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INFLUENCE OF NITROGEN FERTILIZATION ON TWO-ROWED WINTER BARLEY GENOTYPES UNDER 2023-2024 YEAR IN SOUTHEAST OF ROMANIA

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Abstract

This paper presents a one-year study (2023-2024) of 10 winter 2-rowed barley genotypes concerning the effectiveness of nitrogen fertilization on quality parameters that seeds need to accomplish for malting barley. The experiment was conducted at National Agricultural Research and Development Institute Fundulea, in Southeast Romania. The genotypes were sowed in the 2023 year in two technological sequences in 3 replications (T0 - 0 kg urea/ha and T1 - 100 kg urea/ha). It was revealed that were no significant differences in yield between the unfertilized (T0) and fertilized (T1) experience, the difference between the mean value of the experience was 635 kg/ha. The lowest value for protein content to be accepted by the malting industry was registered by the Gabriela variety (T0 - 11.47%) meanwhile the highest value of the experiment was registered by the Ileana variety (T1 - 15%) which indicates a suitable variety for animal forage. Starch content ranged between 61.2% (T0) and 63.9% (T1). A significant difference was observed in grain plumpness between the technological sequences as follows: the mean of the dataset for (T1) was 94.04% compared with 69.51% (T0).

Key words*: barley, variety, quality indicest.*

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one first domesticated small-grained cereal crops globally (Badr, 2000). In Romania, barley is cultivated on 497,770 ha^{-1} with a total production of 1,997,620 tonnes/ha^{-1}, ranking 4th for crop production after wheat, maize, and sunflower (FAOSTAT, 2023). The farmers prefer winter barley varieties with 6 rows because of their higher yield, more stress-tolerant to drought, and more tolerant to winter conditions (Samarah et al., 2009). In contrast, 2-row varieties (mostly for malting) offer higher grain quality, are more resistant to lodging, and have stronger straw (Narasimhalu et al., 1988).

Water deficit causes undesirable effects on grain yield by decreasing photosynthesis activity and accelerating leaves aging (Gerik et al., 1996), limiting cell growth, leaf expansion, and transpiration (Hsiao, 1973).

Thousands grain weight (TGW) expressed in grams is one the most important traits of the obtained yield (Hadjichristodoulou, 1990). The grain filling period is influenced by the environment and it was reported to be low correlate with weight and seed size (Coventry et al., 2003). Seeds with high values of TGW assure an increased content of starch and a low protein content (Burger and La Berge, 1985).

High protein content in the seeds affects the malt extract, including efficiency, time of extract, and profitability (Paynter, 1996), and is influenced by the nitrogen fertilization related to the growing stage, applied rates, and natural environmental nitrogen existing in the soil (Chen et al., 2006).

Barley breeding programs focus on developing genotypes thatpossess increased yield potential, high adaptability, and high responses to agronomic inputs (Pržulj et al., 2014). Grain protein content in barley is highly associated with feed quality and malt quality. A high value for protein content is favorable for feed and forage while a low protein content is suitable for malt quality (Shengguan, 2014). Grain protein content affects malting quality, the most important being yeast nutrition, beer turbidity, and enzyme activities (See et al., 2002; Clancy et al., 2003). Grain protein content is influenced

by the genotype and environment (Jukanti et Fischer, 2008; Smith, 1990). In dry conditions, nitrogen translocation is necessary for cereal production. The heat stress after the flowering phase induces drought stress which limits the nitrogen translocation (Kirda et al., 2001) so yield and protein content are dependent by assimilates translocated from vegetative tissues before flowering (Pheloung and Siddiqquea, 1991). The main objective of the present paper is to asses the influence on nitrogen fertilization on yield and quality parameters of malting barley in 2023-2024 in Southeast of Romania.

MATERIALS AND METHODS

Researches were performed in the 2023-2024 agronomical year in the barley breeding field, on a cambic chernozem in Southeast Romania, at the National Agricultural Research and Development Institute Fundulea (Latitude 44.4547°N, Longitudine**:** 26.5155° E). The analysed genotypes were 10 winter 2-rowed barley (5 varieties and 5 perspective lines), all created at NARDI Fundulea. The sequence of testing genotypes was nitrogen fertilization in 2 rates (T0 - 0 kg of Urea/ha^{-1} and T1 - 100 kg urea/ha^{-1}) applied on the 15th of March, 2024. The soil was tilled in autumn 2023 by harrowing followed by cultivation. The sowing was performed on the 20th of October, 2023 in randomized plots in 3 replications of 6 m^2, at 12.5 cm between rows on a density of 350 seeds/square meter. The weed control has occurred using Stomp Aqua (455 g/l Pendimetalin) applied at a dose of 3 liter/ha^{-1}. In spring it was necessary to spray a second time for weed control, using Axial One (45 g/l pinoxaden, 5 g/l florasulam, 11.25 g/l cloquintocet-mexil) with a dose of 0.8 l/ha^{-1}. The plots were harvested on 20th June 2024 with Wintersteiger Delta combine for the experimental plot. The yield was weighted for 4.5 square meters at 14% moisture, then reported for ha^{-1}. After the yield was assessed, samples were prepared in 3 replications and reached the quality laboratory for further analyses:- thousand grain weight was assessed using a Contador instrument (set by 1000 grains) followed by weighing on a electronic balance.

- assortment (seeds bigger than 2.5 mm diameter) as percent from 100 grams of sample, determined with Sortimat (2.5 mm sieve)
- protein and starch content were analyzed by INFRATEC 1245 (%)

The datasets were analyzed with SPSS version 26. ANOVA with 2 factors was determined to see if the analysed dependent variables were statistically influenced by chosen factors (genotype, fertilization, and the interaction between them). In addition, descriptive statistics were determined (mean, maximum, minimum value) for each category of data.

Total rainfall registered in 2023-2024 (Table 1) from sowing to harvesting was 308.8 mm, with -106.2 mm less than the multiannual average of 415 mm, registered at NARDI meteorological station (mean of 60 year).

The temperatures (Table 2) were higher than the multiannual average with almost 4°C for the entire growing season, the maximum difference occurred in February when the temperatures were at the multiannual average of 8°C.

Table 1. Rainfall (mm) at NARDI Fundulea in the 2023-2024 year

	Month									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun	Sum
Rainfall	29.0	85.6	24.4	17.6	1.4	38.6	62.4	34.2	15.6	308.8
Average	42.3	42.0	43.7	35.1	32.0	37.4	45.1	62.5	74.9	415.0
Dif	-13.30	43.60	-19.30	-17.50	-30.60	1.20	17.30	-28.30	-59.30	**-106.20**

Table 2. Temperatures at NARDI Fundulea in the 2023-2024 year

	Month									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun	Mean
T(°C)	16.1	8.5	4.3	1.0	7.6	8.5	15.0	16.4	26.1	11.5
Average	11.3	5.4	.0	-2.4	-.4	4.9	11.3	17.0	20.8	7.5
Dif	4.80	3.10	4.30	3.40	8.00	3.60	3.70	-.60	5.30	**3.96**

*multiannual average (60 years)
**difference between registered rainfall during the experimental year and multiannual average

RESULTS AND DISCUSSIONS

Grain yield

The yield was significantly influenced by the genotype and fertilizer rate but not significantly influenced by their interaction (Table 3)

Thousands grain weight

Regarding TGW (g) the obtained results registered a difference of 0.75 grams between the average of the analyzed categories (Figure 3).

Table 3. Two-way ANOVA for studied parameters

Source	Yield (kg/ha^{-1})	TGW (g)	Assortment (%)	Protein content (%)	Starch content (%)
Genotype (G)	.000*	.000*	.000*	.000*	.000*
Fertilization (F)	.000*	.000*	.000*	.371^{ns}	.352^{ns}
G x F	.048^{ns}	.000*	.000*	.086^{ns}	.061^{ns}

*The mean difference is significant at the .05 level.

The difference between the yield average of different nitrogen rates was 635 kg/ha^{-1} (Figure 1). Comparing the average yield between the genotypes can be observed that the highest difference between the two nitrogen rates was obtained for DH 417-12 (+1195 kg/ha^{-1}) and DH 403-12 (+978 kg/ha) for T1, while Gabriela variety reached a difference of 683 kg/ha^{-1} for T0 (Figure 1).

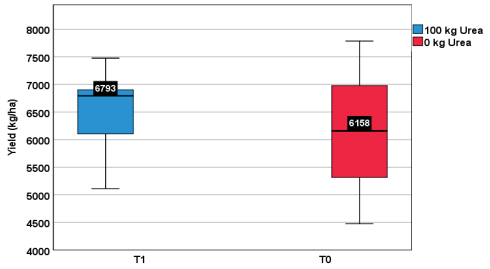

Figure 1. Average yield between two fertilization rates

The most stable genotypes with the lowest variations were Artemis, DH 425-3, DH 425-4, Diana, and the used Check.

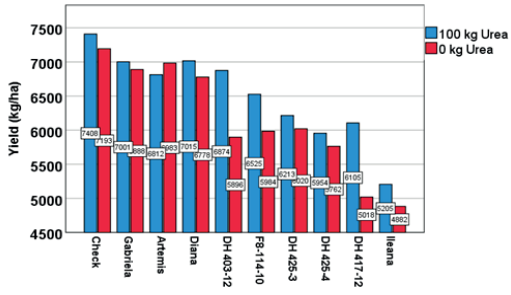

Figure 2. Average yield between two fertilization rates registered for experimented genotypes

The thousands grain weight registered the highest values for the T1 rate for 7 genotypes except only 3 of them which had better results for the T0 application. The biggest difference that this parameter was registered for the Gabriela variety (+3.0 g) and used Check (3.3 g). Ileana variety registered the lowest values both for T1 and T0, below 44.0 g (Figure 4).

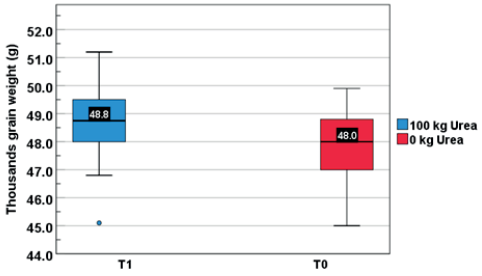

Figure 3. Average TGW (g) between two fertilization rates

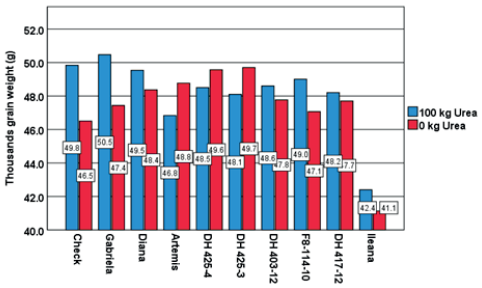

Figure 4. Average TGW(g) between two fertilization rates registered for experimented genotypes

Assortment

Nitrogen fertilization had a very significant impact on seeds size as it is shown in Figure 5.

The difference between TGW(g) for compared categories was 23.7%.

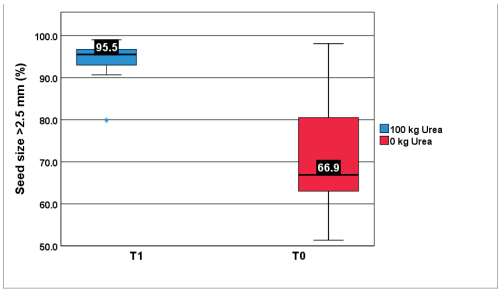

Figure 5. Average seed size (g) between two fertilization rates

Comparing each genotype, the registered values had better responses for the application of nitrogen (T1). Using this sequence the plumpness of seeds is higher than 90% (seeds bigger than 2.5 mm diameter) for almost all tested genotypes except the Ileana variety (only 80%). The highest seed size was registered for DH 417-12 (98.24%) T1, while T0 had very negative effects for the Ileana variety (51.67%) seeds bigger than 2,5 mm diameter (Figure 6). The most stable variety for this parameter was Artemis with a difference of 6.3% between the two fertilization rates.

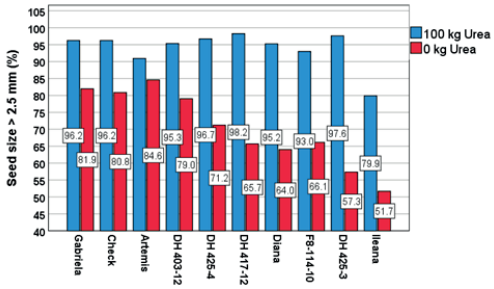

Figure 6. Average seed size (g) between two fertilization rates

Protein content

During studied year it was shown in Table 3. That the protein content was significantly influenced by the genotype but not by the nitrogen fertilization. It is a slightly decrease between the two categories but with no significant impact on the protein content. Regarding the response of the genotype, the protein content has been significantly influenced. The average value for the two categories registered a difference of 0.5% (Figure 7).

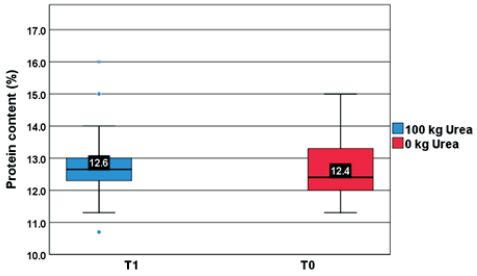

Figure 7. Average protein content (%) between two fertilization rates

The protein content ranged from 11.47% (Gabriela - T0) to 15.00% (Ileana variety T1). Ileana variety registered high values for both fertilization rates (exceeded 15% for T1).

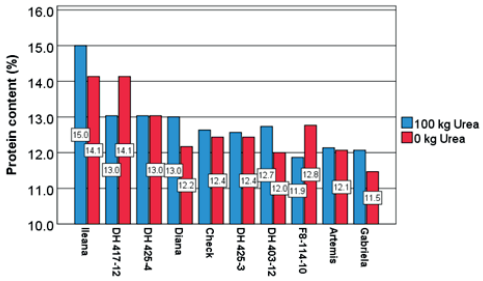

Figure 8. Average protein content between two fertilization rates

The highest difference between two fertilization rates was registered at DH 417-12 (1.56%). The most stable varieties which registered the lowest difference between the two fertilizations strategies were Artemis, DH 425-3, DH 425-4, Gabriela, and the check, which maintain the protein values almost the same.

Starch content

The starch content registered in the experimented year had a slight increase from a minimum of 62.17% (T1) to 62.28% (T0), an opposite effect compared with the other parameters, but statistically insignificant.

The studied 2-rowed genotypes for registered starch content had a better response for N0 fertilization, (Figure 10) shows that the graphic line for T0 starch content is above the T1 line except for DH 417-12, DH 425-4, and the check.

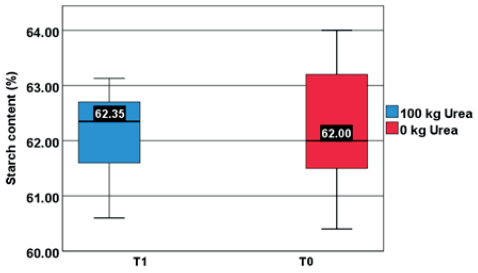

Figure 9. Average starch content (%) between two fertilization rates

The highest value was registered at the Ileana variety for both conditions (63.0% - T0 and 63.0% - T1). On a background of T0, Artemis (+0.5%) and DH 403-12 (+0.63%) variety had a better response regarding starch content.

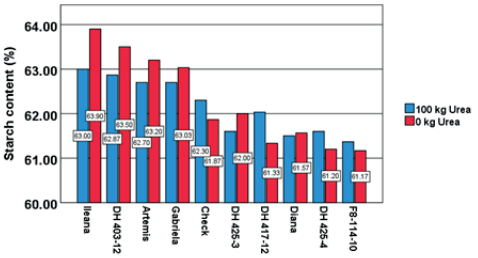

Figure 10. Average protein content between two fertilization rates

CONCLUSIONS

The results obtained during the 2023-2024 year highlighted that the highest values for yield, thousand grain weight, seed size, and protein content were realized using 100 kg of urea (T1). The starch content had the opposite effect, but insignificant, being higher for T0 (without fertilizer application).

The highest yield registered for the Gabriela variety (7684 kg/ha^{-1}) reveals the high adaptability of this variety to drought conditions which have been more frequent in the last year in the southeast of Romania. During the experimental year, we can conclude that in this drought year 2023–2024, nitrogen fertilization was not beneficial for all varieties, some of them being unable to use it due to a lack of optimal growing conditions (Tables 1 and 2).

The thousands grain weight was also affected by the heat and water stress. It was shown that despite those conditions, the Gabriela variety succeeded in thousand grains weight over 50.0 g which empowers this trait as being suitable for the malting industry. The importance of the fertilization strategy was also revealed for the check values which had better response for 100 kg fertilizer.

The effect of seed size was the most affected by the 2023-2024 conditions. Seed size registered a low percent for T0 for all studied genotypes, underlying that without nitrogen the seed size could be affected for malt extract acceptance. The Artemis, Gabriela, DH 403-12 and standard chech registered over 75% of seeds bigger than 2.5 mm in diameter which can be selected both for breeding and selecting for the malting industry.

Protein content was significantly different ($p < 0.05$) only between genotype responses. On a background of nitrogen fertilization, the protein content during the experimental year ranged between 12 -13 % for almost all studied genotypes. Gabriela variety and F8-114-10 line had a low protein content which indicates that raw material is suitable for the malting process. The Ileana variety registered the highest values of proteins for T1 and T0 respectively (over 14%), highlighting this variety as a good row material for animal forage.

Starch content response was the most different compared to the other parameters. The starch accumulated in seeds tends to increase using no fertilizer (T0). Again, the Ileana variety had a good response in this trait for animal forage (starch content exceeded 63% for both conditions).

In conclusion, in the 2023-2024 year, drought background the 2-rowed winter varieties created at NARDI Fundulea had suitable results for malting and animal forage too. The yield, TGW, seed size, low protein content, and starch content for Artemis and Gabriela for both conditions (with and without fertilizer) recommend those varieties suitable for malting, while the Ileana variety is more valuable for animals (high protein and starch content).

Further research would be needed to establish that analyzed parameters tend to maintain or change the tendency registered in the studied year.

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REFERENCES

Badr, A., Müller, K., Sch, R., Rabey, H., Effgen, S., Ibrahim, H. (2000). On the origin and domestication history of barley (Hordeum vulgare). *Mol Biol Evol*, 17: 499–510.

Blakely, P. (1996). Grain protein and malting quality in barley. Farmnote, no. 40/96 *Agriculture Western Australia*.

Burger, W.C., Leberge, D.E. (1985). Malting and brewing quality. In: Rasmussen, D.C. (Ed.), *Barley. American Society of Agronomy*, Madison, WI: 367–401.

Chen, J.X., Dai, F., Wei, K. and Zhang, G.P. (2006). Relationship between malt qualities, amylase activity, and protein content as affected by the timing of nitrogen fertilizer application. *Journal of Zhejiang University Science* B 7(1): 79–84.

Coventry, S.J., Barr A.R., Eglinton, J.K., McDonald, G.K. (2003). The determinants and genome locations influencing grain weight and size in barley (Hordeum vulgare L.). *Australian Journal of Agricultural Research,* 54: 1103–1115.

Clancy, JA., Han, F., Ullrich, SE. (2003). Comparative mapping of α-amylase activity QTLs among three barley crosses. North American barley genome project. *Crop Sci,* 43:1043–1052.

Gerik, TJ., Faever, KL., Thaxton, PM., El-Zik, KM. (1996). Late-season water stress in cotton: plant growth, water use, and yield. *Crop Sci,* 36: 914–921.

Hadjichristodoulou, A. (1990). Stability of 1000-grain weight and its relation with other traits in dry areas. *Euphytica,* 51: 11–17.

Hsiao, T.C. (1973). Plant responses to water stress. Annu. Rev. *Plant Physiol,* 24: 519-570157–185.

Jukanti, A.K., Fischer, A.M. (2008). A high-grain protein content locus on barley (*Hordeum vulgare*) chromosome 6 is associated with increased flag leaf proteolysis and nitrogen remobilization. *Physiol Plant*, 132:426–439.

Kirda, C., Derici, M.R., Schephers, JS. (2001). Yield response and N-fertilizer recovery of rain-fed wheat growing in the Mediterranean region. *Field Crop Res,* 71: 113–122.

Narasimhalu, P., Kong, D. (1998). Choo, T.M. Straw yields and nutrients of seventy-five Canadian barley cultivars. *Can J Anim Sci,* 78: 127–134.

Pheloung, P.C., Siddiquea, K.H.M. (1991). Contribution of stem dry matter to grain yields in wheat cultivars. *Aust J Plant Physiol,* 18: 530–546.

Pržulj, N., & Momčilović, V. (2008). Characteristics of malting barley in Southeast Europe. I. Spring barley. In: Ceccarelli, S., & Grando, S. (Eds.) *Proceedings of the 10th International Barley Genetics Symposium*. 5-10 April 2008. Alexandria, Egypt. ICARDA. PO Box 5466. Aleppo, Syria, 484–494.

Samarah, N.H., Alqudah, A.M., Amayreh, J.A., McAndrews, G.M. (2009).The effect of late-terminal drought stress on yield components of four barley cultivars. *J Agron Crop Sci*, 195: 427–441.

Shengguan, C., Gang, Y., Xianhong, C., Yechang, H., Xiaogang, J., Guoping, Z., Xiaoli, J. (2013). Grain protein content variation and its association analysis in barley. Article in *BMC Plant Biology*, March 2013.

See, D.K., Kephart, V., Blake, K. (2002). Mapping genes controlling variation in barley grain protein concentration. *Crop Sci*, 42:680–685.

Smith, D.B. (1990). Barley seed protein and its effects on malting and brewing quality. *Plant Variety Seed*, 3: 63–80.

https://www.fao.org/faostat/en/#data/QCL/visualize