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STABILITY PARAMETERS FOR TILLERS, GRAIN WEIGHT AND YIELD OF WHEAT CULTIVARS IN NORTH-WEST OF PAKISTAN

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Abstract

Thirteen spring wheat cultivars were evaluated for 2-years at 5 diverse locations of NWFP for stability analysis of tillers per m^2, 1000-grain weight and grain yield. Combined analysis of variance revealed significant differences among locations, years and location×year interactions for these wheat traits. Cultivar×year interaction was highly significant (p=0.01) for 1000-grain weight and grain yield, while cultivar×location interaction was highly significant only for productive tillers per m^2. However, cultivar×location×year interaction existed for all traits (p=0.01). Maximum number of productive tillers of 410 per m^2 were produced by wheat cultivar Dirk followed by Fakhre Sarhad (396 tillers per m^2) and Nowshera-96 (395 tillers per m^2). Cultivars Dirk and Nowshera-96 excelled in 1000-grain weight (43 g). Maximum grain yield of 4259 kg ha^{-1} was produced by cultivar Nowshera-96 followed by Fakhre Sarhad (4183 kg ha^{-1}). Wide range of stability statistics was observed among cultivars for all the three parameters. Though none of the wheat cultivar had b- value equal to unity for tillers m^{-2}, 1000-grain weight or grain yield, but Pirsabak-85, Bakhtawar-92, Nowshera-96 and Fakhre Sarhad were the stable cultivars on the basis of overall mean yields and stability parameters viz., regression coefficients and minimum deviations from regression.

Introduction

The North West Frontier Province (NWFP) of Pakistan has a diversified blend of climatic conditions with distinct agro-ecological zones. Temperature and rainfall patterns vary greatly from year to year as well as from one location to another location. Soil type and fertility level also vary throughout the province. The cultivars developed and adapted in a particular agro-ecological zone usually remain sufficiently stable for the expression of morpho-physiological characters but occasionally behave differently when exposed to other zones with different growing conditions. The degree of variability in the cultivars varies in different areas and poses practical limitations in assessing their effective adaptation (Ali *et al.*, 2008; Baril, 1992). A likely solution to the problem lies in searching the possibility of finding out genotypic characters not easily influenced by the environmental factors. Such characters, if made available to the wheat breeders will help to develop cultivars with stable performance over a wide range of environments (Ehdaie *et al*., 1988). But, exploration and identification of characters showing stable performance and minimum interaction with environments is not possible without extensive testing over several locations (Majid *et al*., 2007).

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In recent years, cultivar development efforts of wheat breeders have been very prolific. Consequently, a substantial number of wheat varieties have been selected and released by the plant breeders (Tajamul, 1997). For determining the magnitude of environmental effects on the performance of characters, several procedures have been developed (Koemel *et al*., 2004; Fehr, 1987; Luthra *et al*., 1974). Two of the most frequently used techniques for cultivar stability estimation are by Finlay & Wilkinson (1963) and Eberhart & Russel (1966). A cultivar is considered stable if it has a unit regression over the environments (b=1) and minimum deviation from regression ($S^2_d = 0$). Therefore, a cultivar with high mean yield over the environment, unit regression coefficient (b = 1) and deviation from regression as small as possible ($S^2d_i = 0$) will be a better choice as a stable cultivar. The estimate of cultivar-environment components vary considerably not only from character to character in the same cultivar but also from cultivar to cultivar at the same location (Patil *et al*., 1992; Tajamul, 1997). But the extent to how far a specific cultivar will show variation under different environments is a matter of systematic research. Therefore, this research was undertaken to know stability performance of 13 landmark wheat cultivars for tillers production, 1000-grain weight and grain yield across major wheat production regions of NWFP.

Materials and Methods

Thirteen landmark wheat cultivars viz., Dirk, Khushal-69, Tarnab-73, Pak-81, Sarhad-82, Barani-83, Pirsabak-85, Khyber-87, Inqilab-91, Bakhtawar-92, Nowshera-96, Fakhre Sarhad and Saleem-2000 were evaluated for two years 2004-2005 and 2005-2006 at 5 divergent agro-ecological zones (DI Khan, Bannu, Peshawar, Nowshera and Mingora) of NWFP. These cultivars, released during the past 40-years, have been the most popular among wheat growers throughout the province and have contributed significantly to wheat yield increase of the province. A randomized complete block design with three replications was used at each location. Each plot had 5 meter long 4 rows, spaced 0.30 meters apart. A seed rate of 100 kg ha^{-1} and fertilizer @ 90 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5 was used. Data recorded on productive tillers m^{-2}, 1000-grain weight and grain yield per hectare were analyzed using the GLM procedure in statistical analysis system (Anon., 2000). Since, error variances were homogeneous among the five test locations, combined analysis of variances were conducted according to Steel & Torrie (1980). Stability analysis of 13 wheat cultivars for all traits was also done using the model proposed by Eberhart & Russel (1966).

Results and Discussion

Combined analysis of variance across the 2-years and 5-locations revealed highly significant genetic variation among wheat cultivars (p=0.01) for tillers per m^2, 1000-grain weight and grain yield per hectare (Table 1). Main effects of locations, years and the resultant location×year interaction were also highly significant for the three traits. Similar trend of significance was also observed for the cultivar×location×year interaction for all the traits which reveal great variation in the performance of cultivars over combination of locations and years though cultivar×year interactions were significant for 1000-grain weight and grain yield but not for productive tillers per m^2. In contrast cultivar×location interaction was highly significant (p=0.01) for productive tillers per m^2 and non significant for 1000-grain weight and grain yield (Table 1). Similar response of wheat cultivars across location and years combination have been reported by Majid *et al*., (2007).

Table 1. Mean squares for productive tillers m^{-2}, 1000-grain weight and grain yield of 13 wheat cultivars evaluated for 2-years at 5-locations in NWFP.

Source	df	Productive tiller m^{-2}	1000-grain weight	Grain yield
Year (Y)	1	177613.6**	2812.9**	60926919.6**
Location (L)	4	589392.6**	356.0**	43576896.0**
Y x L	4	108910.8**	860.9**	34982009.3**
Reps w/n Y x L	20	12706.8	49.5	547632.6
Cultivars (C)	12	42493.5**	86.7**	5550256.9**
C x Y	12	5166.6^{NS}	41.8**	1280668.4**
C x L	48	12816.4**	33.5^{NS}	711991.8^{NS}
C x L x Y	48	6067.3**	29.7**	560764.5**
Error	240	3121.0	9.6	225810.8

*, ** = Significant at 5 and 1% probability level, respectively.
NS = Not-significant.

Table 2. Means and stability statistics for productive tillers m^{-2}, 1000-grain weight and grain yield of 13 wheat cultivars evaluated for 2-years at five locations in NWFP.

Cultivars	Productive tillers m^{-2} (no.)			1000-grain weight (g)			Grain yield (kg ha^{-1})		
	Mean	b	S^2d	Mean	b	S^2d	Mean	b	S^2d
Dirk	410	1.41	23117.6	43	1.24	38.1	2640	0.67	603066.8
Kushal-69	309	0.65	3476.9	41	0.76	16.2	3332	1.37	2245788.2
Tarnab-73	377	1.20	9608.6	41	1.30	44.5	3801	1.10	1565990.3
Pak-81	312	0.68	5231.4	41	0.96	22.5	3659	1.15	1717044.8
Sarhad-82	349	1.06	6965.2	40	0.76	14.3	3869	0.84	1165263.4
Barani-83	306	0.62	4787.5	39	1.16	34.7	3197	1.04	1360582.6
Pirsabak-85	344	0.97	7649.6	39	0.93	25.4	3535	1.03	1597631.6
Khyber-87	366	1.16	10454.2	41	0.78	16.9	3841	1.04	1388479.3
Inqilab-91	335	1.27	10735.4	40	0.97	32.8	3544	0.85	1243390.8
Bakhtawar-92	367	1.16	9637.0	37	1.13	32.3	3973	0.97	1227796.8
Nowshera-96	395	1.41	12763.5	43	1.06	31.2	4259	1.02	1423207.3
Fakhre Sarhad	396	1.05	7542.4	41	0.88	27.3	4183	0.89	1345797.6
Saleem-2000	358	0.62	8127.4	40	0.74	110.4	3977	0.88	1038592.9
Mean	**351**	**0.99**	**8081.5**	**40**	**0.95**	**34.0**	**3764**	**1.02**	**1443297.1**

Means of productive tillers per m^2, 1000-grain weight and grain yield of wheat cultivars averaged across two years and five locations along with stability statistics are given in Table 2. The number of productive tillers varied from 306 m^{-2} for cultivar Barani-83 to 410 m^{-2} for cultivar Dirk. Similar genetic variation in tillers production has been also reported by Ali *et al*., (2008). The regression coefficient (b) values for tillers per m^2 ranged from 0.62 for Barani-83 to 1.41 each for cultivar Nowshera-96 and Dirk and no cultivar had b-value equal to unity (Table 2). Cultivars Dirk, Tarnab-73, Sarhad-82, Khyber-87, Inqilab-91, Bakhtawar-92, Nowshera-96, Fakhre Sarhad and Saleem-2000 had regression coefficients above 1.0 while Khushal-69, Pak-81, Barani-83 and Pirsabak-85 expressed b-values below 1.0 for tillers m^{-2}. The minimum deviation from regression (S^2d) of 3476.9 for tillers per m^2 was exhibited by wheat cultivar Kushal-69, which was released about 40-years ago for cultivation in NWFP. In contrast, cultivar Dirk exhibited the maximum deviation from regression for productive tillers per m^2 (23117.6).

1000-grain weight, a very important yield component in wheat, varied from 37g for Bakhtawar-92 to 43g each for cultivar Dirk and Nowshera-96 (Table 2). As reported by Ali *et al*., (2008), this larger variation in grain weight may be due to diverse genetic make-up of wheat cultivars and their differential response to prevalent environment during grain filling stage. The b values for 1000-grain weight ranged from 0.76 for

cultivar Khushal-69 to 1.30 for cultivar Tarnab-73. Like tillers per m^2, there was mixed trend among cultivars of b-values for 1000-grain weight. Cultivars Dirk, Tarnab-73, Barani-83, Bakhtawar-92 and Nowshera-96 expressed regression coefficients above unity (1.0) whereas, Khushal-69, Pak-81, Sarhad-82, Pirsabak-85, Khyber-87, Inqilab-91, Fakhre Sarhad and Saleem-2000 had regression coefficient below unity (1.0). Similarly, no cultivar showed b value equal to unity for 1000-grain weight also (Table 2). The other stability parameter viz., deviation from regression coefficients (S^2d_i) for cultivars ranged from 14.3 to 110.4. Cultivar Sarhad-82, released by the Cereal Crops Research Institute, Pirsabak (Nowshera) in 1982, had minimum deviation from regression (S^2d = 110.4). In contrast, the recently released wheat cultivar Saleem-2000 had maximum deviation from regression (S^2d = 110.4) for 1000-grain weight.

The grain yield per hectare of wheat cultivars ranged from 2640 to 4259 kg ha^{-1} (Table 2). Minimum grain yield of 2640 kg ha^{-1} was produced by a very old wheat cultivar Dirk. In contrast, maximum grain yield of 4259 kg ha^{-1} was produced by cultivar Nowshera-96 (released by CCRI, Pirsabak in 1996) followed by Fakhre Sarhad (4183 kg ha^{-1}) which was released by the Nuclear Institute for Food and Agriculture (NIFA), Peshawar. Averaged across years, locations and cultivars, the overall mean grain yield was 3762 kg ha^{-1}, which is about 1000 kg ha^{-1} more than the national average wheat grain yield. The regression coefficient or b-values for grain yield of cultivars ranged from 0.67 to 1.37 (Table 2). The lowest b-value for grain yield was observed for cultivar Dirk (b=0.67) and the highest value of 1.37 for Khushal-69. The b-values for grain yield of cultivars Dirk, Sarhad-82, Inqilab-91, Bakhtawar-92, Fakhre Sarhad and Saleem-2000 were below unity (1.0), whereas Khushal-69, Tarnab-73, Pak-81, Barani-83, Pirsabak-85, Khyber-87 and Nowshera-96 had regression coefficients (b-values) above unity. None of the wheat cultivars expressed regression coefficient equal to unity (b=1.0). Rane *et al*., (2007) have also observed a mixed trend in yield performance and stability parameters for advanced wheat genotypes under different environments. Similarly, Majid *et al*., (2007) have also reported a similar trend in wheat cultivars for stability parameters evaluated over numerous locations in Pakistan. The wheat cultivars also exhibited a wide range of values for deviation from regression (S^2d_i) for grain yield. The minimum value of deviation from regression (S^2d = 603066.8) for grain yield was exhibited by cultivar Dirk, while the highest value of deviation from regression (S^2d = 2245788.2) was observed for Kushal-69. Similar range of stability parameters has also been reported for a set of barley cultivars evaluated at several locations (Dehghani *et al*., 2006) and for grain sorghum open pollinated and hybrid cultivars (Saeed *et al*., 1987).

The variation in b values (Table 2) reflected a wide range of stability among the cultivar for all parameters. In previous research, variable stability for productive tillers m^{-2} and yield components has been reported by Ali *et al*., (2007), Bhuller *et al*., (1981), Kumari *et al*., (1989), Kinyua & Ayiecho (1992). Likewise, Rane *et al*., (2007) and Mandal & Das (1989) have also observed similar trend of performance among wheat genotypes and variable stability for 1000-grain weight and grain yield. According to Faris *et al*., (1981), cultivars having small b values for productive tillers m^2 are less sensitive to better environments (e.g., Barani-83), while cultivars with large regression coefficients (e.g., Nowshera-96) indicate significant decrease in production of tillers per m^2 as environment productivity declines. According to Finlay & Wilkinson (1963) stability model, cultivars Dirk, Tarnab-73, Sarhad-82, Khyber-87, Inqilab-91, Bakhtawar-92, Nowshera-96, Fakhre Sarhad and Saleem-2000 with regression coefficient above unity are adaptable to favorable environments, while khushal-69, Pak-81, Barani-83 and Pirsabak-85 having regression coefficient below unity are adaptable to unfavorable environments. None of the cultivars evaluated was perfectly stable for all traits in all environments due to lack of b value equal

to unity (Eberhart & Russell, 1966; Finlay & Wilkinson, 1963). However, Pirsabak-85 shows comparatively minimum value for S_d^2 and a b-value close to unity and hence, it may be considered stable for this character in low yielding environments. The above stability parameters also favor Fakhre Sarhad for its stability in high yielding environments. Thus, Pirsabak-85, Bakhtawar-92, Nowshera-96 and Fakhre Sarhad are the more stable and adaptable wheat cultivars both to favorable and unfavorable production environments of NWFP.

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