Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON THE INFLUENCE OF THE CULTIVATED GENOTYPE AND THE SOWING SCHEME ON THE GRAINS QUALITATIVE PARAMETERS AT TWO-ROW BARLEY

Alexandru Iulian TOMA, Ricuța Vasilica DOBRINOIU, Mihai GÎDEA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: toma.iulian1994@gmail.com

Abstract

The quality of two-row barley grains, the main raw material in the beer manufacturing sector, is directly influenced by the management of some variables related to the cultivation technology, so that the selection of the most valuable genotypes and the establishment of an optimal density of plants per unit area represent the guarantee the success of this culture. The present research aimed to testing the behavior at new two-row barley genotypes and to identify the most optimal sowing scheme so that, at harvest, the grains meet the requirements imposed by the standards in force regarding the physical and chemical parameters which define the quality of the grains. The results of the research highlighted the superiority of the Salamandre variety which, by ensuring a sowing density of 350-450 germinating grains/m^2, was clearly superior to the Tepee and Bosut varieties in terms of grain quality in the soil-climatic conditions specific to the N-W area of the Romanian Plain.

Key words: *two rows barley, sowing scheme, genotype, physical quality parameters, chemical quality parameters.*

INTRODUCTION

Research in recent years has focused on improving the characteristics of current varieties of barley and barley for beer, as well as on using genetic improvement programs to create new genotypes that ensure high productivity and at the same time increase the technological value of the harvest for the brewing sector (Matthies et al., 2014).

Sing et al. (1974) mentioned that barley varieties with 2 rows are preferred for malting over those with 4 or 6 rows. Genotypes with a high grain uniformity value, containing more than 60% starch in grains and as low as possible in protein, are preferred for the purpose of obtaining a quality malt, there being a negative correlation between barley and barley varieties in terms of extracted malt yield and diastatic strength (Therrein et al., 1994).

Verma et al. (2004) reported as the most suitable for malting barley varieties with a mass of 1000 grains of at least 42 g, with 9-11% protein content of the grains, with a malt extract of at least 80% and a diastatic strength between 80ºL-120ºL. The superiority of barley genotypes on 2 rows was also mentioned by Sing (2005) who reported after research that higher weight grains with wrinkle uniformity were obtained which reported from its research that higher weight grains were obtained, with high uniformity, higher starch content and lower protein levels in grains, compared to 6-row barley genotypes.

The choice of valuable varieties that achieve superior yields in terms of quantity and quality is the key to success both on the grain market and in the processing sector for malt and, implicitly, for beer manufacturing (Križanova et al., 2010).

In this context, the research underlying the elaboration of this paper was also incriminated, research aimed at the management of variables of barley culture technology for beer in order to identify the most valuable barley genotypes whose genetic dowry to potentiate, under optimal conditions of crop technology, the productive capacity and technological value of the final grain production as a raw material in the brewing industry.

MATERIALS AND METHODS

The research underlying the preparation of this paper was carried out on medium samples of grains harvested from the experience with barley for beer mounted in the agricultural year 2021-2022 Experimental Field from Moara Domnească belonging to the University of Agronomic Sciences and Veterinary Medicine form Bucharest. The experience was a bifactoral one and aimed to evaluate the behavior of new barley varieties sown at different densities, with following experimental factors:

- Genotype of cultivated barley - Factor A, with graduations:

a1 - Tepee genotype
a2 - Bosut genotype
a3 - Salamandre genotype

- Sowing norm - Factor B, with graduations:

B1 - 250 germinating grains (gg)/m^2
B2 - 350 germinating grains (gg)/m^2
B3 - 450 germinating grains (gg)/m^2

The total area of the experiment was 3000 m^2, with 9 experimental variants arranged according to the method of plots subdivided into 3 repetitions, the calculation and interpretation of the research results being made by the method of variance analysis.

When collecting the experiment, 3 average samples of grains from each variant and experimental repetition were retained in order to determine the main physical and chemical parameters defining the qualitative value of barley grains intended for malting as the main raw material in the brewing process. The determinations which have been carried out after the grain has undergone its seminal rest period and covered the following indicators:

- mass of 1000 grains-MMB (g), by the method of two repetitions of 500 grains (SR 6124/1999);
- volumetric weight (MH) (kg), using Granomat Analyzer (SR 6123/1999);
- uniformity of grains (%), with the help of the Sortimat sieving machine;
- grain moisture (%), with the Granolyser Analyzer (SR ISO 712:99);
- germination energy of grains (%), by germination envelope method (SR 1634:1999);
- protein content of grains (%), using the Granolyser Analyzer;
- starch content of grains (%), using the Granolyser Analyser.

RESULTS AND DISCUSSIONS

The physical purity of barley grains harvested from the three genotypes taken in the study exceeded in all experimental variants the minimum limit of 93% imposed by the standards in force for the purpose of brewing, there being no significant differences in the experimental variants in terms of this physical indicator of grain quality (Table 1).

Table 1. The influence of experimental factors on varietal purity of the grains

Experimental Variant	Varietal purity (%)	Difference (%)	Significance degrees
V1-Tepee-250 gg	94	-0.9	-
V2-Tepee-350 gg	95	0.1	-
V3-Tepee-450 gg	96	1.1	-
V4-Bosut-250 gg	93	-1.9	-
V5-Bosut-350 gg	94	-0.9	-
V6-Bosut-450 gg	96	1.1	-
V7-Salamandre-250 gg	95	0.1	-
V8-Salamandre-350 gg	96	1.1	-
V9-Salamandre-450 gg	96	1.1	-
Experimental average (Control)	**94.9**	Control	Control
	$DL_{5\%}$ = 2.049; $DL_{1\%}$ = 3.022; $DL_{0,1\%}$ = 4.711		

Following the determination of the humidity of the beans, values varied between 11.1% and 11.8%, values that fall within the limits allowed by the brewing chain, the STAS wich specifying a maximum value of this physical quality parameter of maximum 14% (Table 2).

Table 2. The influence of experimental factors on humidity content of the grains

Experimental Variant	Humidity (%)	Difference (%)	Significance degrees
V1-Tepee-250 gg	11.7	0.3	xx
V2-Tepee-350 gg	11.6	0.2	-
V3-Tepee-450 gg	11.7	0.3	xx
V4-Bosut-250 gg	11.6	0.2	-
V5-Bosut-350 gg	11.4	0.0	-
V6-Bosut-450 gg	11.2	-0.2	-
V7-Salamandre-250 gg	11.1	-0.3	xx
V8-Salamandre-350 gg	11.3	-0.1	-
V9-Salamandre-450 gg	11.8	0.4	xx
Experimental average (Control)	**11.4**	Control	Control
	$DL_{5\%}$ = 0.201; $DL_{1\%}$ = 0.295; $DL_{0,1\%}$ = 0.458		

The differences between the experimental variants tested during the research were insignificant (-) in most experimental variants, but the Tepee and Salamandre varieties were highlighted which, at a sowing norm of 250 and 450 germinable grains/m^2, showed a better water retention capacity in grains, differences from the average experience taken as experimental control having distinctly significant positive statistical assurance (xx).

The weight of the grains was directly influenced by the two experimental factors tested during the research (genotype cultivated and sowing density). It is thus observed that there was a great variability between the experimental variants in terms of mass of 1000 grains, the values of this physical parameter of grain quality being between 45.6 g, minimum value recorded for the Bosut variety against the background of a sowing density of 350 germinable grains/m^2 and 50.8 g for the Salamander variety, against the background of the sowing density of 250 germinable grains/m^2 (Table 3).

Table 3. The influence of experimental factors on grains weight

Experimental Variant	Weight of 1000 grains (g)	Difference (g)	Significance degrees	Volumetric weight (kg/hl)	Difference (kg/hl)	Significance degrees
V1-Tepee-250 gg	49.4	0.95	xxx	66,6	0.28	xx
V2-Tepee-350 gg	49.2	0.75	xxx	66.8	0.48	xxx
V3-Tepee-450 gg	48.8	0.35	xxx	66,5	0.18	x
V4-Bosut-250 gg	45.9	-2.55	ooo	66.7	0.38	xxx
V5-Bosut-350 gg	45.6	-2.85	ooo	64.7	-1.62	ooo
V6-Bosut-450 gg	47.4	-1.05	ooo	65.3	-1.02	ooo
V7-Salamandre-250 gg	50.8	2.35	xxx	68.5	2.18	xxx
V8-Salamandre-350 gg	49.6	1.15	xxx	67.9	1.58	xxx
V9-Salamandre-450 gg	49.4	0.95	xxx	68.2	1.88	xxx
Experimental average (Control)	**48.45**	Control	Control	**66.32**	Control	Control
	$DL_{5\%}$ = 0.942; $DL_{1\%}$ = 0.140; $DL_{0,1\%}$ = 0.222			$DL_{5\%}$ = 0.142; $DL_{1\%}$ = 0.220; $DL_{0,1\%}$ = 0.376		

.

Compared to the average experience taken as a control, very positive differences were recorded (xxx) in Tepee and Salamandre varieties, while in Bosut varieties the differences were very significantly negative (ooo), regardless of the sowing scheme practiced at the establishment of the crop. However, it should be noted that the mass values of 1000 grains exceeded the minimum allowable value of 42 g laid down for barley and barley grains as raw material for brewing.

The volumetric weight of the beans is not a parameter that influences the quality of beer, but it is of interest to processors in terms of estimating the storage space they need. Analyzing the behavior of the three barley genotypes taken in the study (Table 3), it is found that, regardless of the sowing norm used when setting up the crop, grains with a volumetric weight higher than the minimum value required by the brewing industry, namely 65 kg/hl, except for the Bosut variety where, due to the use of a sowing norm of 350 germinable grains/m^2, the hectoliter mass of the grains was 64.7 kg/hl. In the Salamander variety, the highest values of the hectoliter mass of grains were recorded, values that varied between 67.9 and 68.5 kg/hl with very significantly positive differences (xxx) from a statistical point of view from the average experience (control).

In order to determine the uniformity of barley grains, as the main raw material in the brewing industry, the sifting of grains was performed with the help of the Sortimat sieving machine, a machine that was equipped with a set of 3 sieves with holes of different diameter, respectively 2.8 mm, 2.5 mm and 2.2 mm. After sifting, the grains remaining on the surface of each sieve were classified in quality classes according to the requirements imposed by the national and international standards used as a benchmark in assessing the uniformity of barley and barley grains destined for the brewing chain.

Table 4. The influence of experimental factors on the grains uniformity

Experimental Variant	Class I 2.8 mm (%)	Diff. (%)	Signif. degrees	Class II 2.5 mm (%)	Diff. (%)	Signif. degrees	Class III 2.2 mm (%)	Diff. (%)	Signif. degrees
V1-Tepee-250 gg	85	2.89	-	9	-1.88	94	6	-1.22	-
V2-Tepee-350 gg	83	0.89	-	10	-0.88	93	7	-0.77	-
V3-Tepee-450 gg	80	-2.11	-	12	1.12	92	8	0.78	-
V4-Bosut-250 gg	81	-1.11	-	10	-0.88	92	9	1.78	-
V5-Bosut-350 gg	80	-2.11	-	11	0.12	91	9	1.78	-
V6-Bosut-450 gg	78	-4.11	-	14	3.12	92	8	0.78	-
V7-Salamandre-250 gg	86	3.89	-	8	-2.88	94	6	-1.22	-
V8-Salamandre-350 gg	84	1.89	-	10	-0.88	94	6	-1.22	-
V9-Salamandre-450 gg	82	0.11	-	14	3.12	96	6	-1.22	-
Experimental average (Control)	**82.11**	Control	Control	**10.88**	Control	Control	**7.22**	Control	Control
	$DL_{5\%}$ = 5.079; $DL_{1\%}$ = 7.666; $DL_{0,1\%}$ = 12.453			$DL_{5\%}$ = 3.441; $DL_{1\%}$ = 4.908; $DL_{0,1\%}$ = 7.165			$DL_{5\%}$ = 3.408; $DL_{1\%}$ = 5.161; $DL_{0,1\%}$ = 8.431		

Analyzing the results obtained from the assessment of the uniformity of barley grains in the 2022 harvest, it is found that all three barley genotypes exceeded the minimum allowable values of grains with a diameter greater than 2.5 mm (80%) - according to international standard), against the background of the three sowing norms taken into account when setting up the crop, with insignificant differences (-) from the average of the experimental variants (Control).

Thus, the percentage of grains with a thickness greater than 2.8 mm, corresponding to Class I of quality, varied between 78% and 86%, the percentage level of grains with a diameter greater than 2.5 mm, classified in the Class II of quality, was between 8% and 14%, and the percentage of grains retained on the sieve with holes of 2.2 mm oscillated between 6% and 9%, there were no significant differences between the test variants analysed (Table 4).

From the point of view of germination energy of barley grains for beer, it is observed that all barley genotypes tested in the research performed very well in terms of this physiological parameter, exceeding the minimum allowable value of 92% provided by the standard in force, regardless of the sowing scheme practiced (Table 5).

Table 5. The influence of experimental factors on the grains germination energy

Experimental Variant	Germination energy (%)	Difference (%)	Significance degrees
V1-Tepee-250 gg	97	0.89	-
V2-Tepee-350 gg	97	0.89	-
V3-Tepee-450 gg	98	1.89	-
V4-Bosut-250 gg	95	-1.11	-
V5-Bosut-350 gg	94	-2.11	-
V6-Bosut-450 gg	95	-1.11	-
V7-Salamandre-250 gg	96	-0.11	-
V8-Salamandre-350 gg	96	-0.11	-
V9-Salamandre-450 gg	97	0.89	-
Experimental average (Control)	**96.11**	Control	Control
	$DL_{5\%}$ = 2.181; $DL_{1\%}$ = 3.310; $DL_{0,1\%}$ = 5.425		

The Tepee and Salamandre varieties were also highlighted in terms of germination energy, whose grains exceeded after 72 hours a germination rate of 95% according to EBC recommendations (2010), except for the Bosut variety where a 94% germination percentage was recorded due to the use of a sowing norm of 350 germinable grains/m^2. In all experimental variants differences from the mean experience had insignificant statistical certainty (-).

The amplitude of protein content of grains belonging to the three analyzed barley varieties varied between 9.6% and 12.4% (Table 6), most of the experimental variants falling within the limits provided by both the European Standard and the National Standard regarding the use of barley and barley grains as essential raw material in brewing, respectively 9.5-11.5%.

Table 6. The influence of experimental factors on the grains protein and starch content

Experimental Variant	Protein content (%)	Difference (%)	Significance degrees	Starch content (%)	Difference (%)	Significance degrees
V1-Tepee-250 gg	10.2	-0.2	oo	59,6	-1.0	ooo
V2-Tepee-350 gg	9.8	-0.6	ooo	60,2	-0.4	ooo
V3-Tepee-450 gg	10.4	0.0	-	61,4	0.8	xxx
V4-Bosut-250 gg	11.3	0.9	xxx	59,5	-1.1	ooo
V5-Bosut-350 gg	10.9	0.5	xxx	59,8	-0.8	ooo
V6-Bosut-450 gg	11.4	1.0	xxx	59,7	-0.9	ooo
V7-Salamandre-250 gg	9.6	-0.8	ooo	61,6	1.0	xxx
V8-Salamandre-350 gg	9.8	-0.6	ooo	61,9	1.3	xxx
V9-Salamandre-450 gg	10.3	-0.1	-	62,1	1.5	xxx
Experimental average (Control)	**10.4**	Control	Control	**60.6**	Control	Control
	$DL_{5\%}$ = 0.131; $DL_{1\%}$ = 0.194; $DL_{0,1\%}$ = 0.301			$DL_{5\%}$ = 0.090; $DL_{1\%}$ = 0.130; $DL_{0,1\%}$ = 0.195		

The results obtained after determining the protein content of the grains revealed that by practicing the three sowing schemes, the barley genotypes tested during the research efficiently used the nitrogen administered in a balanced dose when setting up the crop. Knowing that barley and barley varieties with a low protein content of grains are preferred for brewing, we can say that the most valuable in terms of grain quality were Tepee and Salamandre varieties with the lowest protein content in grains (9.6-9.8%), given the use of sowing norms of 250 and 350 germinable grains/m^2, with distinctly significant negative (oo) and very significantly negative (ooo) towards the experience average (Control).

Following the determination of the starch content of grains, a great variability was observed between experimental variants, the values of this chemical indicator of grain quality oscillating between 59.5% and 62.1% (Table 6). The Tepee and Salamandre varieties were noted, for which, against the background of ensuring a sowing density of 450 germinable grains/m^2, the content of grains in starch exceeded the minimum allowable value of 60% stipulated in the standards with very significantly positive differences (xxx) from the mean of control experience. In the Bosut variety, regardless of the sowing scheme practiced, the starch content was below the permissible mimin level provided by the standards, but very close to this value (59.5-59.8%) with very significantly negative statistical assurance (ooo) compared to the experience control.

CONCLUSIONS

Based on the results obtained from determining the physical and chemical parameters of the barley grain samples taken from the 2022 harvest, we can draw the following conclusions:

There were no significant differences in terms of physical purity of the beans, in all experimental variants taken in the studio the values of this quality indicator exceeding the minimum value imposed by the standard for the destination of brewing.

With grain moisture values between 11.1% and 11.8%, all experimental variants were below the maximum scale of 14% specified by the grain quality standard, as raw material for the chain - Brewing.

All barley varieties have exceeded the minimum limit of 42 g imposed by the standard for the mass of 1000 grains, but the Tepee and Salamandre varieties are significantly superior to the Bosut variety, in terms of the values of this physical indicator of grain quality, exceeding the limit of 48 g, irrespective of the sowing scheme practiced,

Irrespective of the sowing standard used when setting up the crop, for all three barley varieties analysed the volumetric weight of the grains exceeded the minimum limit of 65 kg/hl required by the brewing industry, except for the Bosut variety where the value of this physical parameter it was under the conditions of using a sowing norm of 350 germinable grains/m^2, of 64.7 kg/hl.

The results of the research revealed that the experimental factors tested had a direct and significant influence on the uniformity of the grains, the grains classified in the assortment Class I + Class II quality exceeding the percentage value of 91%, regardless of the genotype of barley cultivated or the density provided per unit area at the establishment of the crop.

The grains belonging to the three varieties of barley recorded, after 72 hours from the moment of laying on the germination layer, a germination rate of over 92% (the minimum limit imposed by the standard), noting the Tepee and Salamandre varieties with a germination energy exceeding 94%.

The most valuable in terms of protein content of grains were Tepee and Salamandre varieties, with values of this chemical quality parameter varying between 9.6% and 10.3%, regardless of the sowing scheme practiced.

The barley variety Salamander was clearly superior to the other varieties also in terms of grain content in starch, the values of this grain quality indicator exceeding 61% in all three sowing schemes practiced at the establishment of the crop, thus exceeding the minimum scale required by the brewing industry.

Based on the results obtained, we can say that, against the background of optimizing the sowing scheme, the three barley genotypes taken in the study performed very well in the specific conditions of the research location, achieving grain productions with high technological value in accordance with the norms imposed by the final destination, beer manufacturing.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the Doctoral School - Plant and Animal Resource Engineering and Management, Agronomy Field, from Faculty of Agriculture at the University of Agronomic Sciences and Veterinary Medicine Bucharest.

REFERENCES

Križanova, K., Psota, V., Sleziak, Ľ., Žofajova, A., Gubiš, J. (2010). *Spring Barley Breeding for Malting Quality*. Potravinarstvo*,* 4(2): 39-44. ISSN 1337–0960.

Matthies, I.E., Malosetti, M. Roder M.S., van Eeuwijk, F. (2014). *Genome*. Wide Association Mapping for Kernel and Malting Quality Traits Using Historical European Barley Records, PLoS ONE, 9(11): e110046. doi:10.1371/journal.pone.0110046

Singh, K. N., Misra, B. N. and Sastry, L. V. S. (1974). For better malting quality 2-row barley. *Indian Fmg,* 24 (1): 9-10.

Singh, B. (2005). Effect of time of sowing and nitrogen application on grain yield and malt quality of barley varieties. *M.Sc. thesis, Punjab Agricultural University, Ludhiana, India*

Therrein, M. C., Carmichael, C. A., Noll, J. S., Grant, C. A. (1994). Effect of fertilizer management, genotype and environmental factors on some malting characteristics on barley. *Canadian J of Plant Sci,* 59: 831–837.

Verma, R. P. S., Sewa, R., Sarkar, B. and Shoran, J. (2004). Malt barley Research in India. Directorate at Wheat Research (ICAR) Post Box 158, Karnal 132001 (Haryana).