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G X E interaction over extended dates of sowing for grain yield and its attributing traits in wheat (*Triticum aestivum* L.)

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ABSTRACT

An experiment was conducted with twenty varieties of wheat for eleven quantitative traits in three environments of extended dates of sowing at 25 days interval viz., 3 Nov. (Early sown as E_1), 28 Nov., (Timely sown as E_2), 23 Dec. (late sown as E_3) during Rabi season. Highly significant variations due to genotypes against pooled deviation revealed the presence of genetic variability for all the traits under study except for biological yield per plant and harvest index. The component G-E Interaction being highly significant indicated that genotypes interacted considerably to environmental conditions in different environments. The predominance of linear component would help in predicting the performance of genotypes across environments. The genotypes PBW 343, PBW 527, PBW 233, PBW 502, UP 2425, UP 2565, C 306 has high mean values for grain yield and non-significant regression coefficient (βi) approaching unity with non-significant deviation from regression were more stable across three environments. Parameters in respects to yield attributing traits revealed that the variety UP 2565 was stable for grain yield per plant and biological yield per plant. While variety PBW 396 had average stability for productive tillers m^{-2}, spike length and UP 2382 has similar response of test weight and days to maturity. Thus the present study brought the fact that PBW 396, UP 2565 and UP 2382 was most stable genotypes for yield and its attributing traits.

Key words: G×E interaction, stability, regression coefficient

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INTRODUCTION

Wheat is an important cereal grain for export and domestic consumption in many countries throughout the world. Thus a continuous supply of wheat to exponentially increasing population is a major concern. The modern wheat breeding programmes focus on the improvement of agronomic and grain quality traits. The manipulation of wheat genetics has led to ever increasing gains in yield and grain quality, while decreasing the ability of wheat to survive in the wild or in varying climate especially with adverse conditions. The ultimate aim of any plant breeding programme is to develop cultivars with high potential and consistent performance over diverse environments. Productivity of population is the function of its adaptability is the compromise of fitness (stability) and flexibility to the buffering environment. Stability of genotypes depends upon the ability to retain certain morphological characters. Steadily and allowing others to vary resulting in predictable G×E interaction for quantitative traits. A population that can adjust its genotypic and phenotypic state in response to environmental fluctuations in such a way to give high and stable yield is termed to be stable.

Information about phenotypic stability is useful for selection of crop verities as well as for breeding programmes. An understanding of environmental and genotypic causes leading to G×E interaction are important at all stages of plant breeding including ideotype design, parental selection, establishing breeding objectives, identify ideal test conditions. A study of individual yield components can lead to simplification in genetic explanation and determination of environmental effects. Therefore, in the present study twenty wheat genotypes were grown over three extended dates of sowing and genotypes possessing stability were identified using the Eberhart and Russell (1966) model.

MATERIALS AND METHODS

Field study were conducted in randomized block design with three replications of three extended dates of sowing at 25 days interval *viz*., 3 Nov. (Early sown as E_1), 28 Nov., (Timely sown as E_2), 23 Dec. (late sown as E_3) during Rabi season at the farm of Genetics Plant Breeding Department, Allahabad Agricultural Institute-Deemed University, Allahabad. Twenty varieties of wheat *viz*., PBW 527, PBW 343, PBW 396, PBW 299, PBW 175, PBW 233, PBW 502, VL 804, VL 738, C 306, UP 2382, UP 2113, UP 1109, UP 2572, UP 2554, UP 2338, UP 262, UP 2565, UP 2425 and WH 896 have been taken for the study in $4m^2$ plot size with 20 cm X 10 cm spacing between and within the rows, respectively. All the recommended agronomic cultural practices were followed. The study was based on eleven quantitative characters *viz*., days to heading, plant height, number of effective tillers (m^{-2}), spike length (cm), days to maturity, number of grains per spike, Biological yield/plant (q/ha), grain yield/plant (q/ha), harvest Index (%), test weight (gm) and grain yield/plot (q/ha).

Data from the three environments and the pooled data are subjected to analysis of variance (Panes and Sukhatme, 1967). The traits which showed the significant G×E interactions were subjected to stability analysis using the Eberhart and Russell (1966) model. As per the model, three parameters ***viz*.,** overall mean performance of each genotype across the environments, the regression of each genotype on the environmental index (βi) and squared deviation from the regression (S^2di) were estimated. The significance of stability parameters and deviations from unity were tested by student't' test.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) for individual as well as pooled environments revealed that the mean difference between genotypes and environments were highly significant for all the traits indicating presence of genetic variability among the genotypes and environments that add scope for selection of promising lines from present gene pool for yield improvement. Significant differences among environments also indicated the differential influence of environment on the character expression. Both linear and non linear components of interactions though present, but major part was accounted by the linear differences among the response of individual verities to the environment.

After computing analysis of variance data regarding all traits showing significant differences were further subjected to stability analysis following Eberhart and Russell (1966). As shown in Table 1 from pooled data there were highly significant differences for genotype X environment interaction, non-significant ($P > 0.05$) difference, were observed for all the traits except for days to maturity, which is highly significant. Genotype X Environment (Linear) was non-significant for all the characters and highly significant for days to heading and days to maturity. The component G-E Interaction being highly significant indicated that genotypes interacted considerably to environmental conditions in different environments. The predominance of linear component would help in predicting the performance of genotypes across environments. The regression coefficient (bi) means the linear response to environmental changes and deviation from regression (S^2di) measures the consistency/stability of that response. According to Eberhart and Russell (1966), βi value around unity and (s^2di) close to zero or minimum is the indication of less response to environmental fluctuation hence more adaptive. A variety with βi value higher than 1 is more responsive meaning suitable for favorable environment and βi value less than 1 is suitable for poor environment.

From Table 2 Generalization regarding stability for all the characters was found to be too difficult. Varieties studied did not exhibit uniform stability and linear response pattern. This could be explained on the basis of the compromises and compensation among the developmental patterns of the different characters. The genotypes PBW 343, PBW 527, PBW 233, PBW 502, UP 2425, UP 2565, C 306 has high mean values for grain yield per plot and non-significant regression coefficient (βi) approaching unity with non-significant deviation from regression were more stable across three environments.

Table 1 Pooled analysis of variance for the eleven characters studied under early, normal and late plantings

Source of variation		G	E + (G×E)	E	G×E	E (lin)	G×E (lin)	Pooled deviation	Pooled error
Traits	d.f. →	19	40	2	38	1	19	20	5
Days to heading		76.17*	76.5*	1326.97*	10.69	2653.95*	15.5*	5.58*	1.28
Days to maturity		9.38*	233.85*	4613.67*	3.33*	9227.35*	5.06*	1.53	0.88
Plant height		231.94*	264.64*	4642.84*	34.21	9285.69*	40.27	26.75*	2.39
Productive tillers/m^2		1161.47	2528.3	31338.8*	1011.9	62677.5*	555.4	1395.1*	98.08
Spike length		4.7*	0.97*	11.2*	0.43	22.4*	0.53	0.32*	0.04
Grains per spike		99.77	54.74	140.01	50.25	280.03	24.24	72.44*	3.76
Biological yield / plant		42.04	26.14	166.98*	18.72	333.97*	7.26	28.68*	1.8
Grain yield / plant		12.96*	7.14	70.84*	3.79	141.69*	1.16	5.67*	0.53
Harvest index		125.18*	63.38	247.99*	53.66	495.99*	57.64	47.2*	1.81
Test weight		65.79*	62*	996.86*	12.8	1993.72*	7.63	17.07*	2.56
Grain yield / plot		0.07	0.16*	2.12*	0.06	4.24*	0.05	0.06*	0.007

** significant at 1% level of significance.*

Table 2: Estimates of mean, regression coefficient and deviation from regression coefficient for eleven characters of wheat genotypes

Characters		Days to heading			Days to maturity			Plant height			Productive tillers/m^2			Spike Length		
S.No	Variety	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di
1	VL 804	85.83	0.88	1.42	123.20	0.86	0.49	103.00	1.28	48.62**	218.70	1.10	13.53**	11.55	0.34	0.38**
2	PBW 396	84.5	1.21	-0.89	124.50	0.93	6.96**	94.50	0.71	25.08**	206.70	0.16	0.69	10.70	0.51	0.05
3	PBW 343	86.83	1.51*	-1.58	123.80	1.01	0.68	94.50	0.73	-0.04	219.30	1.47	5.75*	9.70	0.77	0.47**
4	PBW 175	77.16	0.35	37.63**	120.70	1.03	2.68	105.90	0.96	13.73*	244.70	0.91	4.89*	8.97	1.73	0.70**
5	PBW 527	84.5	1.19	5.74*	123.20	0.92	0.40	110.20	0.95	39.19**	206.70	0.74	2.23	10.25	1.92	0.34**
6	UP 262	78.0	0.49	-0.95	119.70	0.96	0.27	108.60	1.20	52.01**	183.00	2.01*	0.01	10.74	2.47	0.06
7	PBW 233	85.66	1.09	7.01*	123.20	0.93	0.34	92.40	1.10	43.49**	205.20	1.32	23.46**	7.35	0.71	0.14*
8	PBW 502	90.16	1.38	0.15	123.30	1.01	0.67	99.40	0.73	-0.31	222.20	1.39	40.54**	10.41	1.55	0.19*
9	UP 2572	83.83	1.10	0.09	122.50	0.94	-1.07	100.40	0.96	27.63**	214.00	1.62	17.35**	11.65	0.69	0.04
10	UP 2382	76.5	0.67	-1.32	122.00	0.99	-0.34	92.40	0.74*	-2.23	231.00	0.95	25.18**	10.38	2.27	0.29**
11	UP 2425	73.33	0.55	-0.88	118.70	0.95	0.48	95.80	0.86	25.55**	215.50	0.83	1.91	11.23	0.63	0.57**
12	UP 2565	73.5	0.58*	-1.60	118.70	0.92*	-1.13	101.10	0.79	29.60**	190.00	0.46	4.05*	8.98	1.68	0.07
13	WH896	85.17	1.32*	-1.62	122.20	1.26	3.53*	91.40	1.16	43.07**	255.00	0.86	1.16	7.41	0.12	0.12
14	VL 738	86	1.35	-0.41	124.20	0.97	-0.82	103.70	0.98	0.79	243.80	0.51	67.46**	11.90	1.04	-0.041
15	UP 2113	85.5	1.03	9.24*	123.20	1.11	-0.93	109.60	1.47	127.87**	222.30	0.83	13.26**	10.36	0.57	0.03
16	C306	83	1.24	6.56*	123.00	1.12	-0.12	127.10	1.85	15.03**	245.50	1.07	5.58*	9.05	0.24	0.03
17	UP 2338	81.67	0.58	21.82**	123.50	1.07	-1.00	90.90	0.81	-2.00	200.80	1.03	27.31**	10.56	0.45	0.06
18	PBW 299	90.33	1.24	-0.55	123.80	0.92	-0.95	97.20	0.73	-1.75	249.70	1.00	6.72*	9.42	0.86	1.66**
19	UP 2554	89	1.07	0.59	124.50	0.91	-1.08	97.90	0.80	-1.70	214.80	0.73	6.73*	10.72	0.86	0.28**
20	UP 1109	83.67	1.17	-1.16	122.00	1.20	-0.91	109.50	1.18	3.99	220.50	1.00	0.08	10.46	0.58	0.16*
	Mean	83.21	1		122.50	1		101.30	1		220.50	1		10.09	1	
	SE(+/-)	1.67	0.21		0.90	0.1		3.70	0.2		26.40	0.7		0.40	0.54	

**, ** significant at 5% and 1% level of significance, respectively.*

Characters		Grains per spike			Biological yield/ plant			Grain yield / plant			Harvest index		
S.No	Variety	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di	Mean	ßi	s^{2}di
1	VL 804	56.00	2.95	5.45	33.50	0.99	22.31**	13.75	1.27	10.67**	40.69	1.20	5.45
2	PBW 396	53.00	4.52*	5.09	32.17	1.40	222.53**	13.17	0.96	16.80**	41.75	-1.24	5.09
3	PBW 343	42.17	1.93	104.22**	27.83	0.22	-0.41	16.12	2.15*	-0. 49	56.62	3.03	104.22**
4	PBW 175	34.17	0.15	66.79**	25.67	0.97	3.19	10.40	0.50	7.89**	40.75	-1.63	66.79**
5	PBW 527	40.17	0.61	-0.85	28.17	2.08	6.41*	11.29	0.65	12.03**	40.09	-1.25	-0.85
6	UP 262	41.00	2.29	10.11*	24.17	0.96	15.05**	9.38	0.59	-0.30	39.13	-0.89	10.11*
7	PBW 233	43.67	1.61	4.79	27.00	0.12	-0.05	11.78	0.36	0.04	43.64	0.50	4.79
8	PBW 502	43.83	0.33	146.98	26.83	0.89	105.04**	12.75	0.23	-0.01	50.13	3.12	146.98**
9	UP 2572	46.17	1.82	19.62	24.83	2.06	53.13**	10.38	1.35	1.95*	42.78	2.55	19.62**
10	UP 2382	45.33	0.19	-0.70	27.83	0.66	-0.80	10.78	0.68	-0.51	38.75	0.52	-0.70
11	UP 2425	36.83	0.31	3.54	26.33	0.54	65.98**	11.77	0.74	9.89**	45.18	1.94	3.54
12	UP 2565	44.83	-0.71	17.19**	32.67	0.75	-0.49	12.40	1.01	-0.00	37.78	0.52	17.19**
13	WH 896	41.33	-0.02	56.32**	24.50	1.18	-0.69	15.57	0.99	2.09*	63.75	0.59	56.32**
14	VL 738	50.50	-0.33	-0.12	32.33	0.84	-0.83	14.18	1.63	0.06	43.67	2.27	-0.12
15	UP 2113	45.50	0.76	100.17**	22.83	2.51	25.54**	9.87	1.11	-0.05	44.75	1.29	100.17**
16	C 306	39.83	2.08	216.12**	30.67	0.85	10.87*	12.98	1.62	5.69**	42.52	0.21	216.12**
17	UP 2338	49.17	-0.17	26.34**	19.22	0.03	-1.16	7.63	0.98	0.18	39.41	2.43	26.34**
18	PBW 299	55.00	1.11	15.19**	24.67	0.41	0.08	10.45	0.83	5.92**	42.17	1.95	15.19**
19	UP 2554	44.83	-0.54	112.87**	23.00	0.94	11.90**	11.80	1.50	29.34**	50.28	3.06	112.87**
20	UP 1109	40.00	1.09	-1.84	25.67	1.61	-0.09	10.67	0.83	2.04*	41.58	-0.16*	-1.84
	Mean	44.67	1		27.00	1			11.86	1		44.67	1
	SE (+/-)	6.02	2.27		3.79	1.31			1.68	0.89		6.02	2.27

, significant at 5% and 1% level of significance, respectively.*

Characters		Test weight			Grain yield per plot		
S.No	Variety	Mean	ßi	s^2di	Mean	ßi	s^2di
1	VL 804	1.60	1.26*	46.95**	1.60	1.26*	-0.01
2	PBW 396	1.33	0.21	5.21	1.33	0.21	0.01
3	PBW 343	1.41	1.24	-2.18	1.41	1.24	0.02
4	PBW 175	1.31	0.14	-1.81	1.31	0.14	0.03*
5	PBW 527	1.47	0.63	129.21**	1.47	0.63	0.01
6	UP 262	1.36	1.19	-2.78	1.36	1.19	0.24**
7	PBW 233	1.21	0.75	4.67	1.21	0.75	0.02
8	PBW 502	1.49	0.98	-1.87	1.49	0.98	0.01
9	UP 2572	1.52	1.82*	15.88*	1.52	1.82*	-0.01
10	UP 2382	1.52	1.21	-0.41	1.52	1.21	0.08**
11	UP 2425	1.52	0.95	9.19*	1.52	0.95	0.00
12	UP 2565	1.49	1.03	3.28	1.49	1.03	-0.01
13	WH896	1.07	1.19	-0.58	1.07	1.19	0.06**
14	VL 738	1.28	2.09	2.85	1.28	2.09	0.11**
15	UP 2113	1.26	1.59	0.69	1.26	1.59	0.30**
16	C306	1.06	1.32	-2.89	1.06	1.32	-0.00
17	UP 2338	1.23	0.69	12.34*	1.23	0.69	0.09**
18	PBW 299	1.16	0.52	-0.62	1.16	0.52	0.07**
19	UP 2554	1.33	0.20	52.73**	1.33	0.20	0.01
20	UP 1109	1.24	0.96	13.29*	1.24	0.96	0.05**
	Mean	1.34	1			1	
	SE(+/-)	0.18	0.54		0.18	0.54	

**, ** significant at 5% and 1% level of significance, respectively.*

Parameters in respects to yield attributing traits revealed that the variety UP 2565 was stable for grain yield per plant, grain yield per plot and biological yield per plant. While variety PBW 396 had average stability for productive tillers m^{-2}, spike length and UP 2382 has similar response for grain yield per plant, test weight and days to maturity.

Thus the present study brought the fact that PBW 396, UP 2565 and UP 2382 were most stable genotypes for yield and its attributing traits and November 28, timely sown was the most optimum time of planting of wheat crop, because the November 28 was most suitable for maximum grain yield per plot, grains per spike, biological yield per plant, spike length, test weight and plant height. Similar findings were reported by earlier research workers Chaudhry *et al*. (1995) and Iqbal *et al.* (2001).

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