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WINTER BARLEY GRAIN WEIGHT STABILITY UNDER DIFFERENT MANAGEMENT PRACTICES AT NARDI FUNDULEA

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ABSTRACT

Cereals provide over 50% of the total world crop production, their seeds being an important resource for human and animal feed, as well as for the industry. From these, winter barley is an appreciated crops by farmers due its ability to adapt to less favourable environmental conditions and also give high and economically efficient yields.

The barley grain weights (GW) along with grain size are universally considered to be closely correlated with the level of technological quality indicators required by the malt and beer industry. Grain weight is first trait used to classify the barley seed quality.

The objective of this paper was to identify genotypic differences between seventeen Romanian winter barley genotypes in grain weight as related with grain yield and GW stability across different management practices.

Large differences (8.2-20.8%) were found among the tested varieties and advanced lines for GW stability, underlined by the coefficient of variation (CV%).

Based on regressions, varieties and lines can be grouped in more responsive to environments favourable to higher grain weight (winter two row barley lines DH 267-66 and DH 314-1), or able to maintain grain weight in less favourable environments (winter six row barley Ametist, Onix, Lucian and winter two row barley Gabriela varieties).

The lack of correlation between GW and CV% and frequency of GW values above 42 g correlated significantly negative with GW average (r = -0.82), indicates that there are possibilities to improve this trait and also to have progress in its stability.

Keywords: winter barley, variety, line, grain weight (GW), yield, stability.

INTRODUCTION

Barley is a versatile cereal due to a variate utilization in raw industry (malt and beer, feed, variousfood products, alcohol production, food supplements).

Pasam et al. (2012), after they performed a genetic analysis on barley, found that there was a close relationship between grain weight (GW) and grain yield (GY).

Beside that, Marzougui et al., in 2018, found a positive regression between plant height and grain weight (GW), and indicated that an increase of these traits will conduct to an increment of yield.

Grain yield represents the interaction between yield components and these interact with each other. The result can be an increase of one of them leading to a decrease of other, but it is possible to breed a character independently by other (Zhou et al., 2016).

Grain yield is also influenced by environmental conditions and agronomic practices (Oral et al., 2018).

One of the main barley yield components is grain weight (GW) and this trait largely depends on grain length and grain width (Pasarella et al., 2005). Both seed traits are controlled by many genes (Sun et al., 2013) and influenced by environmental conditions (Walker et al., 2013; Öztürk et al., 2018). Optimization of grain weight as trait and its stability can contribute to a real improvement of grain yield (Xu et al., 2018).

Grain weight and size are often used to evaluate the barley grain quality because a

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large and heavy grain is related with water uptake during the malting process (Li et al., 2008) and on the other hand could have a better feed quality due the grain starch content.

The value of barley grains on the market is strongly related with grain weight, this being the first evaluated trait in order to know the yield destination. A very efficient approach to obtain different end use quality of barley grains consists in breeding varieties with enhanced grain weight and also stable under many environments.

MATERIAL AND METHODS

During three growing seasons (2013/2014, 2014/2015, 2015/2016), seventeen winter barley genotypes (11 varieties and 6 advanced breeding lines) created at National Agricultural Research and Development Institute Fundulea, tested in trials that were widely different in nitrogen availability (without nitrogen, with 100 and 200 kg/ha) were investigated for yield and grain weight.

The data were subjected to ANOVA in order to analyze the significance of nitrogen dose, variety and their interaction (dose*variety).

Grain weight was determined by counting 2 x 500 grains in three replicates using a Contador instrument and after that weighing the samples on the electronic balance with 2 decimals.

Stability of grain weight across the different management practices was analyzed using the following statistics parameters:

- amplitude of variation:

$$Ax = xMax - xMin$$

- coefficient of variation (cv%):

$$CV_i = s_i/x_i*100$$

- regression coefficient (b) and the constant (a) as suggested by Finlay and Wilkinson (1963), computed using the Excel software:

$$b^{y}/_{x} = \frac{\Sigma xy - \frac{\Sigma x \, \Sigma y}{N}}{\left(\Sigma x^{2} - \frac{(\Sigma x)^{2}}{N}\right)}$$

$$a_i = y_i. + b_i * x_i.$$

- frequency of cases when grain weight was below 42 g, minimum level required by malt industry for a barley variety.

In order to study the relationship between average grain weight and stability parameters, correlation analysis was used.

Regarding meteorological conditions, NARDI Fundulea area is characterized by a continental temperate climate, with uneven distribution of rainfall by months.

Climatic data during the investigated period (2013-2016) indicate that the years when the researches were conducted were different, both in rainfall quantities and level of temperatures (Figures 1 and 2), as compared with a long term average (1957-2015).

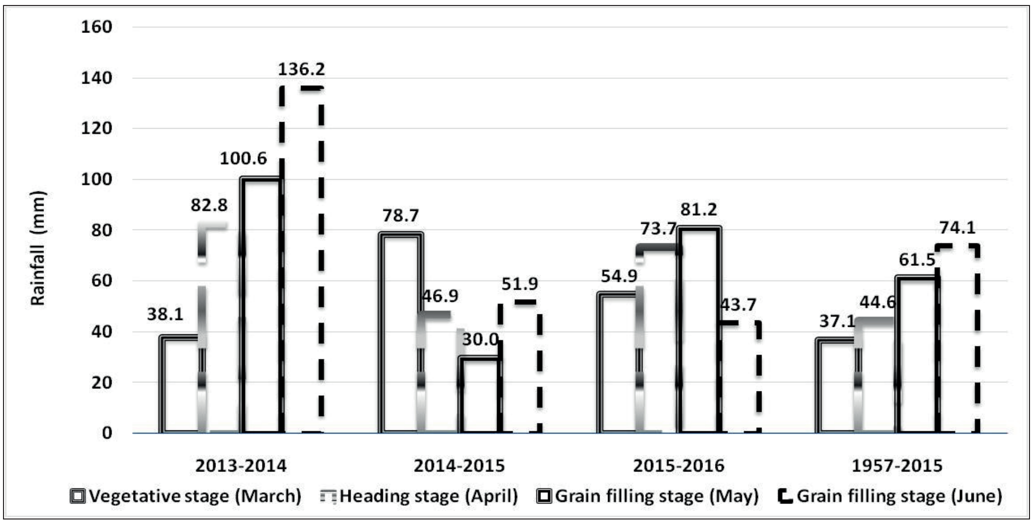

Figure 1. Rainfall data ta from 2013-2014, 2014-2015, 2015-2016 in different development stages and long-term average (1957-2015)

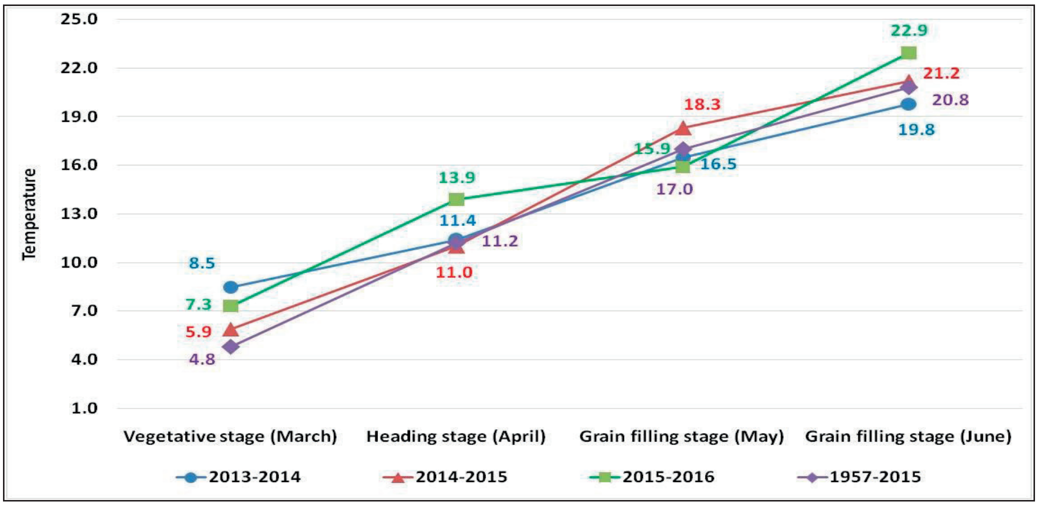

Figure 2. Monthly average temperature data (different development stages) from 2013-2014, 2014-2015, 2015-2016 and long-term average (1957-2015)

RESULTS AND DISCUSSION

Variance analysis showed that the effect of input sistems (N dose) was significant and had the largest effect. Variety and interaction D x V also showed a significant influence on grain weight (Table 1). The fertilizer dose contribution to achieved grain weight was 97% (Figure 3).

Table 1. ANOVA for grain weight (GW) of 17 winter barley genotypes under different management practices (3 doses x 3 years)

Source of variation	SS	df	MS	F	F crit	P-value
Dose	4439.12	2	2219.56	483.58**	3.09	9.07E-53
Variety	552.99	16	34.56	7.53**	1.74	2.46E-11
Interaction DxV	1266.76	32	39.59	8.62**	1.56	2.60E-17
Within	468.17	102	4.59			
Total	6727.03	152				

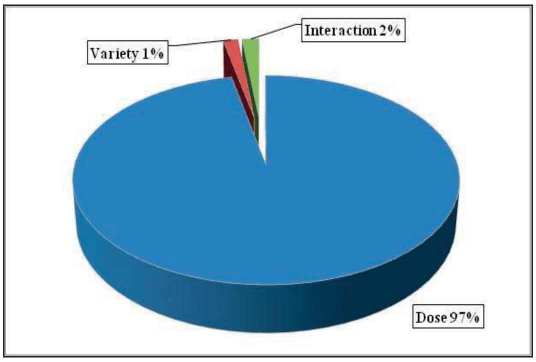

Figure 3. Share of factors (%) in achieving grain weight in tested winter barley varieties and lines under different management practices (NARDI Fundulea, 2013-2016)

The varieties and lines thousand grain weight (GW) averaged over different nitrogen availability varied from 41,3 g (Smarald variety) to 46,5 g (DH 314-1 line) (Table 2). Only Simbol and Artemis varieties and among lines DH 267-66 and DH 314-1 were placed above the regression line and had the higher grain yield (over 5000 kg/ha), which indicates that these genotypes had yield combined with high grain weight values (Figure 4).

Table 2. Average grain weight and some indices of its stability in 17 winter barley varieties and lines

Variety/ line		Average grain weight (g)	Amplitude	Coefficient of variation (%)	Finlay-Wilkinson regression		Frequency of cases below 42 g thousand of grains weight
					a-Intercept	*b*-slope	
♂	Dana	45.2	18.8	14.4	2.01	0.980	4
♂	Cardinal	41.5	16.1	15.4	-0.85	0.960	6
♂	Univers	42.7	15.7	14.3	-1.19	0.995	6
♂	Ametist	46.6	11.7	10.2	14.18	0.736	2
♂	Smarald	41.3	16.8	16.9	-3.02	1.004	5
♂	Simbol	43.9	14.7	13.0	3.55	0.915	5
♂	Lucian	42.4	17.5	16.2	-6.06	1.100	5
♂	F8-19-10	42.8	14.5	13.9	-2.23	1.022	6
♂	F8-3-01	42.8	16.2	13.3	5.13	0.853	4
♂	Onix	44.6	10.5	8.2	29.23	0.349	3
♂	F8-10-12	45.6	11.5	11.1	8.62	0.839	4
♀	Andreea	42.2	17.9	17.7	-6.85	1.112	5
♀	Artemis	46.3	22.3	16.9	-3.04	1.118	3
♀	DH267-66	45.5	22.5	18.7	-18.51	1.451	4
♀	Gabriela	44.3	22.4	17.1	-4.45	1.105	3
♀	DH314-1	46.5	27.5	20.8	-18.49	1.475	3
♀	DH315-10	45.4	23.3	16.5	1.97	0.986	3

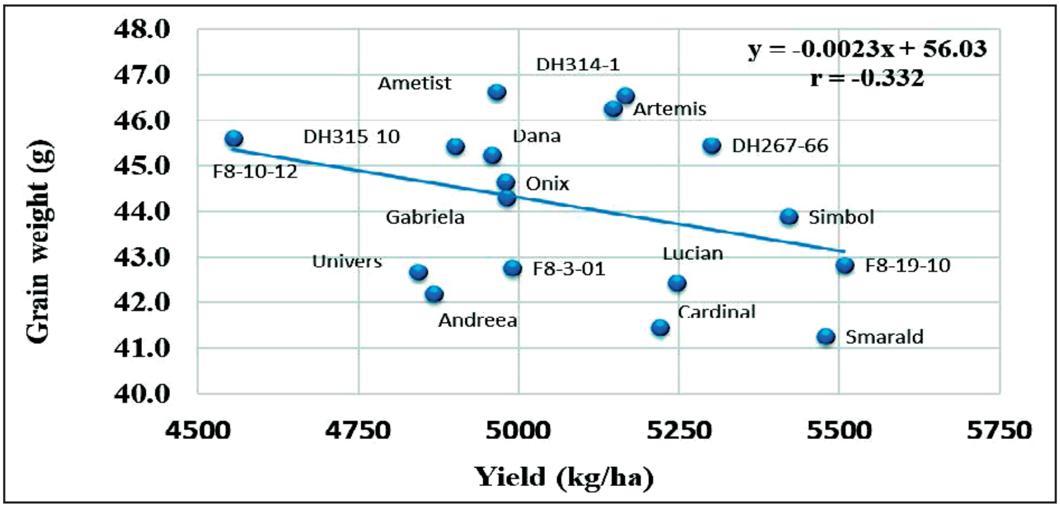

Figure 4. Relationship between grain yield and grain weight averaged over 9 environments, in 17 winter barley varieties and lines

The amplitude of grain weight was very large from 10.5 (Onix variety) to 27.5 (DH 314-1 line), which suggests a different environmental stability between varieties and lines (Table 2).The coefficient of variation across 9 environmental conditions, also largely varied from 8.2% to 20.8%.

This parameter was not correlated with average grain weight. Onix and Ametist varieties as well as F 8-10-12 line combined high values of grain weight (Figure 5) with lower coefficient of variation (under 11%). Among tested winter barley genotypes, eight expressed good grain weight stability (coefficient of variation below 15%) and nine genotypes had values over 15%.

The different response of two pairs of winter barley varieties to the favourability of the environment, considering grain weight, is illustrated in Figure 6 (Ametist and Onix) and 7 (Lucian and Smarald).

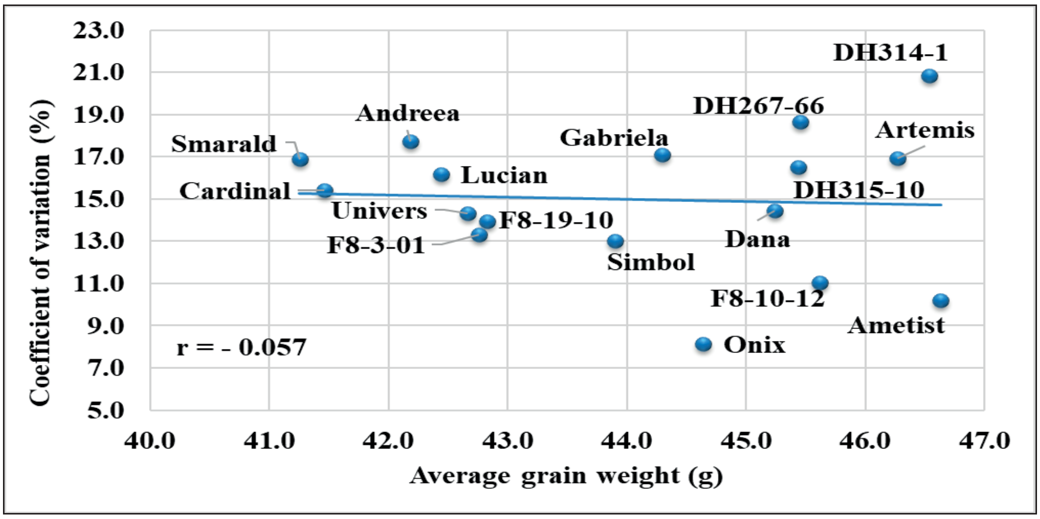

Figure 5. Relationship between average grain weight and the coefficient of variation, in 17 winter barley varieties and lines

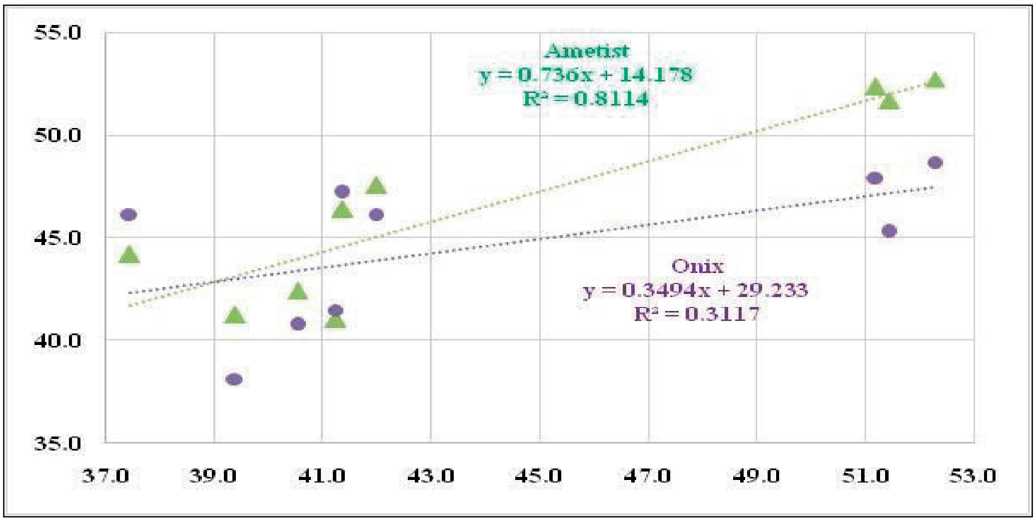

Figure 6. Comparison between regression lines of grain weight vs. grain weight of the trial in varieties Ametist (Δ) and Onix (○)

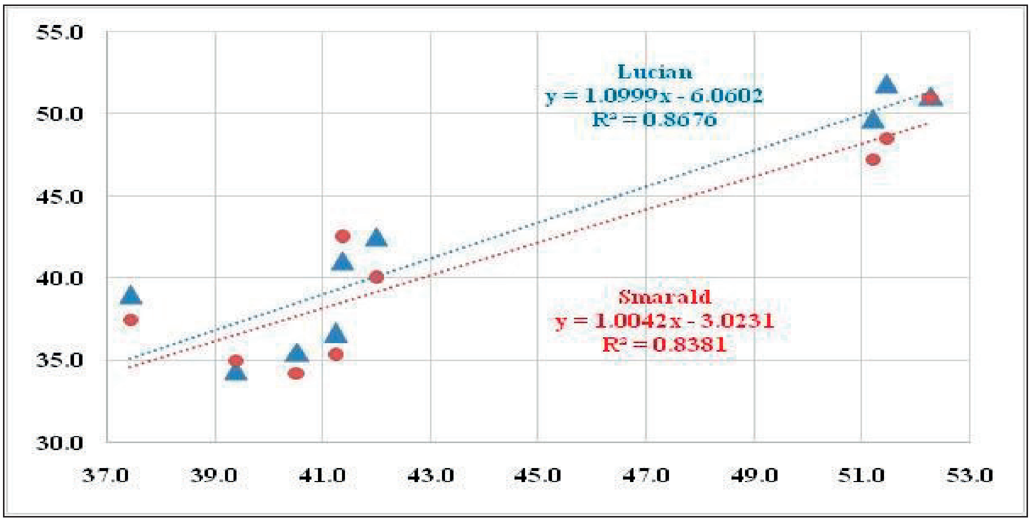

Figure 7. Comparison between regression lines of grain weight vs. grain weight of the trial in varieties Lucian (Δ) and Smarald (○)

The regression of individual variety values vs. average value of all varieties in the yield trial was suggested by Finlay and Wilkinson (1963) as an index which describes stability of a trait, useful to detect the varietal responses differences to favorability of environment. A variety can be characterized as adapted to unfavorable environments when the regression coefficient *b*<1 and the regression intercept *a* is large. When *b*>1 the variety is adapted to favorable conditions and when *b*≥1 and *a* is large, the variety is widely adapted. The studied winter barley varieties and lines from this experiment varied widely both in the regression coefficients *b* and the regression line intercept *a* (Table 2).

The genotypes which had *b* values below 0.9 and positive intercepts (Ametist, Onix, F 8-3-01 and F 8-10-12) had a better response when tested under unfavourable environments, and in contrast genotypes as Andreea, Artemis and Gabriela had a good response under environments favourable to higher grain weight, probably due a better nitrogen utilization. Only two varieties and one line (Dana, Simbol and DH 315-10), with *b* close to 1 and positive intercept, expressed a wide adaptation.

Among studied indices of GW, only the frequency of cases with TGW below 42 g was significantly correlated with the average GW, suggesting that when this parameter decrease the grain weight increase. The number of cases ranged from 2 to 6 for winter six row barley and from 3 to 5 for winter two row barley (Table 2).

Lack of the correlation of average grain weight with others stability indices suggests that breeding for increasing this trait could be combined with a specific response to favorability of the environment.

Both amplitude of variation and coefficient of variation were negatively correlated (Table 3) with *a* - the intercept of regression (-0.77 and -0.94 respectively) and positively correlated with *b* - the slope (0.82 and 0.93). Also, the amplitude of variation was positively correlated with coefficient of variation (0.90) and *a* - the intercept of regression was negatively correlated with *b* - the slope of regression (0.99).

Table 3. Correlation between average GW and several indices of GW stability

Indices	Average GW	Amplitude of variation	CV%	Intercept	b	Frequency
Average GW	1					
Amplitude of variation	0.28	1				
CV%	-0.06	**0.90**	1			
Intercept	0.07	**-0.77**	**-0.94**	1		
B	0.09	**0.82**	**0.93**	**-0.99**	1	
Frequency of cases below 42 g GW	**-0.82**	-0.24	0.10	-0.25	0.12	1

Bold values of correlation coefficients are sigificant at $p<0.05$.

CONCLUSIONS

Grain weight was determined by the variety, fertilizer dose and by their interaction. Grain average weight differences were significant and just 11% of the grain weight variation between studied varieties and lines could be explained by the variation of grain yield.

Among varieties, two winter six row barley (Onix and Ametist) and one winter two row barley (Artemis) varieties had both high TGW and yield higher than average.

The obtained results suggest there are possibilities to breed for higher and stable GW, because of lack of correlation between average GW and stability parameters. Therefore an increased thousand grains is a specific response of GW under a management practice.

It is obvious that the tested genotypes can be classified as varieties and lines with a good response in favourable environments regarding the grain weight (winter two row DH 267-66 and DH 314-1 lines), able to maintain this trait in less favourable environments (winter six row Ametist and Onix varieties, winter six row F 8-3-01 and F 8-10-12 lines) and widely adapted (winter six row Dana and Simbol varieties and winter two row DH 315-10 line).

Frequency of TGW values below 42 g, the minimum required level accepted in the malt industry, was strongly correlated with the average TGW (r = -0.82). The number of cases below the requested value indicated a good stability of the parameter for winter two row barley as compared with winter six row barley.

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