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AGRONOMIC PERFORMANCES OF HETEROGENEOUSLY GROUP OF SPRING WHEAT GENOTYPES

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ABSTRACT

The aim of this study is to test the adaptability and performance of some old Romanian and foreign spring wheat genotypes to actual changing climatic conditions for identification of valuable germoplasm as parental genotypes. Twenty-two spring wheat genotypes were evaluated over three experimental years for main grain yield components, yield quality indices and their ability to capitalize as efficiently as possible on the applied fertilizer. Based on the analyzed traits, genotypes could be highlighted for each of desired morpho-productive and quality traits. Grain yield, as a complex trait which include main yield components, had ranged from 3.64 at Brome to 4.36 t ha^{-1} at Lona variety. Regarding the quality indices, Marcius variety had the highest protein content (14.1%) while for wet gluten content were emphasized Lona and Corso varieties with-31.2%.

Keywords: spring wheat, yield components, yield quality.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the main crop for production in the world, it's adaptability capacity to various environment conditions often being tested as effect of climate change. Wheat production is highly sensitive to climatic and environmental variations (Porter and Semenov, 2005), high temperatures and drought being two major stresses with significant impact on wheat production (Prasad et al., 2011). In Romania, high temperatures quite often affect already wheat yields, as illustrated by the fact that grain weight of some wheat cultivars grown in Fundulea - Romania was much smaller, as compared to published data on the same cultivars grown in England (Şerban et al., 2019). Among the numerous meteorological and hydrological extreme events, droughts are less understood, but often disastrous due to their higher occurrence frequency, long duration, and widespread impacts across larger spatial scales (Yu et al., 2018). These stresses cause many biochemical and physiological changes at cellular and whole plant levels that affect crop yield and quality (Rizhsky et al., 2004; Mittler, 2006; Prasad et al., 2008a). Heat and drought tolerance mechanisms involve a complex interaction among various traits (Mwadzingeni et al., 2016). Reproductive processes and the grain filling period are more sensitive to stress and need lower optimum temperature (15ºC) when compared with the vegetative growth and development (20ºC) (Wardlaw et al., 1989). Breeding widely adapted wheat varieties with high grain yield under high temperatures and drought stress requires targeted efforts to integrate a large number of traits with complex inheritance patterns (Araus et al., 2008; Reynolds et al., 2012). In multiple-stress environments, crop performance in terms of development, growth, and yield depends on the plant's ability to withstand, acclimate or recover (Prasad et al., 2011). High temperature and drought stress often occur simultaneously, but they can have different effects on physiological, developmental, growth and yield processes. The effects of these two stresses on crop plants have been studied independently (Porter and Gawith,

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1999; Wheeler et al., 2000). In southeast Europe short-term adaptations may include changes in crop species (e.g. replacing winter with spring wheat) (Minguez et al., 2007).

Yu et al. (2018) show that incipient drought during the wintering period has no significant impact on the yield of winter wheat, while moderate drought in the same period can reduce the yield significantly.

Spring wheat is a viable alternative to replacing winter wheat, especially when a drought is expected in autumn, which can cause an improper emergence. Spring wheat yield capacity is often comparable with the winter crop, especially when in the fall climatic conditions are unfavorable to grow and to develop the first stages of winter wheat plants (Racz et al., 2019).

Another key to successful crop growing is the supply of the correct amounts of nutrients at the correct time in relation to peaks and troughs of crop growth (Noulas et al., 2018). Nitrogen (N) is an essential mineral nutrient required in high concentrations for plant growth, high grain yield and quality (Koutroubas et al., 2014). In Romania, the optimum N fertilization rate of wheat is locally regarded as 120 Kg N ha^{-1} or 80 kg N ha^{-1} when is cultivated after pea or soybean. Also, yield benefits are greater when N is applied at tillering than when it is applied at planting; higher values of N fertilizer recovery can be obtained after application at tillering (Iancu et al., 2019). Splitting N application into two or three doses during the growing season is considered as a fertilization strategy that will probably increase nitrogen use efficiency- NUE (Limaux et al., 1999). Proper N application timing and rates are critical for meeting crop needs, and indicate considerable opportunities for improving N use efficiency (NUE) (Dhugga and Waines, 1989; Blankenau et al., 2002).

MATERIAL AND METHODS

Twenty-two Romanian and foreign spring wheat genotypes were studied during three consecutive years in a field at Agricultural Research and Development Station from Turda, located in the Transylvanian Plain, Romania (46º35’ N and 23º47’ E). The soil type is a clay chernozem with a neutral reaction (pH 6.9-7.1) and a humus content between 3.56-3.92%; rich in nitrogen (0.183-0.196%) and potassium content (249 ppm); and poor in mobile phosphorus (15 ppm).

Field experiments were organized in a randomized complete block design with three replicates and two levels of fertilization: the basic level of fertilization N:P:K (50:50:0) was applied after plants emergence (BBCH 12-15) and additional level of fertilization was applied in the stage of straw elongation (BBCH 32-33) with 50 kg/ha N active substance. Each harvest plot had 5 m length and 1.3 m width.

Regarding the climatic conditions during the experimental period (Figure 1), the rainfall regime was quite varied manifesting oscillation compared to the multiannual average. Even if the annual mean for each year was close to the multiannual average - 50 years (352.6 mm), their distribution during the spring wheat growth season were different causing the alternation of short drought periods with optimal conditions. Compared to the multiannual average temperature, all three experimental years were warmer with 1.1ºC in first year to 2.5ºC for the second experimental year.

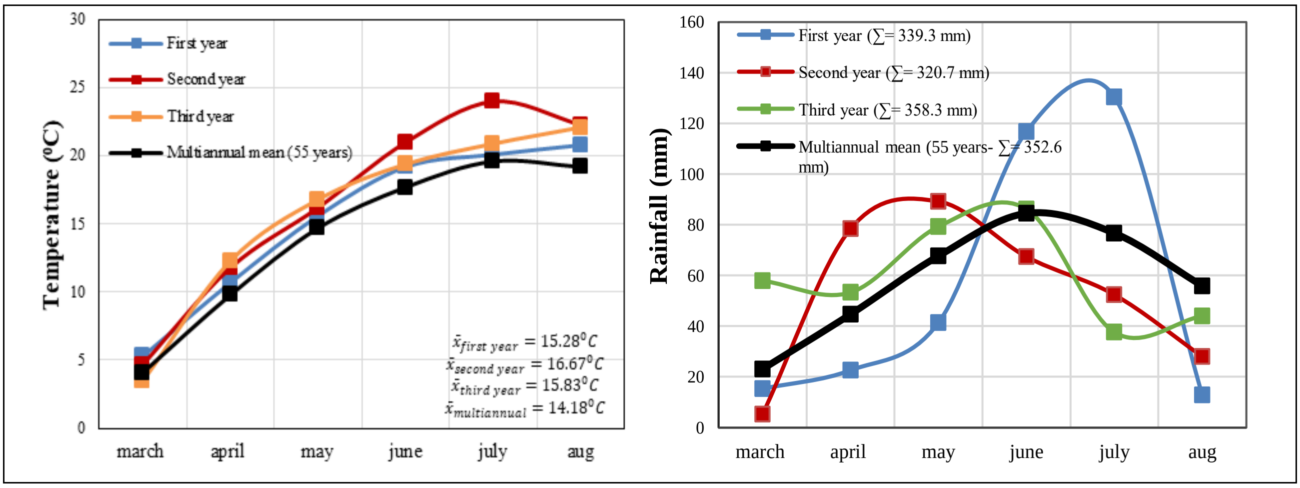

Figure 1. Climatic conditions - temperature and rainfall - during the experimental period

Number of grains per spike (NG), weight of grains/spike (WG), thousand kernel weight (TKW), biologic yield (BI), harvest index (HI), grain protein content (P), wet gluten content (G) were analyzed for each genotype at physiological maturity for each experimental year. Nitrogen use efficiency (kg/kg) was calculated according to Craswell and Godwin (1984) and Delogu et al. (1998) as the ratio of (grain yield at N_x - grain yield at N_0) to applied N at N_x.

The data matrix was prepared and processed in Excel (Microsoft, USA) and ANOVA programs, then chemometric analysis was performed using MatLab (The Mathworks, USA) after mean center preprocessing.

RESULTS AND DISCUSSION

The influence of experimental factors applied on the group of cultivars under yield, yield components and qualitative traits are revealed in Table 1. Spring wheat genotypes are known to react immediately to any change in environmental conditions, therefore testing them under different conditions led to different reactions from insignificant to very significant influence of morpho-productive and quality traits. The different reaction of quantitative characters can be attributed to the complexity of the analyzed character, as well as its genetic determinism.

Thus, all analyzed quantitative traits were very significant influenced by climatic conditions and fertilization - except for the thousand kernel weight on which fertilization has a distinctly significant influence, due to its high heritability. A distinct significant level was observed for weight of grain/spike in relationship with the genotype factor as well as interactions between genotype and other factors. Regarding qualitative grain yield indices, all experimental factors and interaction between them have a very significant influence.

Table 2. ANOVA for yield, yield components and quality traits

Source of variance	DF	GY	NG	WG	TKW	P	G
		MS					
A (year)	2	208.39**	124.77**	309.35**	1114.82**	723.44**	13039.4**
B (fertilization)	1	59.21**	257.15**	107.69**	31.48**	942.83**	64215.2**
A x B	2	4.58	491.58**	266.96**	13.63**	430.03**	8432.8**
C (genotype)	21	5.30**	96.07**	17.75**	32.85**	29.85**	928.0**
A x C	42	5.90**	56.67**	38.06**	18.34**	25.15**	570.2**
B x C	21	0.99	200.47**	152.90**	3.35**	7.30**	265.6**
A x B x C	42	1.44	161.97**	25.18**	4.30**	10.48**	198.4**
Error A	4	1.54416	7.037	0.00278	5.311	0.25152	0.0444
Error B	6	0.74953	0.298	0.00325	7.580	0.25152	0.0297
Error C	252	0.20552	0.904	0.00169	1.774	0.25258	0.0354
Total	**395**						

The mean of quantitative traits is presented in Table 2. Grain yield, as the main important quantitative traits, ranged from 3.64 t ha^{-1} to 4.36 t ha^{-1} with an average yield of 4.03 t ha^{-1}. Regarding the biologic yield, these had an increased value for oldest genotypes, with mean value of 3.07 g. Maximum value for number of grains/spike, weight of grains/spike and harvest index was achieved at SG 5-01 variety, which combine these main yield components with a low thousand kernel weight value 32.8 g. Qualitative grain indices, as protein content, ranged from 11.9 at Prif 3 genotype, to 14.1 at Marcius variety. For wet gluten content ranged from 25.9 at Sigma variety to 31.2 at Lona and Corso varieties. Based on analyzed traits each genotype was noted for its performance being given a note that characterizes its agronomic values. Therefore, the Marcius variety has the highest agronomic value, while Silva has the lowest.

Table 2. The agro-morphological and quality traits of twenty-one spring wheat variety

Genotype	GY	BY	NG	WG	TKW	P	G	HI	NUE	Rank
Pădureni	3.88	**3.69**	31.4	**1.18**	38.0	13.7	27.8	0.36	4.86	4
SG 5-01	4.21	3.43	**36.4**	**1.18**	*32.8*	12.6	27.6	**0.44**	6.00	5
SG V 773	4.12	2.70	34.1	1.12	*32.8*	12.8	29.3	0.37	5.26	8
SG 106-01	4.32	2.91	32.0	1.10	34.9	12.5	30.0	0.32	4.38	11.5
PF 70-35-4	4.17	2.47	34.4	1.16	34.3	12.1	26.9	0.39	5.15	11.5
TD 1524-71	3.67	2.72	*29.3*	1.09	**39.1**	13.3	28.5	0.40	5.53	10
Prif 3	4.27	3.41	35.1	1.13	32.9	*11.9*	28.6	0.35	4.62	9
Uralocica	3.87	3.03	*29.3*	1.10	38.1	13.2	27.8	0.31	4.73	14
Silva	3.92	2.87	29.5	1.03	35.9	12.1	26.8	0.35	4.29	20
Belotserkovskaya	3.84	3.58	30.8	*1.00*	33.7	12.9	27.8	0.34	4.55	17
Sigma	4.07	3.44	31.9	1.02	*32.8*	12.6	*25.9*	0.31	*4.18*	21
Jota	4.16	3.15	32.1	1.10	34.5	12.6	29.7	0.32	4.27	13
Menica	4.09	*2.23*	30.9	1.06	34.3	12.6	28.0	0.35	4.62	16
Mario	3.77	3.41	*29.3*	*1.00*	35.2	13.0	29.0	*0.30*	4.23	18
Prif 4	3.75	3.08	30.3	1.06	36.2	12.8	29.3	0.34	4.72	15
Brome	*3.64*	2.39	31.1	1.09	35.7	12.5	27.6	0.33	4.62	19
Jara	4.14	3.67	30.8	1.04	34.4	13.0	29.3	0.36	5.30	6
Lona	**4.36**	3.60	32.0	1.12	36.3	13.3	**31.2**	0.35	4.90	3
Corso	4.23	2.74	32.3	1.15	35.7	13.8	**31.2**	0.40	6.19	2
Marcius	4.26	3.17	32.1	1.13	35.4	**14.1**	29.3	0.40	**6.32**	1
GK Tovasz	3.82	2.88	31.2	1.07	34.4	13.4	29.9	0.38	5.63	7
Average	4.03	3.07	31.7	1.09	35.1	12.9	28.6	0.36	4.97	-

GY - grain yield t ha^{-1}; BY - biologic yield; NG - number of grains per spike; WG - weight of grains per spike; TKW - thousand kernel weight; P - protein content; G - wet gluten content; HI - harvest index; NUE - nitrogen use efficiency.

Biplot analyses revealed that the desirable yield traits are more or less influenced by the environmental or agro-management conditions (Figure 2a and 2b). Thousand kernel weight, protein and gluten content seem to have a rather small variation even in conditions of additional fertilization, which means that the spring wheat ideotype uses additional fertilization in the direction of increasing productivity and not its quality. Utilization of additional fertilization for morpho-productive plant elements can be observed through the reaction of biologic yield to this factor.

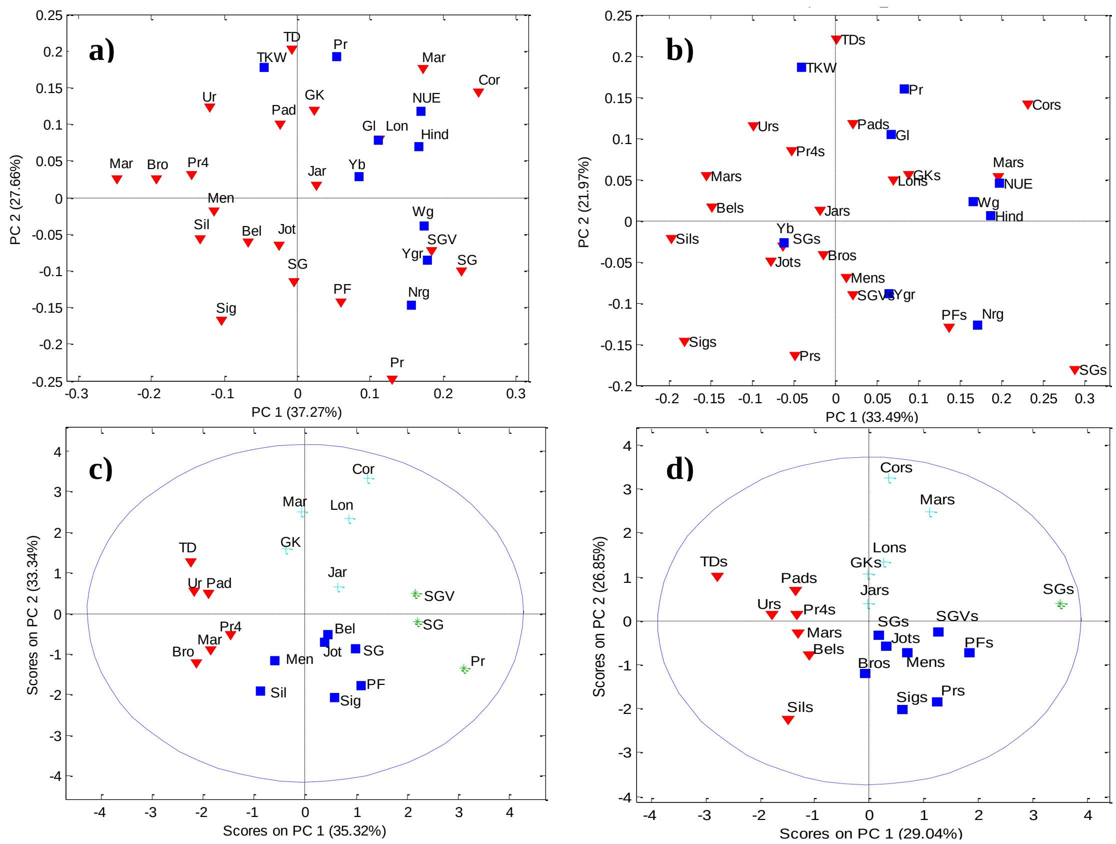

Figure 2. Biplot for the experimental dataset (a - basic fertilisation; b - additional fertilisation) and Score's plot for the PCA model (c - basic fertilisation; d - additional fertilisation)
(GY - yield, BY - biologic yield, NG - number of grains/spike, WG - weight of grains/spike; TKW - thousand kernel weight; P - protein content, G - wett gluten content, HI - harvest index, NUE - nitrogen use efficiency).

The score's plot of the PCA model reveals four classes (Figure 2c and 2d), one consisting of genotypes with a morphological character with a high genetic determinism as thousand kernel weight and plant height (Pădureni, TD 1524-71, Uralocica, Prif 4, Mario and Brome) which can be characterized through a low production and a medium qualitative index. The second-class groups the genotypes with a high qualitative trait as protein and gluten content (Jara, Lona, Corso, Marcius and GK Tovasz) characterized through a medium to high yielding and a high qualitative index. The third class containing the genotypes: PF 70-35-4, Silva, Belotserkovskaya, Sigma, Jota, Menica and SG 106-01 as a medium yield and low qualitative indices genotypes. Fourth class contain genotypes which had a changing behavior in relationship with the fertilization level: SG 5-01, SG 106-01, and Prif 3, capitalizing on additional fertilization through a high level of production.

Regarding the correlation between analyzed traits (Table 3), in case of basic fertilization the relationships between different productivity elements are stronger than in case of additional fertilization, which suggests that the plant has a fairly rigid mechanism for controlling its elements in limited conditions.

Table 3. Pearson correlation coefficient (r) between quantitative traits of twenty-one wheat genotypes at two N fertilization levels (basic fertilization and additional fertilization) during three growing seasons

Quantitative traits		GY	BY	NG	WG	TKW	P	G	HI	NUE
		Basic fertilization								
GY	Additional fertilization		*0.18*	*0.70***	*0.58***	*-0.46*^{0}	*-0.15*	*0.39*	*0.45**	*0.37*
BY		0.21		*0.27*	*0.19*	*-0.06*	*0.35*	*0.30*	*0.05*	*0.17*
NG		0.40	-0.17		*0.76***	*-0.63*^{00}	*-0.34*	*0.08*	*0.25*	*0.15*
WG		0.21	-0.28	0.68**		*-0.02*	*0.02*	*0.13*	*0.49**	*0.44**
TKW		-0.35	-0.05	-0.54^{00}	0.21		*0.52**	*0.02*	*0.11*	*0.21*
P		0.01	-0.08	-0.18	0.17	0.34		*0.48**	*0.29*	*0.56***
G		0.26	0.08	-0.02	0.29	0.26	0.37		*0.20*	*0.42**
HI		-0.02	-0.14	0.53*	0.42*	-0.16	0.25	0.07		*0.90***
NUE		0.04	-0.20	0.46*	0.43*	-0.12	0.53*	0.22	0.90**	

Number of grains/spike and weight of grains/spike, as main yield components, are distinctly significant correlated with grain yield at basic fertilization, as well as weight of grain/spike and number of grains/spike (0.76); protein content and nitrogen use efficiency (0.56); and harvest index and nitrogen use efficiency (0.90). Harvest index was significant corelated with grain yield (0.45) and weight of grains/spike (0.49), while at additional fertilization - harvest index and nitrogen using efficiency are significant correlated with number of grains/spikes.

A significant negative correlation can be observed between grain yield and thousand kernel weight at basic fertilization, which means that for a high thousand kernel weight value, the genotype is using important nutritional resources sometimes even to the detriment of grain yield. The same behavior can be highlighted between thousand kernel weight and number of grains/spikes for both fertilization levels. Regarding the nitrogen use efficiency of studied spring wheat genotypes these traits have same reaction both for basic and additional fertilization, the intensity of this character being tighter at basic fertilization.

CONCLUSIONS

In favorable climatic conditions spring wheat can be an outright alternative for winter wheat, being able to match its productive performance and even surpassing them as is the case of protein and wet gluten content. As a dynamic "ideotype" - spring wheat is receptive to any agro-technical inputs that it capitalizes on very effectively. Regarding the performance of studied genotypes can be highlighted cultivars both for quantity and quality, the most performance genotype which combine this two desiderates being Marcius variety followed by Corso and Lona genotypes.

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