Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 2 (3): 290-293, 2003
ISSN 1682-3974

Response of Durum and Bread wheat Genotypes to Drought Stress: Biomass and Yield Components

Muzammil Saleem
Department of Botany, University of Agriculture, Faisalabad, Pakistan

Abstract: The relative drought tolerance of four durum wheat (*Triticum durum* Desf.) Genotypes and four dread wheat (*Triticum aestivum* L.) Genotypes, was assessed. The biomass production, plant height, ear length, number of spikelets, grains yield and straw weight decreased with water stress in both durum and bread wheat genotypes. However, the tolerant genotypes had less reduction in all these parameters than susceptible ones in response to drought stress. Among the durum wheat genotypes, D-91641 and D-88678 proved to be the most drought tolerant, whereas D-91616 and Wdk-85 were the sensitive ones to drought stress. Among the bread wheat genotypes Inqalab-91 showed the greatest drought tolerance followed by the Chakwal-86, Faisalabad-85 and Pasban-90.

Key words: Durum and bread wheat, drought, biomass, yield components

Introduction

Drought is a major stress which limits the crop production (Iqbal *et al*., 1999). The problem is particularly serious in arid and semi-arid regions (Ashraf *et al.,* 1995), where many developing and under-developed countries happen to fall. In these regions during drought period water potentials in the rhizosphere become sufficiently negative and reduce water availability to sub-optimal levels for plant growth. In Pakistan as well, especially in rainfed areas which constitute nearly 1/3 of the total wheat planting acreage, water is an important limiting factor, (Ashraf *et al.,* 1994 and 1996).

Wheat is an important cereal crop and serves as a staple food in many countries of the world. Water stress is recognized as an important factor that affects the wheat growth and yield (Ashraf and Naqvi, 1995; Ashraf, 1998); however, wheat species and cultivars within species show substantial difference in their response to soil moisture (Rascio *et al.,* 1992; Iqbal *et al.,* 1999). Reduction in yield and yield components due to water stress has been reported in both durum and bread wheat (Sinha *et al.,* 1986).

Increasing wheat production under abiotic stress conditions (salinity, drought etc.) Has become important during recent years, since wheat production in these areas with optimum growth conditions dose not meet the needs of ever increasing population of Pakistan. The objective of this study was to determine the relative tolerance of bread and durum wheat genotypes to drought stress, so that a suitable wheat variety can be recommended to cutivate the drought prone areas of Pakistan.

Material and Methods

Seeds of four durum wheat (*Triticum durum* Desf.) genotypes (D-88678, D-91616, D-91641 and WD-85) and four bread wheat (*Tritium aestivum* L.) Genotypes (Chakwal-86, Faisalabad-85, Inqalab-91 and Pasban-90) were obtained from Wheat Section, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan. The study was conducted at Botanical Research Area, University of Agriculture, Faisalabad under natural conditions. The electrical conductivity of the soil used was 1.6 d Sm^{-1} with pH 7.9, determined after USDA Salinity Lab. Staff Hand Book No. 60 (Richards, 1969). The basic dose of urea (100 kg N ha^{-1} and dia ammonium phosphate (35 kg P_2O_5 ha^{-1}) was broadcasted and mixed with the surface layer prior to sowing pre-planting irrigation (75 mm) was applied. Seed were hand drilled and each genotype was sown in three rows of 2.0 m, with row to row distance of 0.30 m. The drought treatments resumed immediately after sowing. There were two treatments, control (normal irrigation) and terminal drought (no irrigation throughout the crop life). The experiment was laid out in randomized complete block design (RCBD) with irrigation regimes in the main plots and genotypes in the sub plots with three repeats. At maturity the plants were harvested; plant height, plant biomass, ear length, number of spikelets per spike, number of grains per spike straw weight and grain yield were compared by Duncan's new multiple range test (DMRT), at 5% probability (Steel and Torrie, 1980).

Results

Terminal drought stress caused a significant reduction ($P<0.001$) in plant dry mass of all genotypes of both durum and bread wheat wdk-85 (Table 1).Genotypes differed significantly ($P<0.001$) regarding biomass production and the genotypes x treatment interaction was

Table 1: Effect of Terminal drought stress on durum and bread wheat genotypes

Genotype	Treat	Plant Height (cm)	Plant biomass (g)	Ear length (cm)	No. of spikelet/ spike	No. of grains/ spike	100 grain weight (g)	Grain yield/ plant (g)	Straw weight (g) s
D. 91616	Control	82±0.8c	23.7±0.7a	7.3±1.1be	18±0.76bc	45±1.4ef	4.8±0.54abc	9.6±1.1bc	13.5±0.8a
	Drought stress	70±0.8e	16.2±0.8cde	6.3±1.3e	15±1.1e	42±1.2fg	3.9±0.6abc	7.9±1.0bcde	8.7±0.6b
D-91641	control	84±0.6c	24.8±0.7a	7.5±1.0de	20±0.9a	53±1.2d	5.6±0.6a	10.5±1.1ab	15.3±1.4a
	Drought stress	75±1.0d	23.4±0.6a	7.3±1.6de	16±1.4de	45±0.42ef	5.2±0.8ab	9.2±0.9bcd	13.6±1.3a
D-88678	control	75±1.0d	21.3±0.7ab	8.1±0.9bede	18±1.2bc	51±1.5d	5.2±1.1ab	9.8±0.8bc	10.4±1.2b
	Drought stress	60±0.8f	14.2±0.9cdef	6.4±1.5e	15±1.5e	46±1.5ef	4.1±0.9abc	8.1±0.9bcde	8.5±0.9b
Wdk-85	control	82±0.9e	13.9±1.1cdef	8.0±1.6cde	20±0.95a	52±1.6d	4.5±0.7abc	7.3±0.9bcde	7.0±0.6b
	Drought stress	71±0.7de	96.0±1.2ef	6.3±1.6e	16±0.82de	40±0.86abc	3.6±0.6abc	5.0±1.0de	4.5±0.7b
Inqalab-91	control	93±0.6b	18.7±1.0bc	10.2±0.9ab	20±0.85a	63±1.5a	5.6±0.8a	12.0±1.0a	8.1±0.7b
	Drought stress	82±0.8c	16.4±0.9cd	9.7±0.7abc	19±1.1ab	59±1.4b	4.9±0.5abc	10.5±1.1ab	6.8±0.8b
Chakwal-86	control	98±0.7a	16.1±1.1cde	10.4±0.9a	19±0.9ab	57±1.5b	4.6±0.6abc	10.9±0.5a	7.4±1.1b
	Drought stress	83±1.0c	15.2±1.0cdef	9.4±0.9abcd	16±0.76de	46±1.5ef	4.0±0.8abc	9.2±0.8e	5.9±1.2b
Faisalabad-86	control	84±0.8c	15.2±1.0cdef	9.4±0.9abcd	19±1.7ab	56±1.4bc	4.1±0.8abc	8.5±1.1bcd	7.2±0.9b
	Drought stress	71±0.7de	10.5±1.2def	8.3±1.1bcde	17±0.8cd	32±1.3h	2.7±0.8c	6.5±1.0cde	5.9±0.6b
Pasban-90	control	80±0.8c	14.2±1.1cdef	10.1±0.8abc	18±0.9bc	60±1.3b	4.6±0.9abc	9.0±1.1bcd	8.4±0.9b
	Drought stress	70±0.8e	8.4±1.5f	8.1±1.2bcde	16±1.25de	49±1.4de	2.9±0.4bc	5.6±1.0cde	5.2±0.8b

Columns sharing the same letters indicate non-significant differences

Table 2: Correlation of various variables in wheat during water stress

	Plant biomass	Ear length	No. of spikelets/ spike	No. of grains/ spike	100-grain weight	Grain yield/ plant	Straw weight
Plant height	0.31ns	0.76***	0.78***	0.67**	0.45ns	0.31ns	0.19ns
Plant biomass		-0.04ns	0.36ns	0.24ns	0.83***	0.69**	0.94***
Ear length			0.65**	0.74***	0.23ns	0.31ns	-0.13ns
No. of spikeletts/spike				0.68**	0.60*	0.57*	0.28ns
No. of grains/spike					0.62*	0.59*	0.13ns
100-grain wheat						0.86**	0.71**
Grain yield/ plant							0.59*

NS. Non Significant; *, **, ***. Significant at P<0.05, P<0.01 and P<0.001 levels, respectively

also highly significant. Durum wheat *(Triticum durum Desf.)* genotype, D-91641 produced maximum biomass than all other genotype followed by D-888678, D-91616 and Wdk-85 respectively. Among bread wheat (*Triticum aestivum* L.) genotypes, Inqalab-91 responded better followed by Chakwal-86, Pasban-90 and Faisalabad-85.
Water stress significantly decreased the plant height and ear length in all the genotypes. Genotype x treatment interaction was significant only for plant height. Chakwal-86 showed maximum plant height and ear length indicating its superiority over all other genotypes regarding both parameters.

Number of spikelets/spike and number of grains/ear decreased significantly (P<0.001) under water stress. The reduction in number of spikelets/spike and number of grains/ear in Inqalab-91 and D-91641 was significantly less than all other genotypes. Genotype x treatment interaction was non significant the regarding spikelets/spike.

Terminal drought stress significantly reduced the grain weight in all the genotypes studied. Highest 100-grains weight under normal irrigation was recorded in Inqalab-91 & D-91641 (5.6g) followed by D-91616 (4.8g), Chakwal-86 & Pasban-90 (4.6g) respectively. The reduction in hundred grains weight due to terminal drought stress was minimum in D-91641 (7.1%) followed by Inqalab-91 (12.5%). Bread wheat genotype Pasban-90 showed maximum reduction in 100-grains weight (37%) when subjected to terminal moisture stress. Among durum wheat genotypes, maximum reduction in hundred grains weight was recorded in D-88678 (21%) followed by Wdk-85 (20%) and D-91616 (18.7%) respectively.

Grain yield/plant was decreased significantly (P<0.001) in all genotypes in response to water stress. Genotypes differed significantly regarding this variable, whereas, genotype x treatment interaction was non-significant. Under normal irrigated conditions, Inqalab-91 showed maximum grain yield/plant (12.4g) followed by chakwal-86 (10.9g) and D-91641. Maximum reduction in grain yield plant^{-1} was hotical in Wdk-85 (31%) among durum wheat genotypes. D-91641 showed least reduction (12.3%) in grain yield/plant than all other genotypes followed by Inqalab-91 (16.0%).

Plants of all the genotypes showed significantly lower values of straw weight under water stress treatment compared with those of control. Genotypes differed significantly regarding this variable. Whereas genotype x treatment interaction was also highly significant (P<0.001).

Correlation worked out for different parameters revealed that plant height was positively correlated with ear length, number of spikelets/spike and number of grains/spike

(Table 2). Ear length had a positive correlation with number of spikelets/spike and number of grains/spike. A highly positive correlation ($P<0.001$) was observed between grain weight and grain yield/plant. Plant biomass had a synergistic relationship with grain weight, grain yield/plant and straw yield/plant.

Discussion

Plant produce their maximum biomass under adequate water supply, whereas moisture stress causes a marked decrease in plant biomass production Clarke *et al*. (1991); Ashraf, 1998. Hence, in addition to other factors, dry matter production can be used a selection criterion for drought tolerance. Moreover, species and genotypes within species also differ in the degree and time span for which they can endure drought stress (Kumar and Elston, 1992; Khaliq *et al.,* 1999). In present study, reduction in dry matter accumulation was noted in all the genotypes. Durum wheat (*Triticum durum* Desf.) genotypes showed comparatively less reduction in biomass production than bread wheat *(Triticum aestivum* L.) genotypes, except Inqalab-91, which proved to be the most drought tolerant. Bread wheat genotypes Pasban-90 and Faisalabad-85 and durum wheat genotypes, D-88678 and Wdk-85 were proved to be susceptible to drought stress regarding biomass production.

A decrease in plant height was observed in all genotypes due to terminal drought stress. The decrease in plant height was more pronounced in bread wheat genotypes, Faisalabad-85 and Pasban-90 and in durum wheat genotype Wdk-85. The decrease in plant height in response to water may be due to decrease in relative turgidity and dehydration of protoplasm, which is associated with a loss of turgor and reduced expansion of cell and cell division (Arnon, 1972a). In general, ear length of all the genotypes was reduced due to terminal drought stress. However, variation between species and genotypes within species was evident. Inqalab-91 and D-91641 showed minimum reduction in ear length compared with other genotypes. The decrease in stem height and ear length due to water has also been reported by Guinta *et al.* (1998) and Iqbal *et al*. (1999).

There is unanimous agreement and no denying for the fact that the yield of the plant in drying soil is reduced even in tolerant genotypes (Leinhos and Bergmann, 1995; El-Far and Allam, 1995).Grain yield generally depends on ear length, fertile spikelets, number of grains/ear and grain weight (Nachit, 1984). In the present study number of spikelets/ear and 100-grain weight were influenced by terminal drought stress. Inqalab-91 and D-91641 showed minimum reduction in number of spikelets/spike and 100-grain weight in response to moisture stress. It is well established that the number of productive spikelets contributes in increasing the yield under stress condition (Keim and Kronstad, 1981). Hence, Inqalab-91 and D-91641 can be considered as stress tolerant genotypes. The decrease in grain weight may be due to disturbed nutrient uptake efficiency and photosynthetic translocation within the plant (Iqbal *et al*., 1999) that produced shriveled kernels due to hastened maturity (Arnon, 1972b). Drought stress reduced the number of grains/spike and grain yield. The reduction in these variable was more pronounced in bread wheat genotype Pasban-90 and durum wheat genotype Wdk-85, whereas, Inqalab-91 and D-91641 showed better response. It has been reported that genotypes with higher number of grains/ear produce more yield (Iqbal *et al.,* 1999).

There were a significant correlation between plant biomass and grain weight ($P<0.001$), plant biomass and grain yield ($P<0.01$) and plant biomass and straw yield ($P<0.001$) which indicate that plant biomass could be a better indicator of difference in grain and straw yield. On the basis of these results, it is inferred that Inqalab-91 and D-91641 are the most tolerant genotypes to drought stress and Wdk-85 and Pasban-90 are the most susceptible ones.

References

Arnon, I., 1972a. Crop production in dry regions (Ed. N. Polunin), Vol. 1. Leonard Hill Book, London, pp: 203-211.

Arnon, I., 1972b. Crop production in dry regions (Ed. N. Polunin), Vol. 2. Leonard Hill Book, London, pp: 11-19.

Ashraf, M.Y., 1998. Yield and yield components response of wheat (*Trittium aestivum* L.) genotypes grown under different soil water deficit conditions. Acta Agron. Hung., 46: 45-51.

Ashraf, M.Y. and S.S.M. Naqvi, 1995. Studies on water uptake, germination and seeding growth of wheat genotypes under PEG-6000 induced water stress. Pak. J. Sci. Ind. Res., 38: 130-133.

Ashraf, M.Y., A.R. Azmi, A.H. Khan and S.S.M. Naqvi, 1994. Water relations in different wheat (*Triticum aestivum* L.) genotypes under soil water deficits. Acta Physiol. Plantarum, 16: 231-240.

Ashraf, M.Y., A.R. Azmi, S.S.M. Naqvi and A.H. Khan, 1995. Alpha-amylase, protease activities and associated changes under water stress condition in wheat seeding. Pak. J. Sci. Ind. Res., 38: 430-434.

Ashraf, M.Y., M.H. Naqvi and A.H. Khan, 1996. Evaluation of four screening techniques for drought tolerance in wheat (*Triticum aestivium* L.) Acta Agron. Hung., 44: 213-220.

Clarke, J.M., R.A. Richards and A.L. Condon, 1991. Effect of drought stress on residual transpiration and its relationship with water use of wheat. Canidian J. Pl. Sci., 71: 695-699.

El-Far, I.A. and A.Y. Allam, 1995. Responses of some wheat cultivars to sowing methods and drought at different stages of growth. Aussiut J. Agric. Sci., 26: 267-277.

Guinta, F.R., R. Motzo and M. Deidda, 1993. Effect of drought on yield and yield components of durum wheat and *triticale* in a Mediterranean environment. Field Crop Res., 33: 399-409.

Iqbal, M., K. Ahmad, I. Ahmad, M. Sadiq and M.Y. Ashraf, 1999. Yield and yield components of durum wheat as influenced by water stress at various growth stages. Pak. J. Biol. Sci., 2: 11-14.

Khaliq, I., S.A.H. Shah, M. Ahsan and M. Khalid, 1999. Evaluation of spring wheat (*Triticum aestivum* L.) for drought field conditions: A morphological study. Pak. J. Biol. Sci., 2: 1006-1009.

Kumar, A. and J. Elston, 1992. Genotypic difference in leaf water relation between *Brassica juncea* and *B. napus*. Annals Bot., 70: 3-9.

Leinhos, V. and H. Bergmann, 1995. Changes in the yield, lignin content and protein patterns of barley (*Hordeum vulgare* cv. Alexis) induced by drought stress. Angewandie Botanik, 69: 206-210.

Nachit, M.M., 1984. Triticale yield parameters and their interaction with grain yield potential and moisture stress. Vortrage pur pflanzanzuchtung, 6: 187-191.

Rascio, A., C. Platani, N. DiFonza and G. Wittemer, 1992. Bound water in durum wheat under drought stress. Plant Physiol., 98: 908-912.

Richards, L.A., 1969. Diagnosis and improvement of saline and alkali soils. U.S. Department of Agric. U.S.A.

Sinha, S.K., P.K. Aggarwal, G.S. Chaturvedi, A.K. Singh and K. Kailasnathan, 1986. Performance of wheat and triticale cultivars in a variable soil water environment. I. Grain yield stability. Field Crop Res., 13: 289-299.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. McGraw Hill Book Co. New Yark.