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EVALUATION OF PRIMARY YIELD TRAITS IN WHEAT AT SIX ENVIRONMENTS

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Abstract

The magnitude of genotype-environment interaction and the stability parameters of 21 F_6 Near Isogeneic Lines (NILs) of wheat developed from 4 indigenous inbred lines and 2 exotic lines were estimated over 6 seeding dates for 5 morphological yield traits. The NILs were considered as different genotypes and the seeding dates were treated as different environments. Highly significant GE interaction alongwith their significant linear component for all the traits, except the grains/ear and grain yield/plant, predicted the feasibility of the genotypes under different environments. Linear relationship with the environment was found to be predominant in most of the cases compared to that of non-linear relationship. For the estimation of stability parameters the genotypes 10-12 and 16 for SE 3, 10 and 11 for GE and GY proved to be most stable and suitable performer in any environment and could be used for future breeding programme. On the other hand, the genotypes 7, 17 and 18 for most of the traits would be stable and suitable performer under unfavourable environments. Thus, the yield potency might be increased by developing the stable and good performer with either specific or general photothermal adaptation under adverse environments.

Introduction

Yield of a crop plant is highly influenced by the environment and thus any successful variety should perform well in a wide range of environments. The selection of superior genotypes by altering their productivity makes it difficult to judge the genetic potential of any cultivar/strain (Eagles & Frey, 1977). In the presence of any variation, estimates of stability parameters are used to determine the superiority of that genotype across the range of environments. The present study was undertaken to evaluate the primary yield traits in 21 wheat breeding lines and thereafter to find out the superior genotypes.

Materials and Methods

Twenty one F_6 Near Isogeneic Lines (NILs) of wheat (Table 1) raised and evaluated at six seeding dates (S_1 = 10th Nov.'93, S_2 = 30th Nov.'93, S_3 = 20th Dec.'93, S_4 = 15th Nov.'94, S_5 = 5th Dec.'94 and S_6 = 25th Dec.'94) were used as research materials. The seeding dates were considered as different environments and the breeding lines as genotypes. The experiment was conducted in Randomized Complete Block design with 3 replications for each trial in the experimental field of Rajshahi University during 1993-94 and 1994-95 growing seasons. Uniform and standard cultural practices were followed in all the trials to raise the good crop. Data on primary yield traits were recorded from 10 randomly selected plants of each replication

Table 1. Designation, quality and parentage of 21 wheat genotypes (NILs)

No.	Designation	Quality	Parentage
1.	AgFM32903-1-6-3-5	Normal	Ag x FM32851-4-8-4-2
2.	AkFM32906-2-1-6-4	,,	Ak x FM32857-2-6-1-3
3.	AnFM32907-1-3-2-9	,,	An x FM32858-4-1-6-2
4.	KnFM32908-2-4-5-3	,,	Kn x FM32859-1-4-3-5
5.	AkFM139904-3-5-7-1	,,	Ak x FM139863-3-5-4-2
6.	AnFM139902-4-2-4-6	,,	An x FM139864-5-2-7-1
7.	KnFM139905-3-7-1-2	,,	Kn x FM139865-6-7-2-4
8.	AgFM32903-1-6-3-7	Dwarf-III	Ag x FM32851-4-8-4-2
9.	AkFM32906-2-1-6-6	,,	Ak x FM32857-2-6-1-3
10.	AnFM32907-1-3-2-8	,,	An x FM32858-4-1-6-2
11.	KnFM32908-2-4-5-5	,,	Kn x FM32859-1-4-3-5
12.	AkFM139904-3-5-7-3	,,	Ak x FM139863-3-5-4-2
13.	AnFM139902-4-2-4-4	,,	An x FM139864-5-2-7-1
14.	KnFM139905-3-7-1-1	,,	Kn x FM139865-6-7-2-4
15.	AgFM32903-1-6-3-3	Dwarf-II	Ag x FM32851-4-8-4-2
16.	AkFM32906-2-1-6-2	,,	Ak x FM32857-2-6-1-3
17.	AnFM32907-1-3-2-7	,,	An x FM32858-4-1-6-2
18.	KnFM32908-2-4-5-8	,,	Kn x FM32859-1-4-3-5
19.	AkFM139904-3-5-7-5	,,	Ak x FM139863-3-5-4-2
20.	AnFM139902-4-2-4-9	,,	An x FM139864-5-2-7-1
21.	KnFM139905-3-7-1-4	,,	Kn x FM139865-6-7-2-4

of every seeding. Combined one factorial analysis of variance was followed to estimate the magnitude of GE interactions and stability parameters i.e., the regression coefficient (b_i) and deviation from regression (S^2_{di}) were calculated following the model of Eberhart & Russell (1966).

Results and Discussion

Combined analysis of variance for primary yield traits of 21 genotypes at 6 seeding dates (environments) showed considerable variation among the genotypes and environments (Table 2). The genotype-environment (GE) interaction was found to be significant in all the cases and suggested for estimating the stability parameters. The significant E + (GxE) indicated the differential reaction of genotypes upon the environments. Both the significant linear and non-linear (pooled deviation) components of GE interaction in most of the cases indicated that the genotypes differed significantly with respect to their response (b_i) and stability (S^2_{di}). The highly significant GE interaction alongwith their significant linear component in all the cases except grains per ear and grain yield per plant predicted the feasibility of the genotypes under different environments. However, the prediction of the genotypes in the changes of environments appeared to be difficult for grains per ear and grain yield per plant due to

Table 2. Mean squares from the pooled ANOVA for morphological yield contributing traits in 21 wheat genotypes.

Source of variation	Degrees of freedom	Mean sum of squares FT	SE	GE	GW	GY
Total	377	6.564	3.207	67.062	0.212	1.560
Environment (E)	5	9.964	57.421	1877.919	7.033	34.531
Genotype (G)	20	106.864**	31.510**	549.730**	1.157**	13.173**
GxE	100	2.503**	2.356**	41.984**	0.156**	1.140**
E+(GxE)	105	2.858	4.978**	129.410**	0.483**	2.730*
E (linear)	1	15.725**	93.874**	3094.500**	11.718**	57.971**
GxE (linear)	20	2.018**	1.910**	22.283	0.106*	0.464
Pooled deviation	84	0.525**	0.430**	12.210**	0.031	0.345**
Genotype	4	0.136	0.229	6.094	0.045	0.101
2	4	0.256	0.180	15.015	0.022	0.054
3	4	0.178	0.072	9.942	0.002	0.101
4	4	0.497	0.148	1.534	0.025	0.172
5	4	0.167	0.848	0.758	0.005	0.101
6	4	0.123	1.026	52.458**	0.003	0.842**
7	4	0.125	0.012	3.963	0.003	0.065
8	4	0.021	0.283	2.289	0.009	0.029
9	4	0.155	0.302	14.951	0.013	0.145
10	4	0.939*	0.328	3.319	0.015	0.113
11	4	1.577*	0.185	10.297	0.004	0.145
12	4	0.364	0.454	4.816	0.284*	0.441*
13	4	0.110	0.302	14.385	0.000	0.136
14	4	1.610*	0.043	6.373	0.016	0.327
15	4	0.053	1.646*	31.958*	0.138*	0.495*
16	4	2.235**	0.743	11.764	0.001	1.086**
17	4	0.150	0.355	29.860**	0.004	0.599**
18	4	0.444	0.742	4.257	0.012	0.763**
19	4	1.558*	0.102	13.724	0.011	0.551**
20	4	0.170	0.229	17.360*	0.013	0.963**
21	4	0.162	0.804	1.300	0.028	0.121

* and ** = Significant at 0.05 and 0.01 probability level, respectively.

their nonsignificant linear component of GE interaction. The genotype numbers 10, 11, 14, 16 and 19 for fertile tillers (FT); 15 for spikelets per ear (SE), 6, 15 17 and 20 for grains per ear (GE); 12 and 15 for 100-grains weight (GW) and 6, 12 and 15-20 for grain yield (GY) showed their non-linear relationship with the environments as their mean square deviation appeared to be significant.

Stability parameters (b_i and S^2_{di}) and the mean performance of morphological yield traits over all environments for 21 NILs are presented in Table 3. The genotype 20 for FT, 19 for SE, 8 for GE, 5 for GW and 9 for GY showed the highest mean performance over all environments and performed well in most of the specific environments. Differential performing ability under different environments was found to appear among the genotypes.

The significant regression coefficient (b_i) appeared in eighth, twelfth, fourteenth, seventeenth and fifteenth genotypes for FT, SE, GE, GW and GY, respectively indicated their linear sensitivity. Mean square deviation (S^2_{di}) was found to be significant singly in four, four, one and two genotypes for FT, GE, GW and GY indicating their linear sensitivity, respectively. Both the linear and non-linear components were responsible for GE interaction in case of the genotype 11 for FT, 15 for SE, and 12 for GW, as they showed combined b_i and S^2_{di} sensitivity. Many genotypes showed nonsignificant b_i and S^2_{di} combinedly and it indicated the non-existence of genotype-environment interaction in those cases.

The genotypes 10-12 and 16 for SE; 1-3 and 8-12 for GE; 3, 10 and 11 for GW and the 8-14 for GY; and none for FT had near unity b_i values with nonsignificant deviations and their mean performances were higher than the over all mean. These genotypes might be considered as most stable with the change of environments. The genotypes 6, 13 and 17 for SE; 7 and 18 for GE; 2, 4, 7, 8 and 17 -21 for GW and 1, 3, 7 and 18 for GY had also the near unity b_i values with nonsignificant S^2_{di}. Their mean performance were lower than the grand mean, which indicated that they are stable but unacceptable. Due to significant lower regression coefficients with nonsignificant mean square deviations and higher mean performances the genotype 19 for SE, 21 for GE, 5, 6, 13 and 14 for GW might be considered suitable for unfavorable environments. The genotypes 10, 11, 14, 16 and 19 for FT; 15 for SE; 6, 15, 17 and 20 for GE; 12 and 15 for GW; and 16 and 20 for GY were proved to be unstable as their mean square deviations were significant.

The present results indicated that genetic effect was effective like the environment in all cases. Thus, it suggested that both the genotype and environmental components were of major significance, and considerable emphasis should be given on both in case of the evaluation of breeding materials. The results of pooled analysis indicated that both the linear and non-linear components of GE interaction were operative in most of the cases. However, non-linear component was found to be greater significantly than their linear component in case of GE and GY. It indicated that these three characters of the genotypes had less environmental influence. The linear and non-linear relationship with environments have been reported by Finlay & Wilkinson (1963), Eberhart & Russell (1966), Jatasra & Paroda (1979, 1981), Mahajan & Khehra (1992) and Manget (1992) etc.

Table 3. Stability parameters for morphological yield contributing traits in 21 wheat genotypes.

Genotype	FT Mean (X)	FT Response (bi)	FT Stability (S^2di)	SE Mean (X)	SE Response (bi)	SE Stability (S^2di)	GE Mean (X)	GE Response (bi)	GE Stability (S^2di)	GW Mean (X)	GW Response (bi)	GW Stability (S^2di)	GY Mean (X)	GY Response (bi)	GY Stability (S^2di)
1	4.59	1.363*	0.087	21.71	0.533	0.155	54.599	1.319**	5.400	2.28	0.688	0.039	3.30	1.180**	0.051
2	4.83	1.830*	0.207	21.91	0.715*	0.106	53.13	1.522**	14.321	2.43	1.120*	0.016	3.78	0.601*	0.004
3	4.45	2.317*	0.129	21.84	0.57	-0.002	50.56	0.941*	9.248	2.72	1.242**	-0.016	4.02	1.457**	0.051
4	4.44	1.350	0.448	19.41	0.754*	0.074	39.46	0.616**	0.839	2.54	0.892*	0.019	3.43	0.595*	0.122
5	5.43	2.578**	0.118	23.55	-0.018	0.774	46.41	1.622**	0.064	3.19	0.523*	-0.001	4.28	1.797**	0.051
6	4.82	1.676*	0.074	21.73	1.078	0.952	47.88	0.590	51.763**	2.93	0.565**	-0.016	3.70	1.546**	0.792
7	4.51	2.081**	0.076	21.12	-0.004	-0.063	36.46	1.360**	3.268	2.44	0.933**	-0.015	3.44	1.167**	0.015
8	6.58	1.366*	0.034	22.70	0.616	0.209	57.31	1.067**	1.594	2.25	0.869**	-0.009	4.67	0.956**	-0.021
9	6.54	-0.137	0.106	22.82	0.425	0.228	54.00	1.672**	14.257	2.49	0.801	0.007	6.05	1.385**	0.094
10	7.93	1.753	0.894*	22.81	0.985*	0.254	52.49	1.013**	2.625	2.58	1.250**	-0.003	5.45	1.259**	0.063
11	8.97	4.056*	1.528*	22.76	1.353**	0.111	54.31	1.272**	9.603	2.73	0.828**	-0.014	5.86	1.331**	0.094
12	7.77	1.600	90.315	24.86	1.873**	0.379	54.64	0.943**	4.122	2.75	2.415*	0.278*	5.82	1.326**	0.390
13	7.23	1.670*	0.060	22.28	1.377*	0.227	47.13	0.598	13.691	3.00	0.587**	-0.018	5.70	1.105**	0.086
14	8.94	2.707	1.561*	20.63	0.439*	-0.031	44.31	0.606*	5.678	2.55	0.738*	-0.002	4.93	1.042*	0.277
15	6.97	-0.423	0.004	23.12	2.125*	1.572*	54.14	1.018	31.264*	2.31	0.641	0.132*	4.67	0.360	0.445
16	9.25	-3.567	2.186**	23.62	0.945	0.669	56.33	0.591	11.070	2.31	0.568*	-0.017	5.06	0.182	1.036*
17	8.54	-0.294	0.101	22.53	1.017*	0.280	47.23	0.579	29.166*	2.55	1.181**	-0.014	4.73	0.623	0.549
18	5.62	-0.247	0.395	23.49	2.165*	0.668	49.42	1.460**	3.563	2.32	1.200**	0.006	4.42	0.955	0.713
19	11.14	0.133	1.509*	25.41	0.613*	0.028	51.06	0.798	13.030	2.45	1.410**	-0.007	3.84	0.684	0.501
20	11.95	-0.623	0.121	22.27	1.807**	0.155	47.21	0.783	16.666*	2.48	1.474**	-0.005	4.56	0.665	0.913*
21	11.58	-0.385	0.113	22.78	1.976**	0.730	55.85	0.626**	0.606	2.33	1.293**	0.022	4.03	0.726*	0.071

* and ** = bi and S^2di are significant different from 1.0 and 0.0 respectively at 0.05 and 0.01 probability level, respectively.

Finlay & Wilkinson (1963) considered the linear regression (b) as a measure of stability. But Eberhart & Russell (1966) pointed out that the criteria for stability should be a regression coefficient (b_i) and deviation from regression (S^2_{di}) to judge the stability of a genotype. Breese (1969), Reich & Atkins (1970), Paroda & Hayes (1971), Stroike & Johnson (1972) and Langer *et al.*, (1979) observed that the linear regression could simply be regarded as response of a particular genotype. Average response is indicated by regression coefficient of unity ($b_i = 1$). A genotype with $b_i > 1$ and $b_i < 1$ would indicate above average and below average response to the changing environments, respectively. The genotype with low (near to zero) deviation mean square (S^2_{di}) and with near unity (1.00) b_i would be the most stable one. Apparently a genotype that failed to meet these qualifications would be classed as unstable to the changing environments. Hence, a desired genotype should be with high performance, a near unity regression coefficient ($b_i = 1$) and nonsignificant (low) deviation from regression (S^2_{di}) irrespective of sign.

In this respect, the genotypes 10-12 and 16 for SE; 1-3 and 8-12 for GE and 3, 10 and 11 for GY had near unity b_i values with nonsignificant deviations and higher mean performance than the over all means. Thus, these genotypes might be considered most stable with the change of environments and could be used preferably for the future breeding programme. These results are consistent with the findings of Paroda & Hayes (1971).

Many different combinations of stability parameters are possible and each requires somewhat different interpretations. Stroike & Johnson (1972) considered that a genotype having low mean performance, high b_i value and low S^2_{di} value could be described as particularly well suited to unfavourable environments in relation to other genotypes. In this investigation, such stability parameters were found in case of the genotypes 6, 13 and 17 for SE, the 7 and 18 for GE; 2, 4, 7, 8 and 17-21 for GW and 1, 3, 7 and 18 for GY. These genotypes might be stable and suitable for unfavourable environments and the results agreed well with the findings of Stroike & Johnson (1972).

In the present study, certain genotypes showed the combined linear and non-linear sensivity for some characters. This fact indicated that the non-linear component of GE interaction of a genotype was independent of its linear response. Accordingly, stability parameters appeared to be governed by different genes or gene combinations. Thus, the present findings were very much consistent with the concluding remarks of Jatasra & Paroda (1979). Moreover, some genotypes of this study were found to be unstable due to their deviations from regression significantly different from zero. It is consistent with the findings obtained by Chabi & Sapra (1980) in certain Triticale genotypes.

Mahajan & Khehra (1992) evaluated 28 single cross hybrids of maize over 8 environments for grain yield and its component characters. They observed stable ear length and grain yield but unstable kernel weight. The deviation (S^2_{di}) appeared to be more important than the regression (b_i) for measuring their stability. This is contrasting with the present findings. After evaluating 47 rice genotypes under four low land environments De *et al.*, (1992) reported that the linear component was predominant for fertile tillers per hill and non-linear component for grain yield, while both were equally important for panicle length and weight. This is somewhat consistent with the present findings.

The stability parameters as studied in this investigation, for the primary yield traits four genotypes (3, 10, 11 and 12) were found to be stable and suitable for any environments. Because of their high average performance, they responded well to the changing environments and predictable to specified environment(s). Such comparative evaluation would greatly simplify the task of breeder in developing either specific or generally adopted genotypes. As GE interaction is mainly under genetic control, breeders would be able to select suitable genotypes in advanced generations by growing them under different environmental conditions. The present study also revealed that the yield potency can be increased by increasing the performance of the yield components in appropriate environment, since these characters are associated with the yield.

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