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Evaluation of exotic wheat genotypes for yield and yield associated traits under water stress condition

Naveed Yaseen Sial*[1], Mahboob Ali Sial[2], Aurangzaib Jamali[3], Mohammad Ali[4]

[1]*Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan*

[2]*Nuclear Institute of Agriculture (NIA), Tandojam, Pakistan*

[3]*Balochistan Agriculture College, Quetta, Pakistan*

[4]*Agriculture Research Institute, Quetta, Pakistan*

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Abstract

Most of land in Pakistan comes under rainfed condition especially in Baluchistan and some areas of Sindh where rainfall is less than requirement of crops to grow average. Development of cultivars with high yield is the main goal in water limited environments but success has been modest due to the varying nature of drought and the complexity of genetic control of plant responses. Fifteen drought tolerant genotypes of wheat which were received from ICARDA were evaluated along with drought tolerant local check variety Khirman under water stress condition. The experiment was conducted at field area of Nuclear Institute of Agriculture (NIA), Tandojam. Experimental design was Complete Randomized Block Design (RCBD) with three replications. Different six yield and yield associated traits were recorded such as, number of spikelet's spike^{-1}, number of grains spike^{-1}, number of Grains spikelets^{-1}, biological yield plot^{-1}, grain yield plot^{-1}(g) and harvest index. Check variety Khirman produced significantly high values for three different traits viz., number of spikelet's spike^{-1}, number of grains spike^{-1}, number of Grains spikelets^{-1}, while DSBWYT-5 was good in biological yield plot^{-1}, grain yield plot^{-1}(g), however highest harvest index was produced by DSBWYT-10. These results indicate that these genotypes can perform well under drought condition, hence may be utilized in upcoming breeding programs.

* **Corresponding Author:** Naveed Yaseen Sial ✉ naveedyaseen143@gmail.com

Introduction

One of the most produced and grown crop in world is wheat, which is grown in area more than 228 million hectare (Shahryari and Mollasadeghi, 2011). There is a need to increase wheat productivity worldwide, particularly in developing countries and to increase genetic potential of wheat, it is important for to understand the physiological and genetic basis of yield (Yang *et al*., 2006; Shahryari *et al*., 2008).

Area under wheat cultivation in Pakistan is 9.26 million hactor. Wheat play an important role in GDP, it contributes 9.90% in countries agricultural production and 2.00% in GDP 2015-16. Most of land in Pakistan comes under rainfed condition especially in Baluchistan and some areas of Sindh where rainfall in less than requirement of crops to grow average. Drought stress reduces main stem height in crops by decreasing the number of nodes and internodes length. Drought stress leads to a very low dry matter value because of decreased stem height and stem diameter associated with limited leaf expansion and reduced tiller number. It also decreases the number of spikelets in different ways and this reduction is closely correlated with lower dry matter produced. Low spikelet number is essentially linked to the decreased number of flower produced. Reduced number of grains per spike, grain weight and yield indicates that low dry matter accumulation was the main cause for smaller spikes and seed number. Development of wheat varieties with low moisture requirements and their ability to withstand moisture stress may cope well to grip with the oncoming peril of drought. This is because production will tend to be maximized as soon as the yield gap between irrigated and drought stress conditions will begin to narrow down. Present studies were therefore conducted to evaluate newly developed wheat germplasm under water stress conditions and to select some genotypes which possess some drought related traits and better tolerance under water stress condition.

Materials and methods

Origin of wheat breeding material used under study

Wheat breeding material used under study was obtained from Nuclear Institute of Agriculture (NIA), Tando Jam. The experiment was conducted to evaluate the yield potential of 15 exotic advance lines viz., DSBWYT-1, DSBWYT-2, DSBWYT-3, DSBWYT-4, DSBWYT-5, DSBWYT-6, DSBWYT-10, DSBWYT-11, DSBWYT-12, DSBWYT-13, DSBWYT-17, DSBWYT-18, DSBWYT-19, DSBWYT-21, DSBWYT-23 along with drought tolerant local check variety Khirman under water stress conditions.

Experimental location/design

The experiment was conducted at the Experimental Farm of Nuclear Institute of Agriculture (NIA) during wheat growing season 2015-16. The experiment was laid out in randomized complete design (RCBD) using 3 replications. Each genotype was sown with four rows 3m long and 30cm apart between rows. The plot size kept was as 3.6m^2 (3m x 1.2m). Seeds were sown through drill method.

Water stress treatment

The severe water stress was imposed to the experiment on most of the critical growth stages except seedling stage. Single irrigation was applied to the experiment at the early seedling stage after 21 days of sowing and no further irrigation was applied to any critical stage till the maturity of the crop.

Soil analysis and other agronomic practices

The soil at the experimental site was highly fertile and clay loam in nature having pH. 7.5. The fertilizer dose applied to the experiment was (100N: 50P_2O_5 kg/ha). All other related practices such as removal of weeds and off-types were performed regularly and manually.

Yield components studied

The yield associated traits studied were number of spikelets spike^{-1}, number of grains spike^{-1}, number of grains spikelets^{-1}, biological yield plot^{-1}, grain yield plot^{-1} and the harvest index.

Statistical analysis

The data recorded on various yield associated traits of wheat genotypes were subjected to analysis variance (ANOVA) as suggested by Gomez and Gomez (1984) and the means were compared using Duncan's Multiple Range Test (D'MRT) as suggested by Duncan (1955).

The relationship between the traits was determined through Pearson's correlation coefficient studies. The data were analyzed by using statistical software Statistix Version 8.1.

Results and discussion

Number of spikelet's spike^{-1}

Number of spikelet spike^{-1} plays vital role in increase grain spike^{-1}. According to Bhuiya and Kamal (1994) grain yield of wheat is the product of four components viz., number of spike plant^{-1}, number of spikelets spike^{-1}, number of grains spikelet^{-1} and spike length. Analysis of variance display highly significant ($P<0.01$) differences among wheat genotypes for trait number of spikelet's spike^{-1} (Table 1). For character number of spikelet's spike^{-1} all wheat genotypes showed highly significant variation ranged from 18.14 in genotype DSBWYT-11 to 21.44 in check variety Khirman (Table 2). Genotypes DSBWYT-10, DSBWYT-18 and DSBWYT-21 also showed highest values (20.19, 20.28, 20.76 respectively) and stand next to the check variety Khirman as cited above. Number of spikelet's spike^{-1} were highly significantly positive correlated number of grains spike^{-1}, number of grains spikelets^{-1} and main spike yield, however significant positive correlated with peduncle length, while non-significant with rest of the studied traits (Table 3). Cheema *et al.,* (2005) who also reported significant positive associations between grain yield components, such as main spike yield, spikelets spike^{-1}, and grains spike^{-1} under rainfed conditions.

Table 1. Mean squares from analysis of variance for various quantitative traits of wheat genotypes evaluated under water stress condition.

Traits	Mean square (MS) values		
	Replication D.F=2	Genotype D.F=15	Error D.F=30
Number of spikelets spike^{-1}	0.40713	2.24173***	0.37529
Number of grains spike^{-1}	10.1071	87.7940***	20.2219
Number of Grains spikelets^{-1}	0.01714	0.18757***	0.03666
Biological yield plot^{-1}	5902	205320***	4382
Grain yield plot^{-1}(g)	168.7	22242.2***	1223.8
Harvest index	0.2393	38.5848***	3.1091

Number of grains spike^{-1}

Grain number per spikelet was considered as the main yield component in wheat by Hsu and Walton (1971). Analysis of variance showed highly significant ($P<0.01$) differences among wheat genotypes for trait number of grains spike^{-1} (Table 1). Mean performance of wheat for trait gains per spike revealed significant difference among all the genotypes scale from 48.57 in genotype DSBWYT-11 to 67.09 in local check variety Khirman. Genotype DSBWYT-21 also showed significantly the highest (64.76) number of grain spike^{-1} followed by check variety Khirman (67.09) (Table 2). Number of grains spike^{-1} were highly significantly positive correlated with number of spikelets spike^{-1}, number of grains spikelets^{-1} and main spike yield, while non-significant with rest of the studied traits (Table 3). While in correspond to our study Khan *et al.,* (2012) reported that correlation analysis of grains spike^{-1} with main spike weight, were significantly positive.

Number of grains spikelets^{-1}

Analysis of variance exposed highly significant ($P<0.01$) differences among wheat genotypes for trait number of grains spikelets^{-1} (Table 1). Over all mean performance to trait number of grains spikelets^{-1} exposed significant difference among all the genotypes ranged from 2.38 in genotype DSBWYT-8 to 3.32 in local check variety Khirman (Table 2). number of grains spikelets^{-1} were highly significantly correlated with number of spikelet's spike^{-1}, number of grains spike^{-1} and main spike yield, however significantly negative correlated with peduncle length and spike length while non-significant with rest of the studied traits (Table 3). Sial *et al.*, (2007) who calculated the genotypic and phenotypic correlations of bread wheat cultivars and reported number of grains spikelets^{-1} were highly and significantly correlated with number of grains spike^{-1} and grain yield.

Biological yield plot^{-1} (g)

Biological yield has main importance in development of new lines for drought condition. Under drought condition plant loss its weight and that loss also effect the grain yield, that means those genotypescan produce highest biological yield will also good in grain yield (Khavarinejad and Karimov. 2012). Analysis of variance showed highly significant (P<0.01) differences among wheat genotypes for biological yield plot^{-1} (Table 1). Mean conduct of genotypes for the trait Biological yield plot^{-1} exposed significantly variation scaled from 1350g in genotype DSBWYT-9 to 2300g in genotype DSBWYT-5. Biological yield plot^{-1} was highly significantly positive correlated with early ground cover, number of tillers plant^{-1}, peduncle length, grain yield plot^{-1} and harvest index, however highly significantly negative correlated with plant height, while non-significant with rest of the studied traits (Table 3). This result concurs with the findings of Chaturvedi and Gupta (1995) who also reported that biological yield significantly positive correlated with number of tillers plant^{-1} and grain yield.

Table 2. Mean performance of wheat genotypes for number of spikelet's spike^{-1}, number of grains spike^{-1}, number of grains spikelet's^{-1}, biological yield plot^{-1} (g), grain yield plot^{-1} (g) and harvest index %.

Genotype	Number of spikelet's spike^{-1}	Number of grains spike^{-1}	Number of grains spikelet's^{-1}	Biological yield plot^{-1} (g)	Grain yield plot^{-1} (g)	Harvest index (%)
DSBWYT-1	19.47CDEF	54.19CDEFG	2.53DEF	1920.0FG	361.6F	18.8E
DSBWYT-2	18.43GH	49.00FG	2.42EF	2083.3CD	485.0CDE	23.28BCD
DSBWYT-3	19.90BCDE	57.55BCD	2.75BCD	1850.0GH	458.3DE	24.77BCD
DSBWYT-4	18.90EFGH	50.28DEFG	2.51DEF	1960.0EFG	513.3BCD	26.19AB
DSBWYT-5	18.86FGH	49.85EFG	2.47DEF	2300.0 A	571.6A	24.85BCD
DSBWYT-6	18.85FGH	49.14FG	2.39EF	2040.0CDE	546.6AB	26.79A
DSBWYT-10	20.19BCD	58.57BC	2.78 BCD	2000.0DEF	541.6ABC	27.8A
DSBWYT-11	18.14H	48.57G	2.38F	2116.7BC	555.0AB	26.22AB
DSBWYT-12	19.24DEFG	54.95CDEFG	2.69BCDEF	1350.0J	340.0F	25.18BC
DSBWYT-13	19.90BCDE	56.90CDE	2.74BCD	1786.7H	451.6E	25.28BC
DSBWYT-17	19.57CDEF	55.23CDEFG	2.64CDEF	2000.0DEF	530	26.5AB
DSBWYT-18	20.28BC	58.66BC	2.92BC	1926.7 FG	485.0CDE	25.17BC
DSBWYT-19	19.14EFGH	54.28CDEFG	2.65CDEF	1450.0IJ	335.0F	23.10CD
DSBWYT-21	20.76AB	64.76AB	3.00B	2000.0DEF	523.3ABC	26.17AB
DSBWYT-23	19.24DEFG	56.09CDEF	2.70BCDE	2200.0AB	566.6AB	25.75BC
Khirman (Check)	21.44A	67.09A	3.32A	1550.0I	360.0F	23.23CD

Table 3. Correlation coefficient for between verities quantitative traits in hexaploid wheat genotypes.

Traits	Number of spikelets spike^{-1}	Number of grains spike^{-1}	Number of Grains spikelets^{-1}	Biological yield plot^{-1}	Grain yield plot^{-1}(g)	Harvest index
Number of spikelets spike^{-1}	1					
Number of grains spike^{-1}	0.928***	1				
Number of Grains spikelets^{-1}	0.929***	0.968***	1			
Biological yield plot^{-1}	-0.345*	-0.384*	-0.437*	1		
Grain yield plot^{-1}(g)	0.127*	0.089*	0.196*	0.905***	1	
Harvest index	-0.509*	-0.459*	-0.552*	0.841***	0.841*	1

Grain yield plot^{-1} (g)

The grain yield plot^{-1}, a major selection criterion for drought stress tolerance, is a complex trait that is determined by several physiological, biochemical, and metabolic plant processes (Mursalova *et al.*, 2015).

Analysis of variance showed highly significant (P<0.01) differences among wheat genotypes for biological yield plot^{-1} (Table 1). Mean performance for the character grain yield plot^{-1} showed significant difference among all the genotypes. Considering the grain yield plot^{1}, the genotype DSBWYT-5 demonstrated maximum grain yield plot^{-1} (571.67g). While minimum grain yield plot^{-1} was produced by genotype DSBWYT-13 (335.0g) (Table 2). Grain yield plot^{-1} was highly significantly positive correlated with early ground cover, number of tillers plant^{-1}, and biological yield plot^{-1}, however significantly correlated with peduncle length, on a other hand highly significantly negative correlated with plant height, while non-significant with rest of the studied traits (Table 3). Fraihat (2012) determined inter-relationship in 29 promising wheat genotypes and reported that grain yield showed highly significant positive genetic and phenotypic correlation with number of tiller plant^{-1} and biological yield plot^{-1}.

Harvest index (%)

The harvest index as a quantitative trait indicating plant efficiency to distribute dry matter for grain and it is one of the main purposes at the breeding programs of cereals, which introduced genotypes with high harvest index (Zarei *et al.*, 2010). Analysis of variance exposed highly significant (P<0.01) differences among wheat genotypes for harvest index (Table 1). Mean performance of all the genotypes showed significant difference and ranged from 18.8% in genotype DSBWYT-1 to 27.80 in genotype DSBWYT-7 (Table 2). Harvest index was highly significantly positive correlated with peduncle length, 1000 grain weight, biological yield plot^{-1}, however significantly positive correlated early ground cover, number of tillers plant^{-1}, while non-significant with rest of the studied traits (Table 3). Significantly positive association between harvest index and grain yield and other yield related traits has been reported earlier by Majumder *et al.*, (2008); Yousaf *et al.*, (2008) and Singh *et al.*, (1997).

Conclusion

The best option to breed wheat varieties for improved crop production in water scarce conditions is to develop water stress tolerant cultivars.

For this purpose, morpho-physiological parameters of 16 wheat genotypes were assessed for screening drought tolerance by imposing water stress.

On the basis of overall results of this study, the following conclusions can be drawn:

1) All the genotypes revealed significant difference in the ANOVA.
2) Genotype DSBWYT-5 was good biological yield plot^{-1} and grain yield plot^{-1}.
3) Genotype DSBWYT-7 was good in Harvest index.
4) Check Variety Khirman gave good performance in traits number of spikelet's spike^{-1}, number of grain spike^{-1}, number of grains spikelet's^{-1}.
5) All in all, four test entries DSBWYT-5, DSBWYT-7 and check variety showed promising performance for different quantitative traits, indicating that these genotypes possess potential genetic resources, hence may be utilized in upcoming breeding programs.

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