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EVALUATION ON ANATOMICAL AND MORPHOLOGICAL TRAITS IN RELATION TO LOW WATER REQUIREMENT CONDITIONS OF BREAD WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

Six bread wheat genotypes (Sarsabz, Marvi-2000, Bhittai, Khirman, SD-66 and ESW-9522) were evaluated along with drought tolerant variety Barani-86 for low water requirement. The experimental material was planted on the residual moisture after the harvest of rice crop with different irrigation levels. One irrigation, two irrigations and normal irrigation at Nuclear Institute of Agriculture Tandojam during the years 2004-2005 and 2005-2006. Data on anatomical traits were collected during reproductive phase, while the morphological traits were recorded up to maturity. Significant differences were noted among the genotypes for anatomical and morphological traits of all the genotypes. SD-66 showed comparatively more tolerance to water stress environment, which was expressed by higher number of grain/spike, 1000grain weight and grain yield under two irrigations as compared to drought tolerant check variety Barani-86. Anatomical traits also showed more tolerance in SD-66 as compared to other genotypes and check. The tolerance behavior of different genotypes with respect to the anatomical and morphological traits under different water availability regime is discuss.

Introduction

The bread wheat (*Triticum aestivum* L.) is the main staple food of the world population, feeding more than one billion people of the world including Pakistan (Anony., 2003). Pakistan produced 18.2 million tons grains from 8.1 million hectares with an average yield of 2371 kg/^{hac}. The irrigated area consists over 6.69 million hectares and 1.41 millions hectares under non-irrigated and rain-fed conditions (Shah *et al.,* 2005). Being the most important cereal crop, it occupies a key position in the national economy. Wheat contributed 12.5% to value added in agriculture and 2.9% to gross production. (Wajid *et al*., 2002). For the year 2004-2005 the wheat production was 20.00 millions tones (Anony., 2005). Current break through in wheat production is not sufficient to meet the needs of rapidly growing population. This situation is created through water shortage and scanty rainfall. The availability of water in Pakistan at different resources is only 178 MAF by the end of 2025 (Ali, 2004). The annual rainfall is less than 15 inches in 80% of its area. Sindh is completely arid and drought prone area of Sindh was measured 275 million acres, which receives less than 250 mm of rain annually. Sindh is 95% dependent on the Indus River for its agriculture needs (Rahamoo, 2004). To over come, this situation, it is therefore essential and wheat breeders need to evolve low water requirement lines/genotypes to utilize the residual moisture after the harvest of rice crop with one or two irrigations for its sustainable wheat production. Rice - Wheat rotation is considered as the best option for profitable use of residual moisture. Inclusion of rice in rice wheat rotation makes the condition for successful growth of wheat grown after rice (Ghafoor *et al*., 2004).

Tolerance to drought is a complex phenomenon involving several morphological and anatomical characters. Precise information's have been given on breeding wheat varieties on water stress tolerance in Pakistan (Shahid *et al*., 2002).

In the present studies on the tolerance of different genotypes with respect to the anatomical and morphological traits under different water availability regimes is discussed.

Materials and Methods

Six bread wheat genotypes (Sarsabz, Marvi, Bhittai, Khirman, SD-66 and ESW-9522) along with drought tolerant check Barani -86 were sown in normal and different low water requirement conditions at the experimental field of Nuclear Institute of Agriculture, Tandojam under the residual moisture of rice track after the harvest of rice crop. The plot size was measured 2.5 m^2. The experiment was laid out in split design with three replications. Each replication had four rows of 2.5m length planted 30cm apart under four-irrigation treatments i.e., normal irrigations, firstly irrigated the crop after 30 days of the planting, second irrigation was given after 60 days of the planting and third irrigation was given after 90 days of the planting. T_2 (One irrigation was given at 30 days after planting and second irrigation at 60 days after planting with pre anthesis stress) T_1 (One irrigation was given after 30 days of planting with pre and post anthesis stresses). Data on various growth and yield parameters were recorded at maturity. Ten flag leaves were randomly selected to each genotype at heading stage from every irrigation treatment for anatomical studies. Middle portion of the flag leaves were fixed in Formalin, Acetic acid, Alcohol solution. Fifteen days after the fixation, the sample was placed into tap water and kept into the refrigerator for over night to removing the fixative. After removing the fixative, the free hand transverse sections were cut with razor blade in the tap water from the selected portion of the flag leaves (Yousufzai, 1999). Section were dehydrated with Ethyl alcohol (C_2 H_5 OH) series (30, 50, 70, 90 and 100%) and stained with freshly prepared solutions Safranin 'O' and light green. Dehydrated and stained sections were passed into absolute xylene for cleaning the tissues. Section was mounted on the glass slides with euparal. Thickness of cuticle layer, number of vascular bundles number of stomata and number of trichomes were counted with Carl Zeiss Light Microscope at 6X, 10X and 40X magnifications (Siddiqui *et al*., 1998).

The crop was left to maturity and data for morphological traits were recorded. Data from various morphological and anatomical traits were statistically analyzed, following the procedure Steel & Torrie (1980).

Results and Discussion

Significant variations were observed in the morphological and anatomical traits of flag leaves of cultivated wheat cultivars (*Triticum aestivum* L.) are given in Tables 1-7. The result showed that wheat genotypes Sarsabz and Khirman exhibited significantly taller plant height in normal irrigation but in two irrigations Sarsabz possessed 90% water stress tolerance with respect to plant height as compared to others. Plant height was drastically reduced in water stress condition. Wheat genotypes showed differential responses under water stress conditions with each other. Sarwar *et al*., (1991) and Asharf *et al*., (2002) have already reported similar findings in wheat. The newly adopted wheat variety SD-66 showed no reductions in spike length under water stress conditions and exhibited 100% tolerance in two irrigations as compared to others and drought tolerant check variety (Barani-86). Genotype SD-66 exhibited 99% water stress tolerance in grain/spike and 100% in 1000grain weight under two irrigations. Grain/spike and 1000grain weight an important yield-determining factor; reflect the extent of grain development. The differences in behavior of wheat genotypes under water stress appear to be due to inherent potential to sustained drought conditions .It means highly tolerant genotypes SD-66 appears to be due to inherent potential to sustained water stress conditions and may be attributed to their variable genetic make up and impaired physiological mechanisms of plant carried out in the presence of water. The finding is in agreement with various researchers (Rajki, 1982; Monayeri *et al*., 1984; Bessonova *et al*., 1989; Ghandorah, 1989; Shah *et al*., 2005).

Data given in Table 3 revealed that water stress affected grain yield of different wheat genotypes. However, the genotypes showed different responses under normal irrigation and water stress conditions. Sarsabz exhibited significantly higher grain yield under normal conditions as compared to others and check (Barani-86). Under water stress conditions the Sarsabz was reduced the grain yield but SD-66 possessed higher grain yield under water stress condition and showed 100% tolerance in grain yield under two irrigations as compared to check and others. Such similar result was reported by Sarwar *et al*., (1991).

Table 1. Evaluation of morphological traits in relation to low water requirement conditions in bread wheat.

Genotypes	Plant height (cm)			Spike Length (cm)		
	Normal irrigation	Two irrigation	% Tolerance	Normal irrigation	Two irrigation	% Tolerance
Sarsabz	90a	80a	90%	13b	12b	90%
Marvi	65d	50d	86%	13b	11c	83%
Bhittai	87b	75b	76%	14a	11c	78%
Khirman	90a	78b	86%	12c	11c	90%
SD-66	85b	73b	86%	14a	14a	100%
ESW-9522	77c	64c	83%	13b	11c	80%
Barani-86	88b	73b	82%	11d	8d	75%

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Table 2. Evaluation on morphological traits in relation to low water requirement conditions in bread wheat.

Genotypes	Grain /spike			1000grain weight		
	Normal irrigation	Two irrigation	% Tolerance	Normal irrigation	Two irrigation	% Tolerance
Sarsabz	70c	60c	85%	45b	39c	86%
Bhittai	70c	60c	85%	45b	41ab	82%
Marvi	80a	70a	87%	50a	43a	86%
Khirman	75b	65b	82%	46b	43a	88%
SD-66	70c	69b	99%	40b	40ab	100%
ESW-9522	63d	50d	80%	43b	38c	88%
Barani-86	70c	60c	60%	40bc	30cd	90%

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Table 3. Evaluation on morphological traits in relation to low water requirement conditions in bread wheat.

Genotypes	Grain yield/plot (g) Plot size=2.5m^2		
	Normal irrigation	Two irrigation	% Tolerance
Sarsabz	1000a	900a	90%
Bhittai	850d	750b	90%
Marvi	900bc	750b	80%
Khirman	900bc	750b	80%
SD-66	900bc	900a	100%
ESW-9522	900bc	750b	62%
Barani-86	950b	600d	60%

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Table 4. Evaluation on flag leaf anatomical traits in relation to low water requirement conditions in bread wheat.

Genotypes/Lines	(Thickness of cuticle µ)		
	Normal irrigation	Two irrigations	% Increased +
Sarsabz	24b	24e	0%
Marvi	22d	24e	9%+
Bhittai	24b	28b	17%+
Khirman	24b	26c	8%+
SD-66	28a	28b	0%+
ESW-9522	20c	25d	20%+
Barani-86	20c	30a	50%+

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Table 5. Evaluation on flag leaf anatomical traits in relation to low water requirement conditions in bread wheat.

Genotypes/Lines	(Number of vascular bundles)		
	Normal irrigation	Two irrigations	% Increased +
Sarsabz	50b	50cd	0%
Marvi-2000	40c	40e	0%
Bhittai	60a	80a	33%+
Khirman	50b	56c	12%+
SD-66	60a	60b	0%
Barani-86	33d	40e	17%+

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Table 6. Evaluation on anatomical traits in relation to low water requirement conditions in bread wheat.

Genotypes/Lines	(Number of stomata at adaxial surface)		
	Normal irrigation	Two irrigations	% Increased +
Sarsabz	62b	62d	0%
Marvi	63b	66d	5%+
Bhittai	60b	70bc	17%+
Khirman	60b	70bc	17%+
SD-66	70a	75b	7%+
ESW-9522	60b	80a	33%+
Barani-86	40c	57e	30%+

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Table 7. Evaluation on anatomical traits in relation to low water requirement conditions in bread wheat.

Genotypes/Lines	(Number of trichomes at abaxial surface)		
	Normal irrigation	Two irrigations	% Increased +
Sarsabz	100a	100a	0%
Marvi-2000	50d	60b	10%+
Bhittai	80c	100a	20%+
Khirman	90b	100a	10%+
SD-66	100a	100a	0%
ESW-9522	22f	30d	7%+
Barani-86	37e	53c	30%+

Values denoted by different letters in row and column are statistically different with each other ($p \leq 0.05$).

Anatomical traits were strongly supported to morphological traits. The results showed that thickness of cuticle exhibited 100% tolerance in SD-66. Thickness of cuticle increased two fold in most of the entries. Thick cuticle is the characteristic feature of xeric conditions and this may be an adaptations of xeric grasses (Ubeda, 1993), as well as Ramon and Chang also reported (1982) that thick cuticle is the most reliable traits for drought resistant of four clones of tea. Vascular bundles are vital element of the internal anatomy of the plant and any short fall in their number and area could also be minimizing the conduction of solutes. Number of vascular bundles and their area were negatively affected in most of the entries. In SD-66 showed 100% tolerance in vascular bundles in water stress as compared to others and check. It means that induction of water stress apparently does not assist the plants to escapes water stress conditions more successfully in SD-66. Highly developed vascular system in the flag leaf was noted by Skoromnyi (1980) in drought tolerant wheat genotypes which were higher values for yield components especially grain weight per plant, 1000grain weight and number of grains /spike. Venora and Calcagno (1991) noted the higher number of vascular bundles with notable thick cuticle and prominent vascular bundles in high yielding drought resistant durum wheat variety as compared to high yielding variety in normal condition, which was not well developed vascular bundles and with imperceptible cuticle. Drought resistant genotypes were lower yielded in normal irrigation because anatomically those genotypes have higher trichome density, thick cuticle, higher stomatal frequency and compact arrangement of mesophyll cell. Similar finding reported by Richard (1996) in leaf anatomy of wheat such traits waxiness, trichomes, bulliform cells, thick cuticle and higher stomatal frequency decrease the radiation load to the leaf surface. Benefits include a lower evapo-transpiration rate and reduced risk of irreversible photo-inhibition. However, they may also be associated with reduce radiation use efficiency, which would reduce yield under more favorable conditions.

Ubeda (1993) reported similar findings in *Cenchrus cilians* L. As well as number of stomata and number of trichomes were significantly higher in SD-66 under normal irrigation and minimum increased under water stress conditions as compared to check and others entries. It means that newly adopted wheat genotype SD-66 have genes for adaptation of water stress. Some workers reported similar findings in wheat (Nayeem & Narker, 1986; Muhmood, 1987; Nayeem, 1989; Shahid, 2002).

Conclusions

On the basis of results it is concluded that morphological and anatomical traits were strongly recommended that mentioned genotype could be utilized in wheat breeding programme for incorporating drought tolerant genes to any low yielding and adaptable wheat variety for rain-fed and water stress conditions.

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