2018; Berca et al., 2021; Vâtcă et al., 2021).

Table 1 shows the barley plants productivity (agronomic characteristics) as needed by the genotype grown and sowing density: number of tillers/m^2, plants height (cm), number of spikes/m^2, number of kernels on spikes and weight of kernels/spike (g). Out of data analysis it can be seen that for the barley genotypes studied the average shoot percentage did not vary much with seeding density. However, it decreased with increasing seeding density from 96.3% at 200 germinative seeds/m^2 to 91.1% at 350 germinative seeds/m^2 in the Jallon hybrid. In the case of Lucian variety, the germination percentage of barley plants decreased from 91.3% at a density of 300 germinative seeds/m^2 to 87.6% at a density of 600 germinative seeds/m^2.

Table 1. Influence of sowing density and genotypes on productivity elements in autumn barley crop, Giurgiu, 2022

No. crt.	Genotypes	Seed rate/m^2	Emergence percentage (pl/m^2)	No. of tillers/m^2	Plants height (cm)	No. spikes /m^2	No. of kernels on spikes	Weight of Grains/ spike (g)
1.	Jallon	200	95.50	433	19.16	421	38.41	1.533
		200	96.00	466	12.54	456	36.78	1.447
		200	97.50	491	12.55	484	34.56	1.351
		average	**96.33**	**463**	**14.75**	**454**	**36.58**	**1.444**
		250	94.00	551	11.06	540	25.04	0.991
		250	94.60	593	14.97	587	24.43	0.991
		250	95.40	599	11.40	585	24.88	0.966
		average	**94.66**	**581**	**12.47**	**571**	**32.26**	**1.266**
		300	93.50	674	13.50	664	32.52	1.285
		300	93.00	637	15.89	627	30.56	1.214
		300	93.50	677	17.10	660	30.08	1.164
		average	**93.33**	**663**	**15.49**	**650**	**31.05**	**1.221**
		350	91.00	782	13.71	775	27.38	1.081
		350	91.50	768	15.75	753	26.46	1.138
		350	91.00	804	22.83	792	27.19	1.077
		average	**91.17**	**785**	**17.43**	**773**	**28.01**	**1.099**
2.	Lucian	300	92.40	492	15.41	485	30.22	1.206
		300	90.60	475	16.27	467	32.42	1.310
		300	91.00	518	15.04	497	30.45	1.208
		average	**91.33**	**495**	**15.57**	**483**	**31.03**	**1.241**
		400	91.50	569	14.78	558	26.77	1.045
		400	91.00	582	15.55	569	26.97	1.067
		400	90.50	570	8.77	555	26.95	1.097
		average	**91.00**	**574**	**13.03**	**561**	**26.90**	**1.070**
		500	89.50	625	12.96	619	26.51	1.079
		500	89.00	654	12.76	643	25.60	1.020
		500	88.50	668	14.65	651	25.71	1.105
		average	**89.00**	**649**	**13.45**	**638**	**25.94**	**1.148**
		600	88.50	711	14.81	705	24.29	0.946
		600	87.00	736	14.16	724	22.48	0.898
		600	87.50	730	17.06	718	23.65	0.931
		average	**87.67**	**726**	**15.34**	**716**	**23.47**	**0.925**
*P-value**		-	0.000000001	0.0000001	0.0950	0.0000282	0.00000625	0.00000045
LSD			0.835	20.1029	3.5906	21.0946	2.2386	0.0952
Standard Deviation			0.568	13.6707	2.4418	14.3451	1.5223	0.0648

*Significant ($p \leq 0.05$)

However, the tillering capacity was strongly influenced by the seeding density. Thus, in the case of the Jallon hybrid the average number of tillers/m^2 was 463 at a density of 200 germinative seeds/m^2, 581 at 250 germinative seeds/m^2, 663 at a density of 300 germinative seeds/m^2 and 785 when 350 germinative seeds/m^2 were sown. In Lucian, variety the average number of tillers/m^2 also increased from 495 at 300 germinative seeds/m^2 to 726 when 600 germinative seeds/m^2 were sown.

Plant height was strongly influenced by density but also by genotype. Thus, in the case of the Jallon hybrid, the average height of the barley plants usually increased with the extension of sowing density, with the exception of the density of 250 germinating grains/m^2 where the lowest height was recorded 12.47 cm. Following the measurements, we found that for the Lucian variety, the average height of the barley plants did not vary so much depending on the density, with similar values being recorded for the lowest density, 15.57 cm and the highest density, 15.34 cm. The sowing density also greatly influenced the average number of spikes/m^2 for both autumn barley genotypes with the highest number of spikes being recorded at the highest sowing densities.

The number of grains/spike decreased with increasing sowing density with average values for the Jallon hybrid of 36.5 at 200 germinative seeds/m^2, 32.2 at 250 germinative seeds/m^2, 31.0 at 300 germinative seeds/m^2 and 28.0 when 350 germinative seeds/m^2 were sown.

The lowest number of grains/spike was recorded in Lucian field at the highest density tested with an average value of 23.47. Also the average weight of kernels/spike decreased with increasing sowing density from 1.44 g at the lowest sowing rate to 1.09 g at the highest density for the hybrid Jallon and from 1.24 g to 0.92 g in Lucian.

The influence of seeding density and genotype grown on barley yield is shown in Table 2.

Although the rainfall was very low the average yields obtained were satisfactory, the highest yield being obtained in the case of the Jallon hybrid at the density of 350 germinative seeds/m^2, respectively 7,876 kg/ha with 953 kg/ha more than the density of 250 germinative seeds/m^2 considered as the control sample. Although the critical periods with regard to water are from the straw formation stage to tasseling (similar requirements to wheat), at the same moisture regime, barley yields 20-25% higher than wheat (Bîlteanu, 1989).

Table 2. Influence of sowing density and genotype on barley yield, Giurgiu, 2022

Genotypes	Seed rate/m^2	Average yield		Dif. kg/ha
		kg/ha	%	
Jallon	200	6,923	100.0	-
	250	7,363	106.3	440
	300	7,575	109.4	652
	350	7,876	113.7	953
Lucian	300	5,870	100.0	-
	400	6,081	103.5	211
	500	6,274	106.8	404
	600	6,487	110.5	617
*P-value**		*0.0002*	-	-
LSD		*149.77*	-	-
Standard Deviation		*101.85*	-	-

*Significant ($p \leq 0.05$)

In the case of Lucian variety, the highest yield was recorded at the density of 600 germinative seeds/m^2, i.e. 6487 kg/ha, 617 kg more than the density of 300 germinative seeds/m^2 considered as control sample (Table 2).

Quality parameters of winter barley under sowing density and grown genotype influence (TGW – 1000 seed weight, g, protein content, starch content) are shown in the Table 3. Out of data analysis, it is noted that for the studied barley genotypes the TGW didn`t vary too much from point of view of sowing density. For Jallon variety the TGW average values were 42.3 g at a density of 200 germinative seeds/m^2, 42.0 g at 250 germinative seeds/m^2, 41.8 g at a density of 300 germinative seeds/m^2 and 41.7 g when 350 germinative seeds/m^2 were sown. For Lucian variety, the TGW average values were 40.1 g at a density of 300 germinative seeds/m^2, 39.7 g at 400 germinative seeds/m^2, 39.0 g at a density of 500 germinative seeds/m^2 and 38.5 g when 350 germinative seeds/m^2 were sown.

As regards the protein content of barley grains, the highest values were recorded for the hybrid Jallon at a density of 200 germinative seeds/m^2 (9.4%), and for the variety Lucian at the highest seeding rates, respectively of 15% at a density of 500 germinative seeds/m^2 and 14.2% at 600 germinable grains/m^2.

Starch content in grains averaged between 62.8 and 63.3% at Jallon and between 58.7 and 62.1% at Lucian (Table 3).

Table 3. Influence of sowing density and genotypes on quality parameters in autumn barley crop, Giurgiu, 2022

No. crt.	Genotypes	Seed rate (/m²)	TGW (g)	Protein (%)	Starch (%)
1.	Jallon	200	43.23	9.5	63.2
		200	42.41	9.5	62.5
		200	42.33	9.2	62.9
		average	**42.32**	**9.40**	**62.87**
		250	42.20	9.6	62.9
		250	41.98	8.9	63.4
		250	41.98	8.9	63.8
		average	**42.05**	**9.13**	**63.37**
		300	41.90	9.4	62.7
		300	41.72	9.0	62.9
		300	42.06	8.8	63.5
		average	**41.89**	**9.07**	**63.03**
		350	41.78	8.8	63.5
		350	41.73	8.7	63.0
		350	41.71	8.6	62.1
		average	**41.74**	**8.70**	**62.87**
2.	Lucian	300	40.08	12.1	61.7
		300	40.25	11.9	61.5
		300	40.20	10.2	63.2
		average	**40.18**	**11.4**	**62.13**
		400	39.99	14.3	61.0
		400	39.45	14.5	60.8
		400	39.87	11.3	60.5
		average	**39.77**	**13.37**	**60.77**
		500	38.64	15.4	59.4
		500	39.35	15.8	59.6
		500	39.04	14.0	60.0
		average	**39.01**	**15.07**	**59.67**
		600	38.36	14.3	57.0
		600	38.75	14.2	59.5
		600	38.57	14.1	59.6
		average	**38.56**	**14.20**	**58.70**
*P-value**		**-**	*0.0000019*	*0.00002*	*0.000015*
LSD		**-**	*0.3439*	*0.7742*	*0.8656*
Standard Deviation		**-**	*0.2339*	*0.5265*	*0.5887*

*Significant ($p \leq 0.05$)

CONCLUSIONS

Planting density is important factor which influence yield and quality of barley.

From climatic point of view, the 2021-2022 growing season year was unfavourable, extremely dried and hot.

Barley yields were strongly influenced by sowing density and genotype grown. The highest yield was recorded for the hybrid Jallon at a density of 350 germinative seeds/m^2, respectively 7,875 kg/ha and for the variety.

Lucian at a density of 600 germinative seeds/m^2, respectively 6,487 kg/ha.

Productivity elements and yield quality parameters of barley plants were greatly influenced by sowing density and less by the genotype grown.

The results achieved showed that for the barley genotypes studied, the average emergence percentage did not vary much with sowing density, but the tillering capacity, average number of spikes/m^2, and number of grains/spike was strongly influenced by sowing density.

Compared to the Lucian variety, where the height of the barley plants was approximately equal at the four sown densities, in the case of the Jallon hybrid, a greater variation of the plant height was found according to the density. Significant differences in the investigated quality components were established between seeding rates, with ecological factors playing an essential role in achieving quality yields.

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