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THE INFLUENCE OF GENOTYPE AND CLIMATIC FACTORS ON THE QUALITY OF SPRING BARLEY GROWN IN NORTH EAST BARAGAN

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Abstract

Knowing the contribution of genotype and environmental conditions (soil conditions and weather conditions), and especially the contribution of interactions between these factors in achieving quantitative phenotypic traits, is of particular importance for finding the most valuable varieties of barley that can be grown in a certain geographic area. The quality requirements for beer barley are quite strict and directly related to the efficiency of processing and the quality of the product obtained in the industry of malt and beer. Many of the quality traits needed for beer barley are controlled manufacturer, but others are determined by the weather during growing and harvest period. The research was conducted to determine the quality of studied spring barley varieties, compared to the quality standards in the beer industry. The experiments were conducted during 2008 - 2010 in the Vădeni area, Braila County, on four varieties of spring barley (Thuringia, Annabell, Cristalia and Tunika). To determine the quality of barley the following physical indicators were analyzed - the mass of 1000 grains (MMB g), the hectoliter mass (MH kg/hl), assortment (%), chemical indicators - humidity (%), protein content (% d.m.), starch content (% d.m.), and biological indicators - energy and germination capacity (%).The analysis of the quality indices of spring barley varieties in the conditions of Vădeni area highlights the value of these varieties for the production of malt for beer. Following the laboratory tests, we obtained the following results: the mass of 1000 grains (MMB) ranged from 39.06 g for the Cristalia variety in 2009 and 43.50 g for the variety Tunika in 2010; the hectoliter mass (MH) ranged from 57.9 kg / hl for the Cristalia variety and 64.6 kg/ hl for the Annabell variety in 2008; assortment ranged from 85.52% in 2009 for the Cristalia variety and 91.63% for the Tunika variety in 2008; humidity ranged from 12.55% for the Cristalia variety in 2009 and 14.9% for the Thuringia variety in 2010, protein content ranged from 9.75% for the Annabell variety in 2010 and 11.15% for the Cristalia variety 2008; starch content ranged from 56.5% in 2009 for the Cristalia variety and 61.75% in 2010 for the Tunika variety; the germination capacity was between 95% for the Cristalia variety and the 98% for the Thuringia variety. Despite the climatic conditions during the experimental period, the four spring barley varieties were found to match the quality requirements of the brewing industry.

Key words*: barley, varieties, climatic conditions, quality indices.*

INTRODUCTION

Barley can be used for multiple purposes: as human food, as animal food and in the industry (*as raw material in the making of beer* and in the industry of alcohol, dextrin, glucose, etc.) (Drăghici, 1975; Munteanu, 2001; Bâlteanu, 2003, Axinte, 2006).

The quality of barley as raw materiel for the industry of malt and beer is determined by factors of genetic nature (variety of barley), pedoclimatic factors (weather, soil) and by technological elements regarding growing the barley as: crop rotation, fertilization, soil works and the phytotechnical and technological elements of seeding, maintenance and harvesting of this species.

The variety is one of the main factors that determine the crops' success, abundance and its economic efficiency. For this reason, choosing to grow certain varieties of barley that are of superior quality, more productive, resistant to draught, disease and pests, that also correspond to the exigency imposed by malt and beer producers, has become a primary concern of the research of this species (Axinti and Dumitru, 2007).

Evidence the evolution of the number of dairy cows, milk yield and total milk production in the period 1990-2010.

MATERIALS AND METHODS

The experiments were conducted during 2008 - 2010 in the Vădeni area, Braila County, on four varieties of spring barley (Thuringia, Annabell, Cristalia and Tunika). To determine the quality of barley the following physical indicators were analyzed - the mass of 1000 grains (MMB g), the hectoliter mass (MH kg/hl), assortment (%), chemical indicators - humidity (%), protein content (% d.m.), starch content (% d.m.), and biological indicators - energy and germination capacity (%).

The quality parameters obtained after measurements made on grains of barley were compared to the parameters imposed by the norms of the beer industry.

Table 1 presents the standard quality conditions (SR 13477/2003) of malting barley necessary for the beer industry.

Table 1. Quality conditions for malting barley (source: *M.A.D.R.*)

No.	Quality parameter	limit
1	Foreign objects, (%)	max. 3
2	Grain humidity, (%)	max.14
3	Grain larger than 2.5 mm (assortment), (%)	min. 85
4	Germination, (%)	min. 95
5	Viability, (%)	min. 98
6	Mass of 1000 grains (MMB), (g)	min. 42
7	Protein content, (% d.m.)	max. 11,5
8	Variety purity, (%)	min. 93

The experimental perion, 2008-2010, had three dissimilar years in terms of hidric and termin regime.

In terms of rainfall, in comparison with the multiannual average (447 mm) the crop year of 2007-2008 was a normal one (481 mm), 2008-2009 was a draughty one (363 mm) and 2009-2010 was abundant in rain (714 mm) but the precipitations were unevenly distributed throughout the year.

In terms of the average multiannual temperatures recorded in the experimental years, compared to the normal (10.9°C), the crop years 2007-2008 and 2009-2010 were normal, with a positive deviation of 0.7°C from the multiannual average. The crop year of 2008-2009 was a warm year, with a positive deviation of 1.2°C from the multiannual average.

In terms of the evolution of weather conditions during the growing period of spring barley (March to June), in the three experimental years (Figure 1) we can observe that:

- *from a rainfall perspective* in 2008 we recorded values of 185 mm (with a positive deviation of 5mm from the average sum of March-June period), in 2009 of 97mm (with a negative deviation of 83mm from the average sum of March-June period) and in 2010 we recorded 257mm of rainfall (with a positive deviation of 77 mm from the average sum of March-June period.)

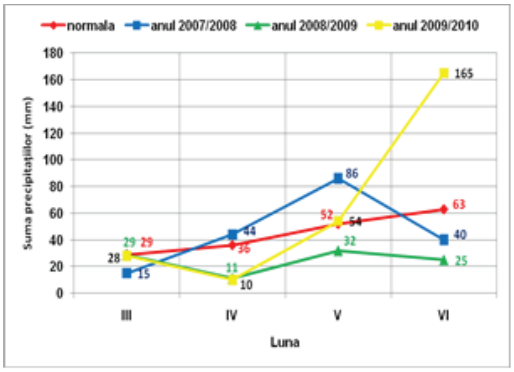

Figure 1. The evolution of monthly rainfall in the growing period of spring barley in 2008-2010, in Vadeni area, Braila county

- *from a thermica perspective*, the temperature distribution in the three experimental years has seen an upward trend, with deviations under 1°C from the normal values, with the exception of the year 2008 when there were positive deviations from the monthly average of 3.7°C in March and 1.4°C in April (Figure 2.)

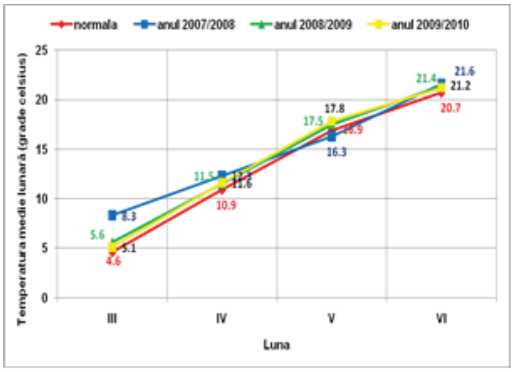

Figure 2. The evolution of average monthly temperatures in the growing period of spring barley in 2008-2010, in Vadeni area, Braila county

RESULTS AND DISCUSSIONS

Table 2 presents the average values of the main quality indices for the grains of barley coming from the varieties studied in Vadeni area, Braila county in 2008-2010.

From the experimental data obtained in 2008-2010, it is found that 2008 has given the best results for the majority of the quality parameters of spring barley, this beying a normal year in terms of weather.

Table 2. Summary of the average values of the quality parameters obtained for spring barley in Vadeni area, Braila county, between 2008 and 2010

Variety	Quality parameters*							
	U (%)	C.S. (%)	MH (kg/hl)	MMB (g)	S (%)	P (% s.u.)	A (% s.u.)	G (%)
2008								
Annabell	13.7	2.20	64.60	43.00	89.82	9.65	63.25	98.75
Thuringia	13.95	2.10	60.30	43.50	90.78	10.50	61.87	96.75
Cristalia	13.75	2.30	59.45	41.50	87.20	11.05	60.50	98.00
Tunika	14.2	1.75	64.30	43.62	91.63	10.05	63.12	99.00
average	13.9	2.08	62.16	42.90	89.86	10.31	62.18	97.94
2009								
Annabell	13.6	3.10	61.85	40.06	86.20	9.85	59.88	98.50
Thuringia	12.9	3.45	58.75	40.93	86.67	10.66	58.50	95.50
Cristalia	12.55	3.00	57.90	39.06	85.52	10.74	56.50	97.37
Tunika	12.75	2.90	61.85	41.31	87.56	10.35	59.12	98.75
average	12.95	3.11	60.08	40.34	86.59	10.40	58.50	97.53
2010								
Annabell	14.2	2.50	62.95	42.18	87.06	9.75	60.87	98.50
Thuringia	14.9	3.15	61.00	42.12	88.02	10.66	59.00	96.13
Cristalia	14.1	3.20	60.25	40.74	85.94	10.84	58.00	97.50
Tunika	14.45	2.83	62.80	43.49	87.56	9.89	61.75	99.00
average	14.41	2.92	61.75	42.13	87.75	10.28	59.90	97.78
2008-2010								
Annabell	13.83	2.60	63.13	41.75	87.70	9.75	61.33	98.50
Thuringia	13.92	2.90	60.01	42.12	88.50	10.61	59.79	95.92
Cristalia	13.47	2.83	59.20	40.44	86.32	10.88	58.33	97.67
Tunika	13.80	2.49	62.98	42.81	89.77	9.90	61.33	98.92
average	13.75	2.70	61.33	41.78	88.07	10.28	60.19	97.75
Standard	max.14	max.4	min.65	min. 42	min 85	max.11,5	57-65	min. 95

*Note: U (%) – barley grain humidity; C.S.(%) – foreign objects; MH (kg/hl) – hectolitric mass; MMB (g) – mass of 1000 grains; S (%) – assortment; P (% s.u.) – protein contents; A (% s.u.) – starch contents; G (%) – germination capacity.

The humidity is an important parameter in measuring the quality of the grains from several points of view. The optimal maturity state for harvesting of the malting barley is characterized by the grains water content, which cannot exceed 14%. Maintaining a high grain humidity for a long time can lead to quantitative and qualitative loses in the mass of spring barley and, as the temperature rises, can favour the appearance of diseases and the devaluation of barley grains. In draughty years, however, the water contents in the grains decreases drastically, making the grain stronger in the face of disease but also putting the grain in the danger of becoming shriveled.

The grain humidity varied between 13.70% for the Annabell variety and 14.20% for the Tunika variety. The grain humidity for the Tunika variety exceeded the maximum allowed standard value (SR 13477/2003) of 14%, which means the grains will have to be slightly dehidrated before storage (Figure 3).

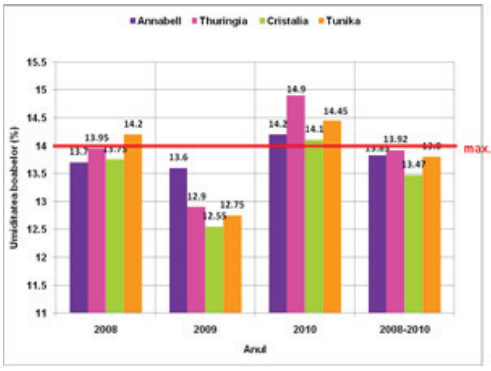

Figure 3. Grain humidity registered for the studied varieties in the three experimental years

The majority of the impurities that show in the grain mass is due to the growing and harvesting

technologies that were used and to the way they adapt to the specific crop conditions.

The foreign objects contents varied between 1.75% for the Tunika and 2.30% for Cristalia, values which meet the quality requirements imposed for malting barley. This parameter depends largely on the harvesting conditions.

The hectolitric mass (MH) is influenced by the grain compaction and intergranulary space, by the nature and quality of the seed that are dry, cracked, shriveled, etc. (Figure 4).

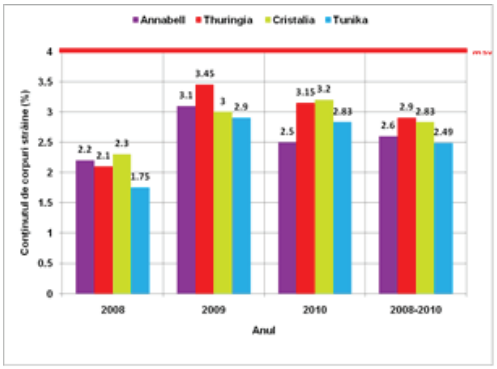

Figure 4. The content of foreign objects registered for the studied varieties in the three experimental years

The hectolitric mass fluctuated between 59.45kg/hl for the Cristalia variety and 64.30kg/hl for the Tunika variety. The Thuringia variety registered a hectolitric mass of 60.30kg/hl, similar to its genetic potential (64.2kg/hl). According to this quality conditions, none of the four studied varieties meets the standard requirement (SR 13477/2003) of min 65kg/hl (Figure 5).

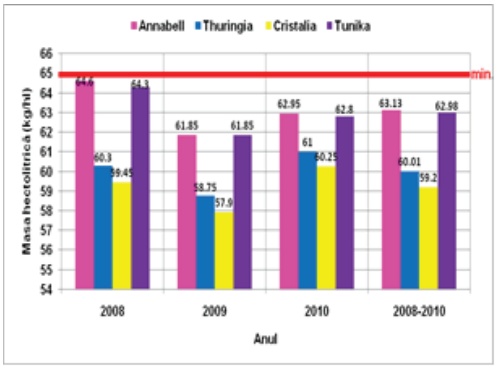

Figure 5. The hectolitric mass registered for the studied varieties in the three experimental years

In terms of ***mass of 1000 grains***, we recorded values between 41.50g for the Cristalia variety, which was below the minimum accepted (SR 13477/2003) (42 g), and 43.62g for the Tunika variety. From this perspective, only the Annabell, Thuringia and Tunika meet the standard requirements imposed (Figure 6).

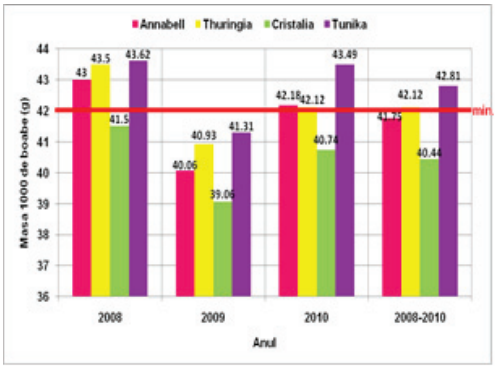

Figure 6. The mass of 1000 grains registered for the studied varieties in the three experimental years

The assortment registered values exceeding the standard (SR 13477/2003) (min. 85%) for all four studied varieties. The Cristalia variety registered 87.20% and the Tunika variety registered 91.63% (Figure 7).

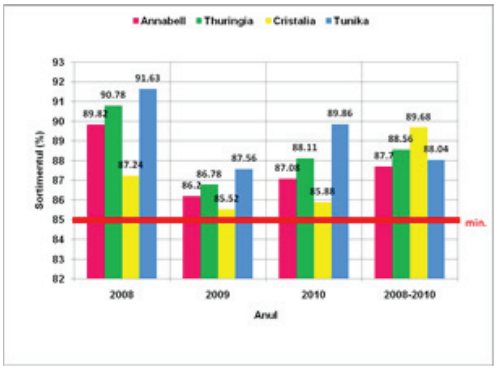

Figure 7. The assortment registered for the studied varieties in the three experimental years

The analysis of the values registered for the mass of 100 grains, hectolitric mass and assortment shows the negative influence of the climatic conditions manifested through the production of big seeds but with low specific mass.

In terms of assortment, all four studied varieties registered values that were superior to the standard (min. 85%).

The germination capacity of the studied varieties fluctuated between 96.75% for the Thuringia variety and 99.00% for the Tunika

variety, values which exceed the standard (Figure 8).

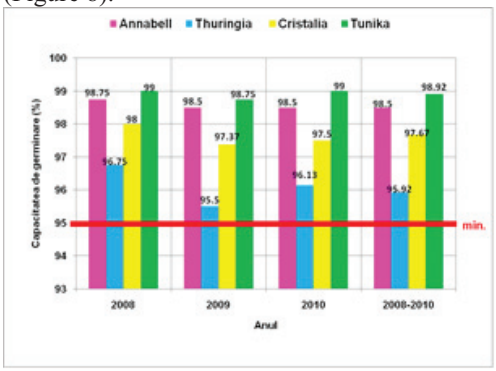

Figure 8. The germination capacity registered for the studied varieties in the three experimental years

The protein contents registered values between 9.65% d.m. for the Annabell variety and 11.05% d.m. for the Cristalia variety, meeting the standard requirement (Figure 9).

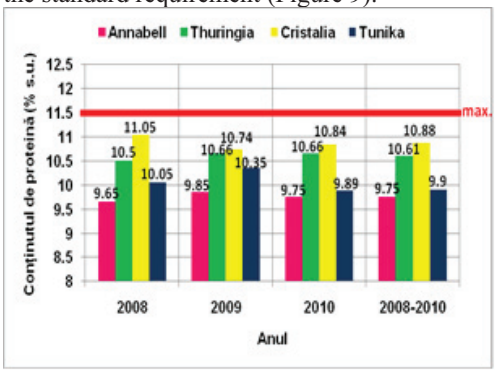

Figure 9. The protein contents registered for the studied varieties in the three experimental years

The starch content fluctuated between 60.50% d.m. for the Cristalia variety and 63.25% d.m. for the Annabell variety, which meets the requirements imposed by the beer industry (Figure 10).

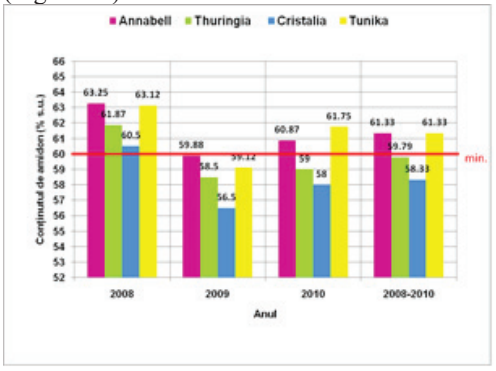

Figure 10. The starch contents registered for the studied varieties in the three experimental years

In **2009**, the reaction of the studied spring barley varieties was different in terms of harvest quality.

The humidity of the grains at harvest varied between 12.55% for the Cristalia variety and 13.6% for the Annabell variety, both of which meet the standard. (SR 13477/2003) (Figure 3).

The contents of foreign objects varied between 2.90% for the Tunika variety and 3.45% for the Thuringia variety, values which meet the quality requirements (Figure 4).

In the conditions of year 2009, ***the hectolitric mass*** for the studied varieties registered values under 65kg/hl, values which varied between 57.90kg/hl for the Cristalia variety and 61.85kg/hl for the Annabell and Tunika varieties (Figure 5).

The mass of 1000 grains for all four studied varietie had values below the standard requirement. (SR 13477/2003) (Figure 6).

In terms of ***assortment***, it obtained values over 85%, fluctuating between 85.52% for the Cristalia variety and 87.56% for the Tunika variety (Figure 7).

The protein content did not exceed the maximum admitted value of 11.5% d.m., varying between 9.85% d.m. for the Annabell variety and 10.75% d.m. for the Cristalia variety (Figure 9).

The starch content fluctuated between 56.50% d.m. for the Cristalia variety and 59.88% d.m. for the Annabell variety, which means that only the Annabell, Tunika and Thuringia varieties met the requirements imposed by the beer industry (Figure 10).

The germination capacity of the studied varieties registered values exceeding the standard (SR 13477/2003), fluctuating between 95.50% for the Thuringia variety and 98.75% for the Tunika variety (Figure 8).

In **2010** the value of the quality indices was also influenced by the environmental conditions. Thereby, the humidity of the grains registered a superior value to the standard admitted for all four varieties due to the weather conditions in the harvesting period, which means the seeds will need to be slightly dehidrated before storage. In terms of the content of ***foreign objects***, the four varieties met the qualitative requirements imposed by the beer industry (Figure 3).

Like in the other two experimental years, ***the hectolitric mass*** registered values below the imposed quality requirements, varying between 60.25kg/hl for the Cristalia variety and 62.96kg/hl for the Annabell variety. (figure 5)
The varieties which presented proper values of the ***mass of 1000 grains*** were Tunika (43.49g), Annabell (42.18g) and Thuringia (42.12g).
In terms of ***protein contents*** and starch contents, all four varieties were considered good for brewing (figure 9).
The germination capacity showed superior values to the standard imposed (SR 13477/2003), and fluctuated between 96.13% for the Thuringia variety and 99.00% for the Tunika variety (figure 8).
The analysis of the aggregated data of the quality indices average values obtained by the studied varieties in 2008-2010 shows the existance of different reactions towards the environmental factors.
In terms of hectolitric mass, the average value of this quality parameter varied between 59.20kg/hl for the Cristalia variety and 63.13kg/hl for the Annabell variety, values under the 65 kg/hl which is the minimum admitted. Only the Thuringia and Tunika varieties obtained values exceeding the standard (figure 5).
In order to be proper for brewing, the protein contents of barley grains must not exceed 11.5% of the dry matter because if this limit is exceeded, the malting process becomes dificult and results in malt with lower extract yield. The analysed varieties presented average values below the maximum standard, varying between 9.75% d.m. for the Annabell variety and 10.88% for the Cristalia variety (figure 9).
The starch content of the grains determines to the highest degree the quantity of extract. The high values of this indicator determine a greater malting quality. Thus, the varieties with a minimum content of starch of 58-60% will be better for malting. The average starch content in the experimental period varied between 58% d.m. for the Cristalia variety and 61.75% d.m. for the Tunika variety, which allows us to state that only the Tunika and Annabell varieties (61.33% d.m.) obtained values that meet the imposed standard requirements (figure 10).
The fast and full germination is an essential condition for the barley varieties used for obtaining the malt and making the beer, ensuring a high quality malt, well and fully disaggregated. The germination capacity of the grains for these barley varieties has to be of at least 95% and the germinative energy after 72 hours has to be 90%. The average values for this indicator were between 95.83% for the Thuringia variety and 99.18% for the Tunika variety (figure 8).

CONCLUSIONS

After an analysis of the data obtained, we can conclude that:
1. The value of the quality indices of spring barley grown in Vadeni area, Braila county was influenced by the specific pedoclimatic conditions of the experimental area.
2. The environmental conditions influence the filling of the grains, as evidenced by the values of the hectolitric mass (MH) and the mass of 1000 grains (MMB) obtained on all four varieties that were studied in the experimental period.
3. In terms of the protein contents of the four varieties, we can observe a good stability of this quality parameter.
4. Out of all four spring barley varieties, only the Annabell and Tunika varieties obtained starch content values that met the requirements of beer producers in all three experimental years.
5. The germinative capacity of all four varieties had values exceeding the minimum admitted by the beer industry in all three experimental years.
6. The lowest values of the quality indices of spring barley were obtained in 2009 both compared to the control year 2008 and to the experimental average.

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