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Yield and yield components of durum wheat (*Triticum durum* Desf.) as influenced by water stress at various growth stages.

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bstract
ne effect of water stress on yield and yield components of two durum wheat varieties was studied at various growth ages, i.e. at vegetative, flowering or grain-filling stage and no stress (control). The decrease in grain yield per plant was ore pronounced (72.62 percent) associated with a reduced number of grains per ear (59.62 percent) and 1000-grain eight (31.98 percent) under water stress applied at flowering stage. Stress at grain-filling stage was less effective than vegetative and flowering stage in both varieties. Variety D-88628 was less affected which showed its adaptability under ater stress conditions.

ntroduction
/ater deficit is frequently the primary factor limiting crop roduction under arid conditions and without supplemental rigation (Baligar and Dunean, 1990). It affects every spect of plant growth and the worldwide losses in yield om water stress probably exceed the losses from all other auses combined because even temporary drought can ause substantial losses in crop yields (Ashraf and Khan, 993).

/ater stress reduces grain yield regardless of the growth tage at which it occurs (Jensen and Mogensen, 1984). he highest reduction in yield and yield components has een noted when plants were exposed to water stress at ooting (Imtiyaz *et al.*, 1983; Jensen and Mogensen, 984), jointing (Hassan *et al.*, 1987), between stem longation and heading (Kalinin, 1988) and at flowering tage (Simane *et al.*, 1993; Ravichandran and Mungse, 995). A small reduction in grain and DM yields has been oted when plants were stressed at vegetative (Nayak *et l.*, 1984), tillering and at grain-filling stage (Ravichandran nd Mungse, 1995). Thus any degree of water imbalance ay produce deleterious effects on growth potentials.

ntil now more research efforts have not been invested in nproving the tetraploid wheat. Traditional growing regions f tetraploid durum wheat in Asia and Africa produce low ield per unit area due to stress of environmental conditions nd primitive cultural practices (Haq and Laila, 1991).

ince wheat production in Pakistan (2026 kg ha^{-1}) is less han that of the developed countries (Chowdhry *et al.*, 1998) therefore, increasing its production under abiotic tress conditions (drought, salinity, heat etc.) has become nportant during recent years to meet the needs of ever creasing population.

aterials and Methods
e experiment was conducted under plastic sheet covered a of the net house of Botanical Garden, University of riculture, Faisalabad. The seeds of two durum wheat ieties, namely, D-91616 and D-88678 were sown in then pots lined with polythene bags and containing field l having EC 1.63 dSm^{-1}, 7.6 pH and saturation 32 percent. After germination plants were thinned out and only five plants per pot were kept. Water stress was imposed at various stages of growth i.e. at vegetative, flowering and grain-filling stage by withholding water till incipient wilting. After the completion of water stress in a treatment, the plants were watered regularly till maturity of crop. Tap water was used for irrigation throughout the growth period as and when needed. The data for yield and yield components i.e. ear length, number of spikelets per ear, number of grains per ear, 1000-grain weight, grain yield per plant and straw weigh per plant were recorded at the maturity of crop.

Data collected were analyzed by analysis of variance technique. Duncan's New Multiple Range Test at 5 percent level of probability was used to test the significant differences of treatment means (Steel and Torrie, 1980).

Results and Discussion
Withholding irrigation at any growth stage significantly reduced yield (grain and straw) and yield components (Table 1). Both varieties as regard to ear length and number of spikelets per ear showed significantly different response towards different treatments applied. The maximum decrease in ear length and number of spikelets per ear due to water stress was noted in D-91616 at flowering stage while in D-88678 at vegetative stage. The differential behaviour of these varieties to water stress may be due to their variable genetic make up. Moreover Swati *et al.*, (1985) has also reported stability in ear length under diverse environments.

Maximum number of grains per ear were found in D-88678 as compared to D-91616 under non-stressed conditions (Table 1). Under water stress conditions the maximum decrease in number of grains per ear was noted in both varieties when stress was applied at flowering stage. Stress at grain-filling stage also affected significantly but a small decrease in number of grains per ear was noted. However, stress at vegetative stage decreased number o f grains per ear in D-91616 followed by D-88678 although the differences between them were non-significant.

Table 1. Yield and yield components of durum wheat after water stress applied at various growth stages

	D-91616				D-88678			
	Control	Vegetative Stage	Flowering Stage	Grainfilling Stage	Control	Vegetative Stage	Flowering Stage	Grainfilling Stage
Ear length(cm)	6.85b ±0.14	5.25e ±0.04	4.77f ±0.09	6.04c ±0.06	7.74a ±0.08	5.55d ±0.16	5.96b ±0.06	6.78c ±0.11
No. of spikelets/ear	16.30b ±0.02	10.12e ±0.09	8.00f ±0.06	12.43d ±0.043	18.93a ±0.05	10.43e ±0.03	12.03d ±0.03	13.43c ±0.33
No. Of grains/ear	27.56c ±1.03	19.89e ±0.87	10.44g ±1.03	25.22d ±1.29	42.89a ±1.34	21.44e ±0.63	17.00f ±0.01	32.33b ±1.18
1000-grain weight (g)	48.56b ±0.42	38.47d ±0.18	28.58f ±0.44	37.18e ±0.14	50.12a ±0.10	45.86c ±0.14	38.54d ±0.42	46.01c ±0.02
Grain yield/plant (g)	1.42b ±0.11	0.76d ±0.07	0.32e ±0.03	1.02c ±0.06	2.15a ±0.11	1.00c ±0.10	0.65d ±0.03	1.47b ±0.06
Straw weight/plant (g)	1.75b ±0.12	1.14cd ±0.10	0.89de ±0.03	1.33c ±0.10	2.20a ±0.14	0.87e ±0.05	1.02de ±0.14	1.61b ±0.19

Note: Mean not sharing the same letter are statistically significant at 5% probability level.

The maximum decrease in number of grains per ear at flowering stage might be due to increase in sterility due to water stress (Dornescu, 1983) or it may be due to decrease in number of spikelets per ear and ear length at this stage. These results are in agreement with the findings of Christen *et al.* (1995) and Guerra (1995).

Statistically a significant increase in 1000-grain weight was recorded under non-stress conditions. The stress at flowering stage resulted maximum decrease in 1000-grain weight in D-91616. D-88628 was affected similarly when stress was applied either at vegetative or at grain-filling stage. However, D-91616 was less affected statistically at vegetative than at grain-filling stage. Maximum decrease in 1000-grain weight due to stress at flowering state may be due to disturbed nutrient uptake efficiency and photosynthetic translation within the plant. Singh and Malik (1983) and Simane *et al.* (1993) had also reported similar results.

Under non-stress conditions D-88678 produced maximum grain yield per plant as compared to D-91616. The maximum decrease in grain yield per plant in D-91616 and in D-88678 was noted when stress was applied at flowering stage. Both varieties were less affected when stress was applied at grain-filling stage than at either stage. These results are in accordance with the findings of Ghandorah (1989), Simane *et al.* (1993) and Christen *et al.* (1995).

Similarly maximum straw weight per plant was found in D-88678 followed by D-91616 under non-stress conditions. Varieties affected differently under water stress conditions. The maximum decrease in straw weight per plant was found when stress was applied at vegetative in D-88678 and at flowering stage in D-91616. Similar results were reported by Duwayri (1984), Shalaby *et al.* (1988) and Tahir (1990).

It is clear from above results that durum wheat is most sensitive to water stress imposed at flowering stage because at this stage the yield components were adversely affected which ultimately reduced grain yield. Variety D-88678 proved better than D-91616 at either stage wi respect to grain yield which showed its adaptability und water stress conditions.

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