Pak. J. Bot., 39(1): 67-71, 2007.

WIDE AND SPECIFIC ADAPTATION OF BREAD WHEAT INBRED LINES FOR YIELD UNDER RAINFED CONDITIONS

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Abstract

Ten elite wheat inbred lines / cultivars were tested for grain yield stability at five different locations under the rainfed conditions in the North West Frontier Province of Pakistan. These inbred lines were exposed to different soil types, soil fertility, moisture levels and temperatures. GxE interaction mean squares were highly significant for grain yield. The overall mean grain yield performance of genotypes across environments ranged from 2.88 to 3.89 t/ha. The stability parameters indicated regression coefficient (bi) value ranging from 0.87 in NRL-9293 to 1.20 in NRL-0306. Cultivar "Tatara" showed the ideal stable performance with regards to mean grain yield of 3.32 t/ha, regression coefficient value of 1.03 and dispersion value (S^2_d) of 0.03. Based on bi and S^2_d values, NRL-0306 was found suitable for favorable environments whereas NRL-9293 can perform well under unfavorable environments.

Introduction

Drought stress is a major limitation to bread wheat (*Triticum aestivum* L.) productivity and its yield stability in arid and semi-arid regions of world including parts of Pakistan. It has been estimated that about one-third of the world's potentially viable land suffers from an inadequate supply of water, and on most of the remaining areas, crop yields are periodically reduced by drought (Kramer, 1980). The rainfed crop production thus depends strongly on both the amount and distribution of rain. Currently, breeding for sustained yields under drought stress is totally dependent on the use of yield as selection indices.

In Pakistan, wheat is the leading food grain and about 20% of the total wheat acreage is planted under rainfed conditions. Wheat production in the country, however, has been well below potential and variable. In the North West Frontier Province of Pakistan the amount of rainfall is low and generally poorly distributed, so periods of water deficit occur during different physiological growth stages of the crop almost every year. As a result, crop yield and water use efficiency (WUE) are generally low and variable. The production of 1 kg of wheat (*Triticum aestivum* L.) grain under fully irrigated conditions requires about 1-2 m^3 of irrigation water (Perrier & Salkini, 1991); in rainfed areas it requires from 1-3 m^3 of rainfed area (Cooper *et al.*, 1987; Perrier & Salkini, 1991). Therefore, selecting wheat inbred lines with improved WUE is vital for meeting the increasing food demand. As drought and high temperature being few of the major reasons for low productivity and instability in Pakistan, therefore, development of cultivars possessing tolerance in this regard is an objective of breeding program. Selection for stress tolerance in breeding program has been impeded by lack of appropriate strategies and screening techniques (Gozlan & Mayer, 1981) and lack of genotypes that show clear differences in response at specific growth stages to well defined environmental stresses (Hanson & Nelsen, 1980). Development or evaluation of stress tolerance screening techniques can be done only if the stress tolerance of a reference set of genotypes is known or can be determined (Nass & Sterling, 1981). Because total drought resistance of a plant genotype cannot yet be defined physiologically (Gozlan & Mayer, 1981) and simple tests of tissue for stress tolerance have not been developed adequately (Fischer & Maurer, 1978), grain yield and yield stability under environmental stress remain major selection for stress tolerance in many breeding programs.

Varietal differences in drought resistance have been reported in wheat (Schonfeld *et al*., 1988 and Steven *et al*., 1990). Interpretation of genotype x environment interactions can assist the breeder in identifying inbred lines with stable yield performance over a range of environments. Introduction of such inbred lines into the local farming system can boost and stabilize wheat production in the country in general and particularly in the North West Frontier Province of Pakistan.

The objectives of the present study were (i) to characterize stress tolerance and adaptation to stress environments in a set of wheat lines using yield responses, (ii) to identify genotypes showing distinct differences in response to environmental stress.

Methods and Materials

Ten genetically diverse bread wheat inbred lines were evaluated for grain yield at five different locations i.e., Peshawar, Kohat, Bannu, D.I. Khan and Mansehra in the North West Frontier Province during 2003-04. These locations differed for soil type, precipitation and temperature. The soil at Peshawar, Kohat and Bannu is clay loam; where as at D.I. Khan and Mansehra is sandy to sandy loam, respectively. Randomized complete-block design with four replications at each location was used. Plots consisted of six rows, each 5m long, spaced 30 cm apart and were seeded with a small plot drill. Sowing was carried out in the first week of November at each location. Nitrogen and phosphorous were incorporated during seed bed preparation @ 120 and 90 kg ha^{-1}. No irrigation was applied during the growing season. At maturity, four central rows (plot size 6 m^2) were harvested to determine grain yield as a direct selection criterion for drought tolerance. Parentage of the studied inbred lines is given in Table 1. Eberhart & Russell model (1966) was used for stability analysis.

Results and Discussion

The grain yield (t/ha) data of wheat lines at different locations is shown in Table 2. Highest mean grain yield was obtained at Kohat (4.07 t/ha) followed by Mansehra (3.91t/ha) and the lowest at DI Khan (2.13 t/ha). The difference in grain yield is due to favorable and unfavorable environmental conditions. Bannu and DI Khan locations are considered as high stress environments, whereas, Peshawar (NIFA), Kohat and Mansehra as low stress environments. However, due to uniform and timely rain fall during the entire growing season through the country, grain yield was not that much affected as for our previous experiments. The inbred line NRL-2017 gave the highest grain yield (4.74t/ha and 4.67 t/ha) at Kohat and Mansehra, respectively, whereas NRL-0306 produced the lowest grain yield (1.64 t/ha) at DI Khan.

The yield-based index over the two severely stress environments (locations Bannu & DI Khan) indicated that NRL-0306, NRL-0337 and NRL-9293 were relatively stress susceptible, while Tatara, NRL-2017, NRL-0227 and NRL-0228 were found stress tolerant. Over all, NRL-2017 yielded the highest (3.89 t/ha) followed by Tatara (3.32t/ha) and NRL-0201 (3.14 t/ha) respectively (Table 2).

Table 1. Code and Parentage of wheat inbred lines.

Inbred lines	Parentage
NRL-2017	AMSEL/TUI
NRL-0116	FOW-2//NS732/HER
NRL-0201	URES / JUN // KAUS
NRL-0211	PFAU/VEE#91/URES/3/PSN/BOW//ERI/4/BUC/CHRC//PRL/VEE#6
NRL-0227	MLT/TUI/TUI
NRL-0228	MLT/TUI/TUI
NRL-0306	ALTAR 84 / AE.SQUAROSA 219//SERI
NRL-0337	PASTOR / 3 / VEE # 5 // 3 / PRINIA
NRL-9293	ATTILA
Tatara	JUP/ALD “S”//KLT “S” /3/VEE “S”

Table 2. Grain yield (t / ha) of wheat inbred lines at different locations during 2003-04.

Inbred lines	NIFA	Kohat	Bannu	DI Khan	Mansehra	Mean
NRL-2017	4.13	4.74	3.88	2.06	4.67	3.89
NRL-0116	3.33	3.81	2.11	2.04	3.83	3.02
NRL-0201	3.37	4.58	2.05	2.21	3.50	3.14
NRL-0211	3.06	3.76	1.98	2.29	4.17	3.05
NRL-0227	3.13	3.81	2.10	2.19	4.08	3.06
NRL-0228	3.58	3.69	2.02	2.25	4.00	3.11
NRL-0306	3.42	4.36	2.19	1.64	3.67	3.06
NRL-0337	3.25	3.90	1.86	2.22	3.58	2.96
NRL-9293	3.04	3.60	2.08	2.02	3.67	2.88
Tatara	3.46	4.50	2.38	2.34	3.92	3.32
LSD 5 %	0.399	0.558	0.488	0.818	0.977	
Mean	3.38	4.07	2.26	2.13	3.91	

LSD: Least significant difference.

It was observed that differences among genotypes were highly significant at NIFA, Kohat and Bannu while non-significant at DI Khan and Mansehra (Table 3). The analysis of variance showed that genotypes (G), environments (E), and the 'G x E' interactions were highly significant for grain yield (Table 4).

Genotype X environment interactions were evaluated further using regression analysis. According to Eberhart & Russel (1966) model a genotype is considered stable over different environments if it has higher performance, unit slope and deviation from regression (S^2_d) near to zero. The same was true in our results for Tatara, NRL-0116 and NRL-0227 by exhibiting comparatively higher mean grain yield, bi values near to unity and dispersion values near to zero. These lines are less responsive to environmental changes and considered to be widely adapted. The over all regression coefficients of inbred lines mean yield on the environmental index resulted in a bi ranging from 0.87 in case of NRL-9293 to 1.20 in case of NRL-0306 (Table 5). NRL-2017 had the highest value of S^2_d (0.47) compared to other inbred lines, indicating that this line is unpredictable across environments. NRL 0306 is high yielding (3.06 t/ha) with regression coefficient value greater than unity (bi=1.20), with minimum dispersion value (S^2_d=0.07) and therefore is specifically adapted to favorable environmental conditions. Similar results have also been reported by Arain & Siddiqi (1977), Sial *et al*., (1999), Shindin & Lokteva (2000).

Table 3. Analysis of variance of wheat inbred lines at different locations during 2003-04.

SOV	df	NIFA	Kohat	Bannu	DI Khan	Mansehra
Replications	3	0.291*	0.273NS	0.064NS	0.806NS	0.108NS
Varieties	9	0.402**	0.835**	1.360**	0.162NS	0.479NS
Error	27	0.076	0.148	0.113	0.318	0.453
Total	39					

df: Degree of freedom

Table 4. Combined analysis of variance over locations.

Source of variation	df	Mean Squares
Locations	4	32.708**
Replications within locations	15	0.309NS
Inbred lines	9	1.687**
Location x inbred lines	36	0.387**
Error	135	0.222
Total	199	

df: Degree of freedom

Table 5. Stability parameters for grain yield (t/ha) of different wheat inbred lines.

Inbred lines	Mean	Regression Coefficient (bi)	Dispersion (S^2_d)
NRL-2017	3.89	1.00	0.47
NRL-0116	3.02	0.97	0.01
NRL-0201	3.14	1.08	0.15
NRL-0211	3.05	0.98	0.11
NRL-0227	3.06	0.97	0.05
NRL-0228	3.11	0.95	0.09
NRL-0306	3.06	1.20	0.07
NRL-0337	2.96	0.95	0.05
NRL-9293	2.88	0.87	0.01
Tatara	3.32	1.03	0.03

The average yields are reported to vary between 2566 kg/ha^{-1} (irrigated) and 1178 kg/ha^{-1} (rain-fed), which indicates a wide gap between the two production regimes (Anon., 2002-03). The situation is further aggravated by a lack of wheat genotypes adapted to these conditions. Therefore, the two wheat inbred lines along with variety Tatara, as found suitable for cultivation in the water stress conditions of the southern part of the province, will be a valuable addition to the existing germplasm being grown in those areas. These could also be used in hybridization programme or in mutation breeding to develop high yielding wheat genotypes suitable for the moisture stress areas of NWFP.

It can be concluded that NRL-0116, NRL-0227 and Tatara are stable and widely adapted for grain yield under rain-fed conditions. Tatara has already been released as commercial variety for general cultivation in the rainfed areas. In the same way the other two mentioned inbred lines can play directly an effective role in the varietal release competition after the completion of mandatory testing for the distinctness, uniformity and stability (DUS) in the registration and for the values for cultivation and use (VCU) in the national trials. The mentioned inbred lines after proving their worth for yield stability can be effectively utilized indirectly in the intra-specific hybridization at the institute. The recommendations made in this study would help in more strengthening the wheat-breeding programs for the rain-fed areas in NWFP.

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(Received for publication 3 March 2005)