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VARIABILITY OF YIELD AND FEW QUALITY COMPONENTS TO SOME MUTANT/RECOMBINANT LINES OF WINTER WHEAT

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Key words: yield, quality components, variability, DH lines, winter wheat

ABSTRACT

Ten DH mutant/recombinant wheat lines viz. Ai-II 126, Ai-II 131, Ai-II 152, Ai-II 172, Ai-II 183, Ai-II 193, Ai-II 201, Ai-II 223, Bi-I 3, Bi-I 40 and their parental forms Izvor and F00628-34 were analyzed for yield and some grain quality parameters (protein and starch content, TKW, hectolitre mass and moisture content). These lines were cultivated in Southern Romania, on chernozen soil in 2015-2017 period. Lines with higher yield potential were identified and of quality. Average yield of 6757 Kg/ha (Ai-II 152) and 6724 Kg/ha (Ai-II 193) were obtained and protein content of 13.35% (Ai-II 126) and 13.10% (Ai-II 172) were realized. Higher variability for TKW was identified and smaller for starch and HM. Significant positive correlation between TKW and protein content and negative correlation between protein and starch and yield was found. The results of this study conclude that on the basis of the analyzed characters there are some lines which can be selected as one of best genotypes.

INTRODUCTION

Wheat (*Triticum aestivum*) is a common crop of temperate regions. It can be also grown in the tropics and subtropics with grain production across wide ranges of altitude (sea level to 3500 m) and latitude (60°N to 60°S) (Curtis, 2015).

Romania occupied place five as regard area cultivated with wheat, 2.11 million hectares after, France, Germany, Poland and Spain. The same position holds as concern production, after France, Germany, United Kingdom and Poland, with 8.28 million tonnes.

The obtaining of varieties with high production capacity and stable was and still is an objective of the agricultural research, especially under the current conditions of climatic changes. Various climate change scenarios suggest a 2.0–4.0°C warming towards the end of this century (IPCC, 2013). So, for many annual crops, yield is affected not only by mean change in temperature, but also by brief periods of high temperature at vulnerable stages of development (Rezaei, E.E. *et al.,* 2015; Prasad, P.V.V. *et al.,* 2017). The impacts of short periods of extreme temperature on wheat seed development and quality are therefore relevant to the global adaptation of the crop today – and even more to adaptation to future climates (Nasehzadeh, M., Ellis, R H., 2017). Environmental variables can have strong impacts on wheat quality, mainly due to variations in meteorological patterns from the experimentation areas.

To be used in a breeding programme, DH plants have to be genetically stable with no aberrant genetic variation arising during the process. Therefore, it is important to determine if any genetic variation is introduced during the production of DH lines (Tadesse, W. et al., 2012).

The aim of this research paper as concern quality of wheat refers to the following properties: protein and starch content, hectolitre mass and moisture content. Also, it was analyzed the influence of environmental conditions upon yield. It is well known that biotic stress in the south of Romania became usual.

After using a special protocol of mutagenesis which included DH technology (biotechnologically system *Zea*) with the aim to obtain allelic mutant and/or recombinant fully homozygous variants in one generation made possible the obtaining of stocks of valuable genetic lines (Giura A., 2011).

MATERIAL AND METHOD

The experimental material for the present investigation comprised 10 diverse DH lines of wheat (*Triticum aestivum* L) and their parental forms. These were planted in randomized block design, in plots of 9m length, in three replications. The material was evaluated at Agricultural Research and Development Station Caracal during 2015-2017 agricultural years. Sowing was made in the last decade of October while harvest was realized in the second decade of July. Standard cultivation technology of wheat was applied. Protein content was performed using Infratec Grain Analyser that use a non-destructive spectroscopic technique based on naturally occurring electromagnetic spectrum. For protein determinations were necessary to weigh about 60 grams wheat samples. The results obtained were compared with those registered for parental genotypes, the cultivar Izvor and the advanced breeding line F00628G- 34. TKW measurements were established using the Contador machine and volumetric mass was determined using a 100-ml graduated cylinder and an analytical balance for weighing.

The mean values presented in the table were calculated using variance analysis method.

RESULTS RESULTS

The climatic conditions of the experimental period (2015-2017) registered reduced variability which was reflected in the grain yield quite high. With all this, the amount of precipitation could ensure wheat requirements if would have been better distributed (figure 2). Once with the increase of average temperatures and the frequency of heat events, it is possible yield reductions, especially if those are appearing during the grain-filling stage. Higher temperatures of 37 - 40°C during seed filling is important for both grain yield and quality (Stone, P.J. and Nicolas, M.E., 1996), but are not desirable during grain-filling (Marcellos, H. and Single, W.V., 1972).

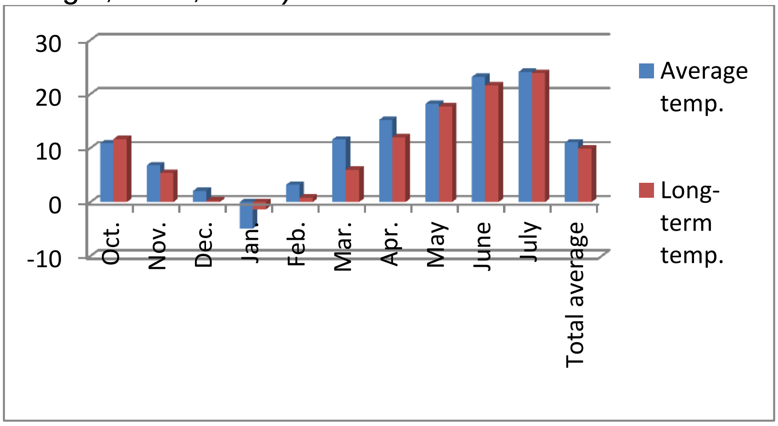

Fig. 1. Average temperature (2015-2017)

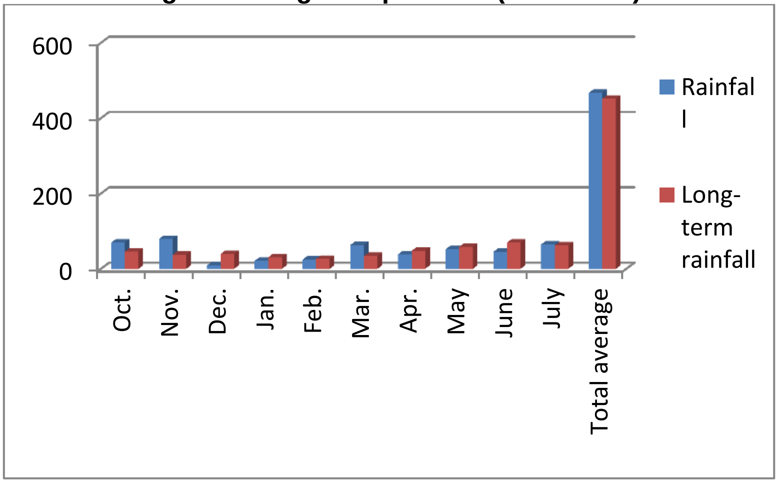

Fig. 2. Average rainfall (2015-2017)

Yield capacity is a complex quantitative character determined by many components and also influenced by environment factors. Pănință, O., 2015 sustain that characters such as the number of seeds/spike, seeds weight/spike (g), no. of spikes/m^2, weight of a thousand seeds (WTS) (g) and no. of emerged plants/m^2 have influence on yield and based on recorded data and statistical processing identified some numbers of links between these characters in an assortment of 25 isogenic lines of wheat. There were also available regression models between some of the studied characters.

Reporting the average yield of the mutant/recombinant lines Ai-II 152 (6757.00 Kg/ha) and Ai-II 193 (6724.00 Kg/ha), to the production obtained by the parental forms, Izvor variety (5955.00 Kg/ha) and F00628-34 line (6687.50 Kg/ha), it may be observed that these realized higher yield than both while Ai-II 223, Bi- I 3 and Bi-I 40 lines presented higher production only comparative with Izvor variety, variety which is recommended for cultivation in drought conditions. The lowest yield was realized by Ai-II 183 line (5633.50 Kg/ha) (table 1).

Although the yields recorded by these lines are promising, the analysis of the variability coefficient reveals very large values, some of them outside permissible limits, which presume further investigations. It seems that increase of temperature from the experimentation area is beneficial for these DH mutant/recombinant wheat lines and these could be considered as an adapted material for the climate change.

In other experience with DH lines, Iancu Paula et al., 2017 reported a good behavior of A i-II 107, A i-I 77, A i-II 123 and A i-I 75 mutant/recombinant lines as concern yield a suitable adaptation in the experimentation area which means these are best-suited for cultivation in different locations from south part of Romania.

Grain quality is important from the producer to the consumer. Therefore, grain quality is an essential element of the entire value chain to produce a quality product, store, process and eventually supply it to the consumer's use.

The achieved improvement of wheat production potential obtained over time has been accompanied by the maintenance in most of the cases to improve the quality of the potential of bread (Săulescu şi colab., 1995; Tianu şi colab., 1995).

The quality of grain is affected by various factors, including cultivation practices, time of harvest and harvesting practices, handling, storage and transport practices. Grain quality to a great extent depends on the type of grain, genetics, cultivation practice and handling and storage of the grain.

Grain quality is a function of grain composition, principally in proteins, which depends on the genotype and the environment. The content of protein is presented in table 1. The majority of DH lines were grouped in ranges of 12.2% - 12.95%, including parental forms. Higher protein interval varied between 13.1% - 13.35%, while lower protein content varied between 11.8% - 11.95%. Variability coefficient presented values under 10 which mean homogenous and uniform lines as concern protein content.

These data are similar with those obtained by Dobre Paula Steliana et al., 2016 which analyzed a set of wheat mutated and mutated/recombinant DH lines founded a range of protein between 13.5% and 19.5%.

Starch content varied in smaller limits (72.40 - Ai-II 172 and 73.50 - Bi-I 3), all of the DH lines outrunning Izvor variety (71.95%), while the other parental form presented the highest value (73.90%). Variability coefficient presented smaller values (table 1).

Protein, starch and dietary fibres are the major grain nutritional components that account for about 90% of the dry weight. Other components like minerals, vitamins, lipids, phenolic compounds and terpenoids are among the minor grain nutritional constituents found in wheat. A major component of the endosperm comprises about 80% of starch and about 10% of other constituents, including minerals and some phytochemicals, which are mostly concentrated in the wheat bran area (Shewry, P.R. et al., 2013).

Besides the bakery industry, wheat is commonly used as a raw material for a variety of snacks. The starch granules of the flour (those that give the texture) vary widely in dimensions (2-35 μm), but are relatively large compared to other cereal starches (rice, maize). In starch of the wheat amylose represents about 20-25%, which leads to a very good expandation and this is desirable in the manufacture of snacks (Bonciu Elena, 2016).

Thousand kernel weight of DH lines varied in higher limits. Ai-II 201 line presented the lowest value (37.17 g) while Bi-I 40 line, the highest (50.02 g)(table 2). Parental forms registered values of 39.03 g (Izvor) and 44.28 g (F00628-34 line). It can see that most of the experimented lines presented higher values than Izvor parental form and some of them for the variability coefficient, so these can be useful sources of future breeding.

Those lines with lower TKW proved to have a longer vegetation period so higher temperatures from June lead to a reduced final grain weight and yield.

The mass of 1000 grains as a final component of grain yield depends on many components that develop in the previous phases of ontogenesis. It is possible to influence the mass of 1000 grains by agro-ecological conditions, agrotechnical measures such as date and quality of sowing, mineral fertilizers and irrigation (Alda Liana Maria et al., 2010). Hectolitre mass (HM/VM), also known as volumetric weight, is regarded as the most common and easiest way of quantifying wheat. It measures the grain mass density and is expressed as mass per volume. It is an important quality property because it provides an estimate of meal yield. The HM of grain is influenced by many factors, including climatic conditions during the growth period of the grain, frost damage, climatic conditions during harvest and foreign matter in the grain. The basic factors affecting the HM are grain size and shape, grain density, maturity of wheat, diseases and cultivar.

Table 1

Variability of yield, protein and starch content of the grains (average 2015 - 2017)

Line	Grain yield (Kg/ha)		Protein content (%)		Starch content (%)	
	Average	s%	Average	s%	Average	s%
Ai- II 126	5932.00±2538.51	42.79	13.35±0.49	3.71	72.70±0.85	1.17
Ai-II 131	5847.00±1852.62	31.68	12.95±0.35	2.73	73.45±1.48	2.02
Ai-II 152	6757.00±2644.58	39.14	12.40±0.85	6.84	73.40±0.42	0.58
Ai- II 172	5714.50±1823.63	31.91	13.10±0.14	1.08	72.40±0.71	0.98
Ai- II 183	5633.50±2540.63	45.10	12.20±0.57	4.64	72.95±0.21	0.29
Ai- II 193	6724.00±2332.04	34.68	12.60±0.57	4.49	73.10±2.55	3.48
Ai- II 201	5770.00±1973.54	34.20	11.90±1.13	9.51	72.85±0.22	1.26
Ai- II 223	6392.50±1792.52	28.04	11.80±0.85	7.19	73.45±1.90	1.64
Bi- I 3	6345.00±1725.34	27.19	11.95±0.49	4.14	73.50±1.56	2.12
Bi-I 40	6606.00±1829.99	27.70	12.60±0.28	2.24	72.85±1.48	2.04
Izvor	**5955.00±2552.66**	**42.87**	**12.90±0.14**	**1.10**	**71.95±1.91**	**2.65**
F00628-34	**6687.50±1325.83**	**19.83**	**12.30±0.14**	**1.15**	**73.90±1.41**	**1.91**

Table 2

Variability of some grains characters (average 2015 - 2017)

Line	TKW (g)		HM		U%	
	Average	s%	Average	s%	Average	s%
Ai- II 126	41.86±3.51	8.40	79.55±0.07	0.09	13.15±0.21	1.61
Ai-II 131	42.99±9.80	22.80	79.50±2.40	3.02	12.60±0.57	4.49
Ai-II 152	40.66±6.03	14.84	79.50±1.56	1.96	13.15±0.21	1.61
Ai- II 172	38.08±6.77	17.77	78.80±1.27	1.62	12.85±0.21	1.65
Ai- II 183	42.39±8.39	19.78	78.10±0.57	0.72	12.70±0.28	2.23
Ai- II 193	39.90±3.06	7.67	79.60±1.27	1.60	13.25±0.49	3.74
Ai- II 201	37.17±1.26	3.39	77.40±1.27	1,64	12.60±0.14	1.12
Ai- II 223	45.04±6.63	14.71	78.25±1.48	1.90	12.50±0.28	2.26
Bi- I 3	45.32±12.50	27.59	78.30±2.55	3.25	12.55±0.49	3.94
Bi-I 40	50.02±10.16	20.32	77.45±0.49	0.64	11.85±1.06	8.95
Izvor	**39.03±0.28**	**0.71**	**79.85±1.20**	**1.51**	**12.25±0.78**	**6.35**
F00628-34	**44.28±7.89**	**17.82**	**77.50±2.97**	**3.83**	**12.65±0.92**	**7.27**

HM presented smaller variability, most of the lines registering values close to those realized by parental forms or higher. Lowest value presented Ai-II 201 line (77.40) and highest values Ai-II 193 line (79.60). Variability coefficient presented smaller values (table 2).

Moisture content is one of the main grading factors in grain, as it is a critical factor in grain storage. It is an indication of the water per unit mass of grain and is expressed on a percentage basis. Moisture content does not affect grain quality directly, but influences quality, as grain spoils at moisture content higher than that recommended for storage.

The maximum moisture at which wheat, barley and oats can be stored is 13%, for canola it is 8% and for maize 14%.

U% registered values between 11.85% (Bi-I 40 line) and 13.15% (Ai-II 126 and Ai-II 152 lines). Parental forms recorded values intermediate to these limits (12.15% Izvor and 12.65% F00628-34 line). Variability coefficient presented smaller values (table 2).

Using statistic method it was calculated the correlation indices between the experimented characters. To these DH lines it seems that there is a significant positive correlation between TKW and protein content, also some authors say that these characters are generally negative (Dobre Paula Steliana et al., 2016). As concern the correlation between protein and starch and yield, it was found a negative correlation. Similar correlation was between yield and starch content and TKW (table 3).

Table 3

Correlation between analyzed characters

	Protein	Starch	Yield	TKW	HM
Starch	-0,837				
Yield	-0,873	-0,973			
TKW	0,910	-0,247	-0,975		
HM	0,047	-0,677	-0,227	0,205	
U%	0,657	-0,677	-0,725	0,728	0,468

CONCLUSIONS

The influence of the environmental factors from the experimental area upon yield and its quality emphasize few DH lines which can be utilized in future breeding programs to obtain new varieties with good performances.

Some mutant/recombinant lines prove to be adapted for ARDS Caracal area and can ensure high yield and were not influenced by the high temperatures from the summer. It seems that rainy 2015 autumn and 2016 spring were favorable in wheat yield, but not in grain protein content.

Experienced mutant/recombinant lines could be considered as a complex of new entries that should be proper for the specific environment from ARDS Caracal.

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