BASAL STERILITY OF WHEAT EARS - INDEX OF SENSITIVITY TO DELAYED SPRING FROZEN AND ITS RELATIONSHIP WITH YIELD AND PRODUCTIVITY ELEMENTS, IN THE CLIMATIC CONDITIONS OF 2020 YEAR AT ARDS CARACAL

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ABSTRACT

The special climatic conditions manifested in the spring of 2020 at ARDS Caracal by the appearance of frosts delayed for 2 consecutive days, brought changes in the architecture of the wheat ear by the appearance of the phenomenon of basal sterility. For 200 wheat varieties of different origins (Romanian, French, Austrian, German, Swiss, mixed, hybrid wheat germplasm) the basal sterility manifested was determined at maturity. Ten ears of each variety / replication constituted the analyzed sample. Mixed germplasm (52 wheat varieties from all over Europe) had an basal sterility average rate of 11.4% - the lowest in the experiment. At the opposite pole was the German germplasm with an average percentage of 17.1%. The lowest amplitudes between the maximum and minimum values of basal sterility were recorded in hybrid wheat and Romanian germplasm (13.5-13.6%). The highest amplitude was recorded in the French germplasm – 19,1 %. The correlations performed highlighted the distinctly significant negative relationship between the basal sterility and the yield obtained; the significant positive relationship between yield and the note reflecting frost resistance; the significant negative relationship between the test weight and the days from 01.01 to heading date.

INTRODUCTION

The basal sterility of the wheat ear is a common phenomenon in the years when delayed spring frosts are present. The increase in grain number per spike contributes considerably to improve wheat grain yield potential. A wheat spike is composed of spikelets which produce reproductive structures called florets. The grain number and grain weight in wheat are influenced by both genetic and environmental factors (Li Y. et al, 2016).

Grain yield is under big influence of ear properties, and interdependence and correlation between spike length and spikelet number per spike (Martincic et al.,1996).

All spikelet florets are not fertile and the number of fertile florets depends significantly of genotype and ecological factors (Sabo et al.,2002). The grain yield of wheat is variable trait that depends on numerous yield components and environmental factors (Kraljevic-Balalic et al.,1995).

The genotype - environment interaction presence complicate selection of superior genotypes. Understanding of environmental and genotypic causes of significant genotype - environment interaction is important in all stages of plant breeding (Dhungana et al., 2007).

In her study, Zecevic and all (2013) founded that average values for spike length varied from 8.1 cm to 14.5 cm, and for number of spikelets per spike varied from 20.4 to 25.8. Heritability in broad sense for spike length was about 98%, and for number of spikelets per spike about 75%. Statistical analysis of variance established highly significant differences in mean values for spike length and number of spikelets per spike. Phenotypic analysis of variance indicated that ecological factors had higher impact on the expression of number of spikelets per spike, but genetic factors had higher impact on the expression of spike length.

Wheat is occasionally exposed to freezing temperatures during ear emergence and can suffer severe frost damage. Few studies have attempted to understand the characteristics of freezing and frost damage to wheat during late development stages.It was clearly shown that wheat appears to have an inherent frost resistance to temperatures down to −5 °C but is extensively damaged below this temperature (Fuller et al., 2007).

Low temperatures during the flowering period of cereals can lead to floret sterility and yield reduction, resulting in economic losses in Australian crops. Results suggested that long-maturity varieties were best suited to an early sowing time (mid-April). Kittyhawk (wheat), Urambie (barley) and Banister (oat) avoided frost damage during the critical period around anthesis. Later sowing was best suited to short-maturity types such as La Trobe (barley) and Cutlass (wheat) (Ferrante et al., 2019).

Frost damage in cereals is a significant annual production constraint for the Australian grain industry and can result in considerable yield losses (Zheng et al., 2015).

Extreme climate events have increased significantly. As a result, low temperature in spring has become a major constraint of winter wheat production, especially in southern Huanghuai and the middle and lower reaches of the Yangtze River, China. Moreover, the increase in global average winter temperatures promotes winter growth, increasing cold vulnerability in the spring (Li X. et al., 2016).

Low temperatures in spring generally occur between the end of March and beginning of April, during which time wheat ears are in a critical period of meiosis and tetrad formation and are, therefore, highly sensitive to temperature stress. If exposed to low temperature at this time, the entire wheat spike or parts of the spikelet will fail to set after tassel formation, decreasing yield by 30–50% (Zhang et al., 2011).

Zhang and all (2019) used two wheat varieties differing in cold sensitivity (sensitive variety Yangmai 18 and tolerant variety Yannong 19) to examine the effect of low temperature on wheat grain number at booting stage. The grain number per spike and 1000-grain weight showed a downward trend following low temperature stress.

MATERIAL AND METHOD

The pedoclimatic conditions available at SCDA Caracal are favorable for the cultivation of hail cereals, as they possess a soil of baticalcaric cambic chernozem type with a high potential for fertility and a good production capacity. In general, chernozems do not pose any particular problem in terms of cultivation with a comprehensive assortment of agricultural plants (Roșculete et al., 2019).

In the spring of 2020, in Caracal, two consecutive days (March 16 and 17) were recorded low temperatures (-6^{o}C and -6.3^{o}C, respectively). As the plants progressed in vegetation and the ears appeared, it was observed that some of them show basal sterility, the variability being from the absence of the phenomenon at basal sterility on one third of the ear.

For 200 wheat varieties of different origins (Romanian, French, Austrian, German, Swiss, mixed, hybrid wheat germplasm) the basal sterility manifested was determined at 10 ears / replication by ratio between the number of sterile spikelets per ear and the total number of spikelets / spike.

Correlations were made between the basal sterility and the other determined characters: yield, test weight (TW), thousand kernel weight (TKW), note for delayed spring frozen resistance (SFR) – only 120 varieties, days from 01.01 to heading date (DHD). The correlation coefficient and the determination coefficient resulted.

RESULTS AND DISCUSSIONS

The grouping of the assortement tested by provenance showed differences between averages and between minimum and maximum at basal sterility (Table 1).

Table 1

Basal sterility at groups of tested germoplasm in 2020 on the chernozem from Caracal

Germoplasm provenance	Average %	Amplitude %
Romanian germoplasm (25 varieties)	14,0	7,1-20,7
Austrian germoplasm (22 varieties)	15,2	7,9-23,6
Swiss germoplasm (25 varieties)	15,9	7,8-26,5
French germoplasm (36 varieties)	14,3	4,8-23,9
German germoplasm (25 varieties)	17,1	7,4-24,9
Wheat hybrids (20 hybrids)	13,9	6,4-19,9
Mixed germoplasm (52 varieties from all over Europe)	11,40	3,8-20,9

Mixed germplasm (52 wheat varieties from all over Europe) had an basal sterility average rate of 11.4% - the lowest in the experiment. At the opposite pole was the German germplasm with an average percentage of 17.1%. The lowest amplitudes between the maximum and minimum valuesof basal sterility were recorded in hybrid wheat and Romanian germplasm (13.5-13.6%). The highest amplitude was recorded in the French germplasm – 19,1 %.

The correlations performed highlighted the distinctly significant negative relationship between the basal sterility and the yield obtained; the significant positive relationship between yield and the note reflecting frost resistance; the significant negative relationship between the test weight and the days from 01.01 to heading date (table 2).

The strongly negative correlation between basal sterility and yield makes this character an index of wheat sensitivity to delayed spring frosts, having reducing yield effect.

Among the correlations made were also highlighted: the distinctly significant negative correlation between yield and test weight; significantly positive correlation between thousand kernel weight and test weight; the significantly negative correlation between test weight and note for delayed spring frozen resistance and the significantly positive correlation between note for delayed spring frozen resistance and days from 01.01 to heading date.

Table 2

The correlations between the characters determined in 2020 in Caracal

	Yield	TKW	TW	SFR	DHD
Basal sterility	-0,193^{oo}	0,085	0,044	0,137	0,133
Yield	1	0,065	-0,204^{oo}	0,188*	-0,077
TKW	-	1	0,174*	-0,094	-0,047
TW	-	-	1	-0,225^{o}	-0,275^{oo}
SFR	-	-	-	1	0,155*
DHD	-	-	-	-	1

(P5% = 0,140; P1% = 0,180 for 200 cases studied; P5% = 0,180; P1% = 0,230 for 120 cases studied according to the annex showing the correlation coefficients that can be considered significantly different from 0 at the level of 5% and 1% - Săulescu and Săulescu, 1967).

The interpretation of the detected correlations suggests that varieties with late heading date are more sensitive to delayed frosts but not necessarily by decreasing yield but by decreasing the test weight.

The coefficients of determination show that the variability of basal sterility is associated with 3.7% of the variability of yield; yield variability is associated with 3.5% of the variability of the notes reflecting delayed spring frozen resistance and with 4.1% of the variability of the test weight; the variability of the test weight is associated with 7.6% of the variability of the days from 01.01 to heading date and with 5% of the variability of the notes; the TKW variability is associated with 3% of the TW variability and the notes variability is associated with 2.4% of the heading date variability.

From the graphical representation of the 200 varieties tested, important are those that are placed in the quadrate with high basal sterility values but also with high yields. Of these, the varieties that obtained: 12726 kg / ha with 26.5% basal sterility; 13027 kg / ha with 22.2% basal sterility and 12942 kg / ha with 19.7% basal sterility. All three of these exceptions are part of the Swiss germplasm (Figure 1).

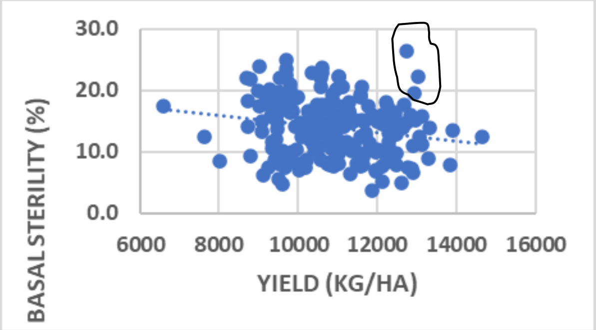

Figure 1. The relationship between yield and basal sterility in 2020 on the Caracal chernozem

CONCLUSIONS

Mixed germplasm (52 wheat varieties from all over Europe) had an basal sterility average rate of 11.4% - the lowest in the experiment. At the opposite pole was the German germplasm with an average percentage of 17.1%. The lowest amplitudes between the maximum and minimum valuesof basal sterility were recorded in hybrid wheat and Romanian germplasm (13.5-13.6%). The highest amplitude was recorded in the French germplasm – 19,1 %.

The strongly negative correlation between basal sterility and yield makes this character an index of wheat sensitivity to delayed spring frosts, having reducing yield effect.

Exceptions (high sterility-high yield) are search through the breeding plant and these are mainly represented by the Swiss germplasm in our experiment.

The interpretation of the detected correlations suggests that varieties with late heading date are more sensitive to delayed frosts but not necessarily by decreasing yield but by decreasing the test weight.

The coefficient of determination show that the variability of basal sterility is associated with 3.7% of the variability of yield

BIBLIOGRAPHY

1.**Dhungana,P.,Eskridg,K.M.,Baenzige, P.S.,Campbell,B.T.,Gill,K.S.,Dweikat,I.**, 2007 - *Analysis of genotype-by-environment interaction in wheat using a structural equation model and chromosome substitution lines*. Crop Science, 47, pp.477-484.

2.**Ferrante, A., Biddulph, B., Able J.A.**, 2019 – *Evaluating wheat, barley and oat for early sowing under frost-prone field conditions in southern Australia*. Proceedings of the 2019 Agronomy Australia Conference, 25 – 29 August 2019, Wagga Wagga, Australia

3.**Fuller, MP, Fuller AM, Kaniouras S., Cristophers J.**, 2007 – *The freezing characteristics of wheat at ear emergence.* European Journal of Agronomy 26(4): 435- 441

4.**Kraljevicbalalic,M.,Dimitrijevic,M.,Petrovic,S.**, 1995 - *Genotype/environment* *interaction of yield components. Book of Abstracts from the first Symposium of Breeding Organisms*. Vrnjacka Banja, pp. 58.

5.**Li X., Jiang D., Liu F.,** 2016 - *Winter soil warming exacerbates the impacts of spring low temperature stress on wheat.* J. Agron. Crop Sci. *202* 554–563. 10.1111/jac.12177

6.**Li Y, Cui Z, Ni Y, Zheng M, Yang D, Jin M.** 2016 - *Plant Density Effect on Grain Number and Weight of Two Winter Wheat Cultivars at Different Spikelet and Grain Positions*. PLoS ONE 11 (5): e0155351.doi:10.1371/journal.pone.0155351

7.**Martincic,J.,Bede,M.,Maric,S.,** 1996 - *Connection between ear length and kernel yield and quality in winter wheat varieties*. Proc. 10th Inter. Cereal Breed Congr., Port Caras, pp. 111.

8.**Roșculete, E., Roșculete C.A., Petrescu E., Păunescu, G**., 2019 - *Production performance of some wheat varieties in the pedoclimate conditions from SCDA Caracal.* Analele Universităţii din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series) Vol. XLIX/2019 190-194

9.**Sabo,M.,Bede,M.,Hardi,Z.U**., 2002 - *Variability of grain yield components of some new winter wheat genotypes (Triticum aestivum L.).* Rostilnná Výroba,48 (5), pp.230-235.

10. **Săulescu, N.A., Săulescu, N.N**., 1967- *Câmpul de experienţă*, Ediţia a II-a, Editura Agro-Silvică, Bucureşti

11.**Zečević, V., Bošković, J., Knežević,D., Milenkovć,S., Mićanović D.,** 2013 - *Study of some spike characteristics in wheat (Triticum aestivum l.)* Review on Agriculture and Rural Development vol. 2. (1) ISSN 2063-4803 478-483

12.**Zhang X. F., Zheng Y. F., Wang C. Y., Chen H. L., Ren Z. H., Zou C. H.**, 2011 - *Spatial distribution and temporal variation of the winter wheat late frost disaster in Henan*, *China*. Acta Meteorol. Sin. *25 249–259. 1*0.1007/s13351-011-0031

13.**Zhang, M., Wang, J., Huang, Z., Lu Mi L., Xu, K., Wu, J., Fan, Y., Ma, S., Jiang, D**., 2019 - *Effects of Low Temperature at Booting Stage on Sucrose Metabolism and Endogenous Hormone Contents in Winter Wheat Spikelet*. Front Plant Sci.; 10: 49

14.**Zheng B, Chapman SC, Christopher JT, Frederiks TM, Chenu K**., 2015 - *Frost trends and their estimated impact on yield in the Australian wheatbelt.* Journal of Experimental Botany 66 3611-362.