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Asian Journal of Plant Science and Research, 2020, 10(4):1-5

ISSN : 2249-7412
CODEN (USA): AJPSKY

Genotypes x Environment interaction for growth attributes and yield in wheat (Triticum aestivum L.) at New Halfa irrigated scheme

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ABSTRACT

A multi- locations field trial was conducted for two consecutive seasons 2017/2018 and 2018/2019 at three locations of Newhalfa irrigated scheme to estimate genotype by environment interaction for some growth attributes, yield and yield components of two wheat genotypes. A randomized complete block design with three replicates was used to lay out the field trial. Highly significant differences at the genotypes level, season x genotypes and season x location x genotypes levels for leaf area, number of spike lets per plant, grain yield per plant, straw weight, grain yield per m2 and harvest index was detected. Dry weight showed non – significant differences at the genotypes and genotype x season interaction levels, whereas, the number of grains per plant showed non-significant difference at the genotypes level only. In addition, the results indicated that, the genotypic variances were greater than the environmental ones for yield and its components. From this study, it can be concluded that, sufficient genetic variability was available in the tested materials and selection of a desirable genotype of wheat, is to be made after it thoroughly tested for more than one year and at more than one location.

Key words: *Triticum aestivum*, Genotype x seasons, Genotype x locations, Yield.

Introduction

Wheat (Triticum aestivum L.) belongs to the family Gramineae, is one of the most important crop plants in the world. The unique characteristics of gluten made wheat flour with a wide range of uses for human food and animal feed. It grows under a broad range of latitudes and altitudes; it is not only the most widely cultivated crop but also the most consumed food crop all over the world [1]. The crop is a winter crop grows from temperate, irrigated to dry and high rain fall areas, and from warm, humid to dry, cold environments [2]. According to Hanchinal et al. [3] wheat is the most Important crop and rank first among world food crops, measured either by cultivated area or by production. The average world wheat areas were about 224.7 million hectares producing 689.1 million metric tons with average yield estimated at 3.08 tons per hectare. This explains the urgent need to raise yield by cultivation of high yielding and adapted varieties in low yielding areas. The leading producing countries of wheat are USA, Canada, Australia, Russia, China and Argentine. Among Arab countries, Iraq, Algeria, Tunisia, Egypt and Sudan [4]. The crop in Sudan is grown under irrigation, during the short growing season from November to March [5]. Knowledge of the relative contributions of genotype, environment and genotype by environment interaction effects on wheat (Triticum aestivum L.) quality leads to more effective selection in breeding programs and segregation of more uniform parcels of grain better suited to the needs of customers. Grain quality is a complex character that depends on a number of traits, and the individual contribution of each trait varies depending on specific reaction to environmental conditions [6].

Improvement of end-use quality in bread wheat depends on a thorough understanding of current wheat quality and the influences of genotype, environment and genotype by environment interaction on quality traits. The successful process of wheat breeding is based on the knowledge of characteristics of genotypes, environment and its interaction. Evaluation of genotypes across diverse environments and over several years is needed in order to identify spatially and temporally stable genotypes that could be recommended for release as new cultivars and/or for use in the breeding programs [7]. According to Yan and Kang [8], it is known that mean yield across environments are sufficient indicator of genotype performance only in the absence of genotype by environment interaction. Most of the time, GEI complicates breeding, in testing and selection of superior genotypes. It is important for breeders developing new varieties to identify specific genotypes adapted or stable to different environment(s), thereby, achieving quick genetic gain through screening of genotypes for high adaptation and stability under varying environmental conditions prior to their release as cultivars. Becker and Leon [9] stated that, successful varieties must show good performance for yield and other essential agronomic traits, their superiority should be reliable over a wide range of environmental conditions. Therefore, the objective of this study was to evaluate two varieties of wheat under three irrigated environments over two seasons 2017/2 018 and 2018/ 2019, with aim of estimating GxE interaction and identifying their performance for yield and other agronomic traits at varying environments of New Halfa irrigated scheme.

Material and Methods

The experiment was carried out for two consecutive seasons(2017/2018 and 2018/2019), at three sites of New Halfa irrigated scheme, Sudan, namely, Hajer (HA) represents South of the scheme, Faculty of Agriculture and Natural Resources (FA) of the University of Kassala, represents central area of the scheme and Shebiake (SH) which represent North part of the scheme. (Latitude 15º 19´ N, Longitude 35 º 36´ E. and altitude 450m asl.). Two wheat cultivars seeds (Bohain and Debaira) were obtained from the Agricultural Research Corporation (ARC) of New Halfa. At each location, a randomized complete block design with three replicates was used. The plot size was 4.5 x 6 m. Sowing date was on 12th and 14th November, for the first and the second seasons, respectively. All cultural practices were followed as recommended from ARC. Data were collected on the following parameters: Leaf Area (LA), Dry Weight (DW), Number of Spikelet/Plant(NSPP), Number of Grains/Plant(NGPP) , Straw weight (g) (SW), Grain yield/Plant (g) (GYPP), Grain yield per m2 (GY/M2), and Harvest index (HI). All the data were analyzed according to the procedure described by Gomez and Gomez (1984). Using statistix computer software package (version 9-1). Analysis of variance for all studied traits was carried out to test the significant differences among the treatment means. Moreover, the combined analysis of variance for the data over the two seasons and across the three locations was calculated to test for the interaction effect among the treatments means.

Result and Discussion

Crop improvement depends upon the availability of variability for the characters being selected. The variation in a character is specified by the phenotypic variance, which includes genetic and environmental variances and their interaction. One of the challenges for the plant breeders is to determine to what extend the desirable character is heritable or influenced by the environment. In this study, the combined analysis of variance revealed highly significant differences at the genotypes level, season x genotypes and season x location x genotypes levels for most of the character under study viz; Leaf area, number of spike lets per plant, grain yield per plant, straw weight, grain yield per m2 and harvest index, (Table 1). Dry weight showed non – significant differences at the genotype and genotype x season interaction levels, whereas, the number of grains per plant showed non-significant difference at the genotypes level only. This indicate that the two genotypes were not consistent in their performance in different environments. Which indicate the importance of GxE interaction in determining the expression of these traits, and , moreover it indicates that selection of a desirable genotype is to be made after it thoroughly tested for more than one year at more than one location. Zerihun etal. [10] found similar results of the genotype, environment and genotype x environment interaction effects for yield and its components in barley land races.

The size of the genotypic components, relative to that of GxE interaction components, is a crucial factor in determining the most likely area for the successful performance of a cultivar. If the interaction components is larger than the genotypic components, the breeder would select for a cultivar to meet the specific requirements of the environment; but if the reverse is true, the breeder would select for a cultivar with wide adaptability and stable performance over a range environment.

Table 1: Mean squares from the combined analysis of variances of some growth attributes, yield and yield components for two wheat genotypes evaluated over two seasons and three locations.

Characters	Genotype	Seasonx Gen.	Loc.x Gen.	Seas.x Loc.xGen.	Pooled error
	df=1	df=1	df=2	df=2	df=2
LA	9034249***	424813***	2693265***	2317736***	22199.6
DW	11.15NS	8.97NS	28.71**	19.04*	4.16
NSPP.	3367***	5569***	904***	2242***	38
NGPP	39NS	6735*	75908***	154853***	1735
GYPP.	22.27***	46.75***	11.26***	42.56***	0.93
SW(kg)/m2	0.1076*	0.1666**	0.1066**	0.1877***	0.0168
Yield/m2	43276***	8160***	60473***	10373***	209
HI	1748.5***	2192.0***	1989.0***	1374.4***	21.3
*, **, ***, are significant at 0.05, 0.01, 0.001 probability levels, respectively. NS, not signifiant.					

Table 2: Phenotypic, Genotypic and Environment Variances for some growth attributes, yield and yield components for the two wheat genotypes (Bohain and Debaira) evaluated at Hajer location for two seasons 2017/018 and 018/ 2019.

Character	2017/2018			2018/2019		
	σ^2_p	σ^2_g	σ^2_e	σ^2_p	σ^2_g	σ^2_e
Bohain						
LA	6047.63	1233.7	4813.9	80134.7	33665.7	46469
DW	8.44	4.66	3.79	4.29	4.07	0.22
NSPP	118.01	110.52	7.49	79.54	65.38	14.16
NGPP	371.63	335.26	36.36	182.61	168.21	14.39
GYPP	0.73	0.54	0.19	0.2	0.1	0.1
SW(kg)/m^2	0.008	0.003	0.005	0.49	0.07	0.43
Yield/m^2	1278.31	1265.81	12.5	121.46	109.27	12.19
HI	5.89	3.71	2.18	77.48	65.39	12.09
Debaira						
LA	5477.33	1178.67	4298.67	80134.7	33665.7	46469
DW	2.27	-0.34	2.61	4.29	4.07	0.22
NSPP	92.08	68.01	24.06	79.54	65.38	14.16
NGPP	441.45	416.98	24.47	182.61	168.21	14.39
GYPP.	0.34	0.03	0.31	0.2	0.1	0.1
SW(kg)/m^2	0.007	0.002	0.005	0.81	0.23	0.58
Yield/m^2	558.3	457.86	100.43	240.4	218.23	22.17
HI	4.43	1.74	2.69	77.48	65.39	12.09

Table 3: Phenotypic, Genotypic and Environment Variance for some growth attributes, yield and yield components for the two wheat genotypes (Bohain and Debaira) evaluated at Faculty of Agriculture location for two seasons 2017/018 and 2018/2019.

Character	2017/2018			2018/2019		
	σ^2_p	σ^2_g	σ^2_e	σ^2_p	σ^2_g	σ^2_e
Bohain						
LA	4659.03	1427.4	3231.63	4775.17	2626.87	2148.3
DW	2.12	0.89	1.23	1.29	0.55	0.74
NSPP	575.6	542.11	33.49	102.88	97.85	5.03
NGPP	3927.03	3474.13	452.9	169.43	158.02	11.42
GYPP	0.65	0.38	0.27	0.51	0.15	0.36
SW(kg)/m^2	0.0063	-0.0007	0.007	N.A.	-	-
Yield/m^2	1289.47	1263.05	26.42	947.35	931.08	16.27
HI	13.01	11.17	1.84	214.03	212.4	1.63
Debaira						
LA	6096.8	66	6030.8	3610.5	79.2	3531.3
DW	0.21	-0.07	0.28	0.1	-0.05	0.15
NSPP	142.38	125.97	16.4	132.05	129.08	2.97
NGPP.	387.54	347.57	39.97	504.19	493.45	10.74
GYPP.	0.62	0.2	0.42	0.92	0.78	0.15
SW(kg)/m^2	0.03	0.02	0.01	1.98	1.62	0.36
Yield/m^2	652.39	614.05	38.34	638.75	628.14	10.62
HI	14.31	11.95	2.36	177.69	166.33	11.36

Table 4: Phenotypic, Genotypic and Environment Variances for some growth attributes, yield and yield components for the two wheat genotypes (Bohain and Debaira) evaluated at Elshebaik location for two seasons 2017/018 and 2018/2019.

Character	2017/2018			2018/2019		
	σ^2_p	σ^2_g	σ^2_e	σ^2_P	σ^2_g	σ^2_e
			Bohain			
LA	7447.63	4857.8	2589.83	1181.84	1113.07	68.77
DW	2.35	-0.25	2.6	0.12	-0.07	0.19
NSPP.	225.9	214.06	11.85	1.36	0.58	0.78
NGPP	3761.67	3681.83	79.83	16.11	11.55	4.56
GYPP.	1.05	0.13	0.92	0.0134	-0.0003	0.0138
SW(kg)/m^2	0.016	0.002	0.014	0.0015	0.0009	0.0006
Yield/m^2	6293.33	5800.83	492.5	375.55	356.94	18.61
HI	16.29	8.71	7.57	33.49	25	8.49
			Debaira			
LA	8614.47	8607.57	6.9	4398.83	4397.07	1.77
DW	2.36	0.48	1.88	0.27	0.17	0.1
NSPP.	219.04	204.29	14.75	1.17	-0.15	1.32
NGPP	5702.33	-519.7	6222	18.27	15.55	2.72
GYPP	1.23	0.98	0.24	0.014	-0.008	0.022
SW(kg)/m^2	0.0173	0.0008	0.0165	1.406	-0.008	1.414
Yield/m^2	3097.21	3056.03	41.18	936.88	925.33	11.55
HI	5.44	-0.72	6.16	67.49	62.44	5.05

Table 2, 3 and 4 showed the phenotypic, genotypic and environmental variances for some growth attributes, yield and yield components for the two wheat genotypes (Bohain and Debaira) evaluated at the three locations for two seasons 2017/018 and 018/ 2019. At the three locations and over the two seasons. For both cultivars, the genotypic variances for leaf area, number of spikelets per spike, number of grains per plant, grain yield per plant, yield per m2 and harvest index are greater than the environmental variances, which indicate that, these character are heritable and reliable for the direct selection to improve the yield of the cultivars. On the other hand, the dry weight and straw weight showed higher environmental variances relative to the genetic ones. This inconsistence performance with the change in the environment, implies that these two traits are less reliable to be considered in selection procedures for further breeding programmees. These results are inconformity with those reported by Singh and Yadava [11], Bange et al. [12] and Mohamed and Abdella [13,14].

Conclusion

1 – High level of genetic variability for the traits under study are available for the tested materials, which is a very important resources for yield improvement of the crop.

2- Wheat crop is very sensitive to environmental changes, since a high significance variations were detected at the genotypes, GxS, GxL and GxSxL levels. Therefore, evaluation of the crop for more than one seasons and at more than one location is a crucial factor prior to their release.

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