Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 1, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SYNTHETIC AMPHIDIPLOID WHEAT LINES WITH LARGER GRAIN SIZE

Paula IANCU, Marin SOARE

University of Craiova, Faculty of Agronomy, 19 Libertatii Street, 200583, Craiova, Romania

Corresponding author email: soare_marin@yahoo.com

Abstract

Modern genetic methods of breeding leaded to the obtaining of new wheat germplasm, which can be an important source for higher yield potential. The present study describes the data obtained by 10 synthetic amphidiploid lines for some morphological and quantitative characters and their correlation. The analysis of variance for analyzed characters showed highly significant differences among the genotypes under study, indicating the presence of considerable amount of variability in the lines. E6-A line combined well yield, protein and starch content while the lines with highest length and width of grains presented the lowest yield.

Key words*: synthetic amphidiploid wheat lines, grains, size, quantitative characters.*

INTRODUCTION

Global increased demand for continuous wheat production to keep up with the world's increasing population needs a significant yield jump like in the Green Revolution, but global warming is becoming a worldwide threat, with more severe drought and heat occurring at higher frequencies.

In wheat, yield capacity is a complex quantitative character, determined by the components of production and resistance to the unfavourable action of external factors. In turn, they have multi-genic determinism. However, it is know that polygenes do not have the exclusivity in the genetic control of production and its components.

The creation of varieties with high yield potential requires the optimization of morphogenesis processes. As crop formation is a sequential process, possibilities for genetic manipulation in order to increase production potential exist in each phase.

The size of the grains depends on the size of the ovaries and floral coverings, the filling time of the grains, the size of the assimilating surface and its photosynthetic efficiency, the longevity of the leaves correlated with the longevity of the root system, the competition between plants for light, water and nutrients.

Most of the successes obtained in improving yield capacity were attributed to the selection for some characters with simple heredity, including the grain size, which proved to be correlated with the production potential.

Grain size is a major selection and breeding target in modern tetraploid wheat (Gegas et al., 2010) because it is in association with other important characteristics. Research has to find new methods to increase yield potential of plants. Advances in new technologies have made possible to identify genes which control wheat grains size that enabling an increase for width and length. So, characterisation of a gene (GW2) which is responsible for control of grain width and construction of a triple mutant indicate an increase in seed size of 20% (https://www.jic.ac.uk).

Grain size is an important yield component and new technologies use the ability of gene-based on SNP markers to follow specific alleles for bolder, bigger grains could help to improve milling yields, increase the specific weight of varieties and may also help improve yield stability. Introduction in modern agriculture of new material such as amphidiploid species represent a diversification of existing high yield varieties.

Amphidiploids are plant organisms made by biotechnological methods based on wide hybridization and combining the genomes of the parental species involved in the cross (Stoyanov, 2013a). A large number of amphidiploids were created into the *Triticae* tribus and cultivated forms are synthetic hexaploid wheat (2n=6x=42, AABBDD), because of the identity of their genomic constitution with that of bread wheat *Triticum aestivum* (2n=6x=42, AABBDD), allows for the introduction of various genes from wild species (Stoyanov, 2014).

Grains size (its dimensions), as the degree of filling, are important characteristics depending upon the weight of the grain and the yield of the flour respectively the quality of the milling (Ciulca et al., 2020). Also, wheat embryo and the lining are more plastic than the endosperm and the humidity contained in whole wheat is distributed differently which significantly influences the milling process (Matei and Dodocioiu, 2016).

The purpose of this research was to experiment some new amphidiploid wheat in order to identify high-yield forms which could take part in future breeding programs leaving from larger grain size characteristics.

MATERIAL AND METHOD

Biological material and its genealogy is presented in Table 1.

The mentioned lines above were sowed in the field from Agricultural Research and Development Station Caracal of University of Craiova (440 06' N, 240 21' E and 98 m altitude) in 2016- 2019. Sow was made in last decade of October and the harvest was made in the first 10 days of July. A completely randomized block design was used in three repetitions and standard agronomic practices were followed.

Water conditions of the three years during wheat vegetation period and especially during the grain filling period were different (Table 2).

Table 1. Biological material and its genealogy

No.	Code	Genealogy		Origin country
		T. durum genotype	*Ae. squarrossa* biotype	
1	E 1-A	Pandur	Ae. squarrosa typica - 2472	Iran
2	E 5-A	Agedur	Ae. squarrosa strangulata - 2475	Iran
3	E 6-A	Agedur	Ae. squarrosa meyeri - 2530	Iran
4	E 7-A	Elidur	Ae. squarrosa meyeri - 2386	Pakistan
5	E 17-A	Amadur	Ae. squarrosa typica - 2472	Iran
6	E 19-A	Grandur	Ae. squarrosa strangulata - 2377	Iran
7	E 24-A	Condur	Ae. squarrosa strangulata – 2464	Iran
8	E 25-A	Condur	Ae. squarrosa typical - 2472	Iran
9	E 32-A	DDU 297	Ae. squarrosa strangulata - 2569	Kazahstan
10	E 55-A	Grandur	Ae. squarrosa strangulata - 2569	Kazahstan

Source: ADER 116/2015 project

Table 2. The variation of precipitation recorded during the years of experimentation and the calculation of deviations from the multiannual values

Year		Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Sum
2016-2017	Value	46	63.8	103	38.8	56.4	86.4	104.6	55.6	10.2	39.6	604.40
	Deviation	5.6	11.4	56.3	0.7	18.5	45.6	52.7	-8.1	7.3	-14.9	175.10
2017-2018	Value	56	48	14	6.8	12.4	53	54	84.8	17.6	101.4	448.00
	Deviation	15.6	-4.4	-32.7	-31.3	-25.5	12.2	2.1	21.1	14.7	46.9	18.70
2018-2019	Value	7.4	46.8	53.4	38.6	14.2	25.2	44.4	69	28.5	60	387.50
	Deviation	-33	-5.6	6.7	0.5	-23.7	-15.6	-7.5	5.3	25.6	5.5	-41.80
Multianual		40.4	52.4	46.7	38.1	37.9	40.8	51.9	63.7	2.9	54.5	429.30

RESULTS AND DISCUSSIONS

Umesh et al., 2019, sustain that synthetic hexaploid wheat (AABBD'D') is developed by artificially generating a fertile hybrid between tetraploid durum wheat (*Triticum turgidum*, AABB) and diploid wild goat grass (*Aegilops tauschii*, D'D'). It is known that *Aegilops* species contributed to wheat breeding despite the difficulties involved in the handling of wild species, such as crossability and incompatibility.

Grain size in wheat is the most stable component with favourable effect on flour yield (Giura and Saulescu, 1996) and is characterized by grain weight and area, whereas shape means a relative proportion of the main growth axes of the grain and also estimated by length, width, vertical perimeter, sphericity and horizontal axes proportion (Breseghello and Sorrells, 2007).

Average data and variations coefficients for the studied characteristics are presented in table 3 where it can be seen smaller or larger variations among the analysed lines for the studied parameters. So, the highest grains (both for length and width) were measured in E32-A line (8.64/3.37 mm), while the shortest in E6-A line (7.78/3.26 mm) and variation amplitude of 0.87/0.32 mm. Values below 7 mm for grains length were reported by Mandea et al., 2016 in some important cultivars experimented in yield trials performed also in South Romania.

Spike length varied from 10.20 cm (E19-A line) to 13.30 cm (E25-A line) with variation amplitude of 3.10 cm and a coefficient variation of 8.19. No. of spikelets/spike varied from 18.20 (E25-A line) to 22.00 (E1-A line) and 6.38 variation coefficient. No. of grains/spike presented higher variation, from 38.80 (E32-A line) to 56.60 (E7-A line) which means a variation amplitude of 17.80 spikelets. Grains weight/spike was the most variable character presenting a variation coefficient of 25.96% and a minimum value of 1.87g (E32-A line) and a maximum of 4.79g (E5-A line). TGW varied from 45.58g (E5-A line) to 61.66g (E25-A line) comparative to an average of 53.87g.

The argic chernozem from ARDS Caracal is a very fertile soil and water as vegetation factor has a high influence for the capacity of production of the varieties (Matei et al., 2017).

Yield varied in larger limits from 3640.00 kg/ha (E32-A line) to 7560.00 kg/ha (E1-A line) which means 3920.00 kg/ha variation amplitude and 24.52% variation coefficient. It can be noticed that the most productive line do not have the highest grain length or grain width, but over average number of fertile tillers, spike length, no. of spikelets/spike, no. of grains/spike and grains weight/spike. TGW, protein content and starch content were under the average of the lines.

Protein content varied from 10.70% (E5-A line) to 15.60% (E35-A line) while starch content varied from 69.60% (E1-A line) to 79.60% (E19-A line). E6-A line combined a good yield with protein and starch content.

Stem length presented variation amplitude of 27.60 cm varying from 98.40 cm (E6-A line) to 126 cm (E24-A line) and number of fertile tillers varied from 9.40 (E6-A line) to 13.80 (E7-A line). Giura, 2021 stated that longer stem can provide larger assimilation area and allows storing more assimilates that could be available for grain filling.

Analyses of the obtained data revealed that grain length and width are largely independent traits. This can be the result of artificial selection during breeding since these characters are independent variables in parental forms.

Accurate characterization of grain size and shape remains a big challenge due to complex nature of wheat grain shape (Patil et al., 2013).

Highly significant and positive correlations were identified between some of the experimented characters (table 4): grain width and protein content (0.860), grain length and protein content (0.720), no. of spikelets/spike and no. of grains/spike (0.735), no. of spikelets/spike and grains weight/spike (0.769), no. of spikelets/spike and yield (0.883), no. of grains/spike and yield (0.842), grains weight/spike and yield (0.880) and TGW and yield (0.920).

Grain characteristics, particularly grain weight, grain size and shape and grain protein, are important components of grain yield and quality in wheat due to their significant effect on grain yield, milling yield, end-use quality and market price (Abdipour et al., 2016).

Grain length is significantly increased by chromosomes 4A, 4B, 2B, 3A and 1B while grain width by chromosomes 1A and 1B (Giura and Saulescu, 1996). Larger grains is not only directly relate to grain yield, but also have favorable effects on seedling vigor and early growth, thereby promoting and stabilizing yielding ability (Cristina et al., 2016).

Table 3. Variation limits for analyzed characters (2016-2019)

	Grain width (mm)	Grain length (mm)	Stem length (cm)	No. of fertile tillers	Spike length (cm)	No. of spikelets/ spike	No. of grains/ spike	Grains weight/spike (g)	TGW (g)	Yield (Kg/ha)	Protein content (%)	Starch content (%)
E1-A	3.16	7.92	121.40	11.00	12.50	22.00	56.40	4.22	51.85	7560.00	12.80	69.60
E5-A	3.04	7.97	103.40	10.80	10.50	21.80	51.80	4.79	45.58	7020.00	10.70	71.30
E6-A	3.26	7.78	98.40	9.40	10.80	21.60	47.40	3.39	52.61	6980.00	13.10	71.60
E7-A	3.31	8.14	99.20	13.80	12.40	20.80	56.60	2.96	48.71	5800.00	13.00	72.30
E17-A	3.27	8.13	102.00	9.20	11.70	21.40	42.40	3.21	53.48	5080.00	13.90	72.40
E19-A	3.34	8.46	105.60	10.40	10.20	20.40	47.20	2.72	52.84	5280.00	13.50	79.60
E24-A	3.34	8.27	126.00	13.40	12.10	20.20	44.40	2.87	55.29	4740.00	13.80	72.80
E25-A	3.36	8.42	121.60	10.00	13.30	18.20	40.40	2.62	61.66	4060.00	14.80	70.40
E32-A	3.37	8.64	105.80	9.80	12.70	19.40	38.80	1.87	57.46	3640.00	14.60	74.10
E35-A	3.34	8.54	103.00	9.40	12.20	18.40	39.00	2.49	59.20	3920.00	15.60	71.50
Average	**3.28**	**8.23**	**108.64**	**10.72**	**11.84**	**20.42**	**46.44**	**3.11**	**53.87**	**5408.00**	**13.58**	**72.56**
Standard deviation	0.10	0.27	9.73	1.55	0,97	1.30	6.35	0.81	4.54	1325.96	1.27	2.63
Min.	3.07	7.78	98.40	9.20	10.20	18.20	38.80	1.87	45.58	3640.00	10.70	69.60
Max.	3.37	8.64	126.00	13.80	13.30	22.00	56.60	4.79	61.66	7560.00	15.60	79.60
Variation amplitude	0.32	0.87	27.60	4.60	3.10	3.80	17.80	2.92	16.08	3920.00	4.90	10.00
Variation coefficient	2.99	3.33	8.96	14.46	8.19	6.38	13.68	25.96	8.43	24.52	9.38	3.62

Table 4. Correlation coefficient value for analyzed characters (2016-2019)

Specification	Grain width	Grain length	Stem length	No. of fertile tillers	Spike length	No. of spikelets/spike	No. of grains/spike	Grains weight/spike	TGW	Yield	Protein content
Grain length	**0.716**										
Stem length	0.088	0.115									
No. of fertile tillers	0.006	-0.127	0.304								
Spike length	0.425	0.362	0.484	0.153							
No. of spikelets/spike	-0.732	-0.843	-0.217	0.163	-0.540						
No. of grains/spike	-0.606	-0.664	-0.052	0.558	-0.247	**0.735**					
Grains weight/spike	-0.964	-0.817	0.012	0.100	-0.425	**0.769**	**0.694**				
TGW	**0.745**	**0.670**	0.386	-0.379	0.606	-0.853	-0.813	-0.744			
Yield	-0.808	-0.915	-0.108	0.154	-0.474	**0.883**	**0.842**	**0.880**	-0.784		
Protein content	**0.860**	**0.720**	0.153	-0.302	0.570	-0.816	-0.761	-0.860	**0.920**	-0.829	
Starch content	0.389	0.451	-0.240	-0.007	-0.513	-0.077	-0.150	-0.407	-0.040	-0.265	0.083

CONCLUSIONS

Experimented synthetic hexaploid wheat provides a valuable diversity for different traits, such as larger grains size or higher protein content.

Across the 10 amphidiploid lines, individual grain length varied between 7.78 (E6-A) and 8.64 cm (E32-A). Larger grain size is negative correlated with yield, but positive with protein content.

REFERENCES

Abdipour, M., Ebrahimi, M., Darbandi, A.I., Mastrangelo, A.M., Najafian, G., Arshad, Y., Mirnyam, G. (2016). Association between Grain Size and Shape and Quality Traits, and Path Analysis of Thousand Grain Weight in Iranian Bread Wheat Landraces from Different Geographic Regions. *Notulae Botanicae Horti Agrobotanici*, *44*(1), 228–236.

Breseghello, F., Sorrells, M.E. (2007). QTL analysis of kernel size and shape in two hexaploid wheat mapping populations. *Field Crops Research, 101*. 172–179.

Ciulca, S., Giura, A., Ciulca, A. (2020). Grain size and other agronomical traits variation in a winter wheat population of doubled haploid lines. *Notulae Botanicae Horti Agrobotanici* Cluj-Napoca *48*(3), 1369–1386.

Giura, A. (2021). Grain size and plant height correlation in doubled-haploid (dh) progenies of a cross between contrasting winter wheat (*Triticum aestivum* L.) parents. *Romanian Agricultural Research*, *38*.

Giura, A., Saulescu, N.N. (1996). Chromosomal location of genes controlling grain size in a large-grained selection of wheat (*Triticum aestivum* L.). *Euphytica, 89*. 77–80.

Daniel C., Ciuca, M., Cornea, P.C. (2016). Genetic control of grain size and weight in wheat - where are we now? *Scientific Bulletin. Series F. Biotechnologies, 20*. 27–34.

Gegas, Vasilis, Nazari, Aida, Griffiths, Simon, Simmonds, James, Fish, Lesley, Orford, Simon, Sayers, Liz, Doonan, John, Snape, John (2010). A Genetic Framework for Grain Size and Shape Variation in Wheat. *The Plant Cell.*, *22*. 1046–1056.

Mandea, V., Mustățea, P., Săulescu, N.N. (2016). Cultivar and environment effects on grain weight and size variation in winter wheat, grown in a semi-continental climate. *Romanian Agricultural Research*, *33*. 23–28.

Matei, Gh., Dodocioiu, A.M., Petrescu, E., Rădoi, D. (2017). Comparative study of an assortment of winter wheat grown in Caracal plain. *Research Journal of Agricultural Science*, *49*(3), 106–112.

Matei, Gh., Dodocioiu, A.M. (2016). Monitoring of the indices of bread on an assortment of common wheat and flours obtained from these. *Research Journal of Agricultural Science, 48*(3), 68–77.

Patil, R.M., Tamhankar, S.A., Oak, M.D., Raut, A.L., Honrao, B.K., Rao, V.S., Misra, S.C. (2013). Mapping of QTL for agronomic traits and kernel characters in durum wheat (*Triticum durum* Desf.). *Euphytica, 190*. 117–129.

Rosyara, U., Kishii, M., Payne, T., Sansaloni C.P., Singh, R.P., Braun, H.J., Dreisigacker, S. (2019). Genetic Contribution of Synthetic Hexaploid Wheat to CIMMYT's Spring Bread Wheat Breeding Germplasm. *Sci. Rep., 9*. 12355.

Stoyanov, H. (2014). New amphidiploid wheat species as a result of artificial hybridisation. *Scientific Papers. Series A. Agronomy*, *LVII*. 331–338.

Stoyanov, H. (2013a). Status of wide hybrids in Poacea: problems and prospects, *Agricultural Science and Technology*, Trakia University - Stara Zagora, *5*(1), 3–12.

https://www.jic.ac.uk

https://www.bakeinfo.co.nz