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EFFECT OF WATER STRESS ON YIELD AND YIELD COMPONENTS OF WHEAT (*TRITICUM AESTIVUM* L.) VARIETIES

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Abstract

Experiments were carried out to study the effect of different water stresses applied at different crop development stages on the yield and yield components of 25 wheat varieties. In a complete randomized block design, replicated 4 times, the 5 water stress treatments i.e. T1 (control), T2 (post flowering drought), T3 (Pre-flowering drought), T4 (Tillering stage drought) and T5 (terminal drought) were applied. Water stress significantly reduced the plant height, spike length, spikelets per spike, grains per spike and 1000grain weight of all 25 wheat varieties. The highest reduction in all parameters was found in T5, while T2 and T3 affected the 1000 grain weight significantly. The varieties Sarsabz and Kiran-95 showed significantly good performance than other wheat varieties in control as well as at terminal drought stress.

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop in the world (Akbar, 2001; Zahid *et al*., 2003; Tunio, 2006), and the major source of staple food for the inhabitants of Pakistan (Chaudhary, 1999; Anon., 2005; Malik, 2006). Being main staple food of rapidly increasing population of Pakistan, wheat occupies central position in the agricultural policies of the country. It contributes 12.5% to the value added in agriculture and 2.9% to GDP (Muhammad *et al*., 2005). Pakistan is ranked 9^{th} in wheat production (Anon., 2000). According to recent statistics, the average grain yield of wheat in Pakistan is 2379 kg^{ha-1} which is much lower than other wheat growing countries of the world (Sial *et al*., 2003; Malik, 2006).

In Pakistan wheat is grown under a wide variety of climatic and soil conditions. About one third of the total acreage falls in the rainfed regions where rainfall is scarce (Khanzada *et al*., 2001b). However, drought and salinity are the most serious threats to agriculture and are far more important globally (Altman, 2003), water stress is major harmful factor in arid and semi-arid regions worldwide (Ranjana *et al*., 2006) that limits the area under cultivation and yield of crops. Drought is observed in irrigated areas due to insufficient supply of water and canal closure (Hafeez *et al*., 2003). Water deficit/drought affects every aspect of plant growth and the yield modifying the anatomy, morphology, physiology, biochemistry and finally the productivity of crop (Jones *et al*., 2003; Hafiz *et al*., 2004). 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 (Sadiq, 1994).

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It is the need of time to develop the varieties, which have drought tolerant potential to increase area under cultivation and yield of wheat crop. The present study was aimed to screen out drought tolerant varieties of wheat, which can spell drought. The information derived from the study will be helpful in breeding wheat for drought tolerance and early selection of genotypes with the desirable traits to be used in the breeding programs.

Materials and Method

Experiment was conducted in the research field of the Department of Botany, Shah Abdul Latif University, Khairpur, Pakistan. The experimental material comprised of 25 varieties of wheat (*Triticum aestivum* L.). The experiment was laid out in a randomized complete block design replicated 4 times with 5 irrigation regimes. The pre-sowing irrigation (75 mm) was applied, prior to sowing; the soil of the replications was carefully leveled to ensure even distribution of water.

Soil samples from the individual blocks were randomly collected at 0-15 cm and 16-30 cm depths before sowing the seeds and then analyzed for determination of various physico-chemical properties (Table 1). Recommended dose of fertilizers was applied at the time of sowing. Seeds were hand drilled, after soil become in conditions of sowing, each genotype was allotted four rows of three meters length. Inter row and inter plant distance was maintained at 30 cm and 15 cm respectively. The following water stress treatments were imposed to simulate the type of drought:

Control (T1): Normal five irrigations as recommended for wheat crop.

Post flowering drought (T2): No irrigation was given after flowering (H_2O stress or drought was imposed after flowering).

Pre flowering drought (T3): No irrigation was given before flowering stage.

Tillering stage drought (T4): No irrigation was applied after tillering stage.

Terminal drought (T5): No irrigation was applied during the entire crop growth.

Table 1. Soil characteristics of experimental site.

	Soil profile	
Characteristics	**0-15 cm<------Depth------->16-30 cm**	
Texture	**Sandy loam**	**Sandy loam**
Water holding capacity	38.20	38.00
Nitrogen %	0.050	0.040
Available P (ppm)	4.500	4.00
Exchangeable K (ppm)	82.00	72.00
Organic matter (%)	0.78	0.62
Ece (ms/cm^{-1})	0.13	0.18
pH	8.40	8.10
Exchangeable Na^+ (meq/100g)	0.10	0.10
Gypsum (meq/100g)	0.00	0.00

Weeding and hoeing were carried out manually to keep the crop free from weeds throughout the growth period. At maturity data on 5 plants of each variety per treatment were selected at random, tagged and labeled properly to record plant height, spike length, spikelets per spike and 1000-grain weight. The spikes collected from marked plants were manually hand threshed and seeds obtained were weighed in grams with the help of an electric balance. Data was subjected to analysis of variance and means were compared using least significant differences according to procedure followed by Steel & Torrie (1980).

Results and Discussion

Plants were found to have capability to adjust to environmental conditions, which is usually unstable due to the various environmental factors. Water stress has the drastic effect on the plant height of all the wheat varieties used in the experiment. The wheat varieties used in this experiment showed significant differences ($p<0.05$) between them at increasing level of water stress for plant height, spike length, number of grains per spike, and 1000 grain weight (Tables 2-5).

Table 2. Effect of water stresses on plant height (cm) of wheat varieties.

Varieties	T1	T2	T3	T4	T5	Mean
Abadgar-93	74.28	70.73	67.48	62.23	56.12	66.14
Anmol-91	84.31	81.71	76.64	71.84	59.38	75.97
Bakhtawar	73.21	70.15	66.26	61.36	56.54	65.05
Inqlab-91	73.06	69.86	65.04	61.60	53.15	64.54
Iqbal	71.24	68.13	62.03	57.24	50.16	61.76
Johar-78	71.92	69.63	64.07	60.57	54.21	64.07
Khirman	85.05	81.63	77.24	72.28	61.25	76.49
Kiran-95	87.93	84.57	79.09	74.17	68.06*	78.76
Mangla	69.78	64.41	60.04	55.12	50.27	59.92
Marvi	77.46	75.97	71.24	66.20	59.58	70.05
Mehran-89	68.73	64.47	61.73	56.27	51.61	60.56
Pavon	71.35	68.88	65.17	61.65	54.95	64.42
Sarsabz	88.35	85.44	81.29	75.57	70.08**	80.14
Sindh-81	83.33	77.34	74.42	69.48	60.13	73.73
Soghat-90	75.55	70.01	64.71	61.23	55.16	65.33
Sonalika	71.88	68.07	63.38	57.27	51.41	62.41
T.J-83	79.51	76.38	70.76	68.17	60.62	71.28
WL-711	72.55	67.78	64.23	59.69	53.21	63.49
Yecora	67.01	57.29	52.57	47.41	42.65	53.38
Zardana	72.05	69.4	65.03	60.24	54.67	64.27
Z.A-77	72.85	68.13	65.95	60.62	55.89	64.68
RWM-9313	72.57	69.97	62.94	57.42	51.55	62.89
ESW-9525	78.62	75.85	71.45	64.61	60.42	70.19
SI-9590	69.32	65.71	61.09	55.26	50.57	60.38
ESW-9613	67.85	64.62	59.16	54.75	50.26	59.32
Mean	75.18	71.44	66.92	62.08	56.31	

$LSD_{(0.05)}$ for treatments = 3.04
$LSD_{(0.05)}$ for varieties = 3.5

Table 3. Effect of water stresses on spike length (cm) of wheat varieties.

Varieties	T1	T2	T3	T4	T5	Mean
Abadgar-93	11.06	10.86	10.06	9.57	8.96	9.74
Anmol-91	12.75	12.12	11.85	11.12	10.61	11.53
Bakhtawar	9.85	9.85	9.25	9.14	9.27	9.52
Inqlab-91	9.55	9.55	9.15	9.15	8.89	9.25
Iqbal	8.55	8.55	8.55	8.25	8.15	8.41
Johar-78	9.78	9.78	9.48	9.14	8.84	9.14
Khirman	12.21	12.01	11.15	11.03	10.61	11.48
Kiran-95	13.03	12.03	12.94	11.53	11.10*	12.01
Mangla	10.48	10.48	9.85	9.73	9.33	9.97
Marvi	12.33	11.13	11.15	11.03	10.85	11.35
Mehran-89	10.12	10.12	9.82	9.22	8.93	9.64
Pavon	9.63	9.63	9.35	9.13	8.68	9.28
Sarsabz	16.13	13.55	12.94	12.39	12.13**	13.14
Sindh-81	13.05	11.05	10.65	10.15	10.02	11.09
Soghat-90	10.12	10.02	9.91	9.63	9.48	9.88
Sonalika	9.71	9.71	9.81	9.41	8.99	9.52
T.J-83	12.53	11.53	11.33	11.13	10.68	11.44
WL-711	10.31	10.31	9.96	9.66	9.41	9.93
Yecora	10.21	10.21	9.95	9.75	9.25	9.87
Zardana	11.25	11.25	10.95	10.62	9.85	10.78
Z.A-77	10.46	10.46	10.19	10.01	9.54	10.13
RWM-9313	10.22	10.12	9.85	9.71	9.08	9.18
ESW-9525	12.15	12.05	11.13	10.05	9.84	11.17
SI-9590	10.43	10.43	10.12	9.86	9.46	10.06
ESW-9613	10.63	10.63	10.41	10.17	8.94	10.16
Mean	10.98	10.67	10.41	10.09	9.63	

$LSD_{(0.05)}$ for treatments = 0.85
$LSD_{(0.05)}$ for varieties = 1.52

The effect of different water stress levels was clear on all the traits of wheat varieties. Almost all the varieties had produced good plant height, spike length, grains per spike and 1000 grain weight in control having normal 5 irrigations, while all the parameters were significantly reduced at highest drought i.e., the terminal drought. The plant height of variety Yecora was most significantly affected at higher water stress level while variety Sarsabz produced taller plants in response to all stress levels than other varieties (Table 2). Plant height plays an important role in photosynthesis. Malik & Hassan, (2002) and Khanzada *et al*., (2001a) have earlier reported that shoot length of guar genotypes significantly reduced under water stress. Similarly Inamullah *et al*., (1999) also observed that plant height in wheat varieties reduced significantly under water stress when it was compared with irrigated. The variety Sarsabz showed significantly highest spike length than other varieties at all water stress levels (Table 2). Lowest spike length was produced by Iqbal in control as well as at terminal drought. Khanzada *et al*., (2001a), found that pod length in guar genotypes decreased significantly with application of water stress when compared with control. Qadir *et al*., (1999), also found that water stress reduced the spikelets per spike in wheat.

Table 4. Effect of water stresses on spikelets per spike of wheat varieties.

Varieties	T1	T2	T3	T4	T5	Mean
Abadgar-93	15.46	15.02	14.03	13.04	12.16	14.15
Anmol-91	19.13	18.08	18.01	18.04	15.24	18.46
Bakhtawar	16.76	16.09	15.04	14.04	13.04	15.21
Inqlab-91	14.76	14.22	13.08	13.01	12.11	13.57
Iqbal	14.71	14.12	13.09	13.21	12.41	13.68
Johar-78	17.21	16.05	16.01	15.21	15.02	15.29
Khirman	18.81	18.11	17.56	17.56	14.71	17.74
Kiran-95	20.22	19.04	19.00	19.00	18.44*	19.12
Mangla	16.23	15.09	15.05	14.08	13.82	15.24
Marvi	20.12	19.04	18.07	18.07	15.94	18.94
Mehran-89	17.21	16.06	16.01	15.01	14.23	15.84
Pavon	16.35	15.19	15.06	14.06	13.75	15.23
Sarsabz	20.71	20.31	20.12	20.01	19.63**	20.12
Sindh-81	18.25	17.85	16.18	16.08	15.14	17.14
Soghat-90	17.21	16.32	15.16	14.07	13.85	15.46
Sonalika	14.48	14.32	13.17	12.09	12.02	13.45
T.J-83	18.14	17.21	16.04	16.04	15.81	16.72
WL-711	15.55	15.11	14.13	13.04	12.72	14.21
Yecora	15.93	15.51	14.19	14.12	13.42	14.78
Zardana	16.60	16.41	15.14	14.02	13.12	15.08
Z.A-77	15.61	15.21	13.07	13.01	12.00	13.92
RWM-9313	15.79	15.13	14.08	13.01	13.00	14.55
ESW-9525	17.42	16.21	15.06	14.01	13.61	15.48
SI-9590	15.98	15.27	14.12	14.01	13.12	14.16
ESW-9613	16.31	15.17	12.09	12.03	11.17	13.78
Mean	16.97	16.39	15.17	15.11	14.31	

$LSD_{(0.05)}$ for treatments = 0.64
$LSD_{(0.05)}$ for varieties = 1.23

The highest number of grains per spike was produced by the variety Sarsabz at control as well as terminal drought and lowest number of grains produced in Inqlab-91 at control and at terminal drought lowest number of grains was produced by Bakhtawar (Table 4).

Tompkins *et al*., (1991) reported the significant suppressive effect of water stress on number of grains per spike. Khanzada *et al*., (2001a) and Qadir *et al*., (1999) have earlier reported that water stress throughout vegetative and reproductive development caused a significant reduction in number of grains per spike in wheat. Drastic decrease in 1000-grain weight was recorded (Table 5) as the drought stress increased but highest reductions were found in T5 (Terminal drought) followed by T2 (Post flowering drought). Lowest of 1000 grain weight was recorded in S. I.-9590 in control and RWM-9313 at terminal drought. The highest 1000-grain weight was recorded in Sarsabz at control as well as at terminal drought. These results are in agreement with those of Khan *et al*., (2005) and Qadir *et al*., (1999) who observed that 1000-grain weight of wheat was reduced mainly due to increasing water stress.

Table 5. Effect of water stresses on number of grains per spike of wheat varieties.

Varieties	T1	T2	T3	T4	T5	Mean
Abadgar-93	42.17	40.12	37.01	31.17	28.12	35.88
Anmol-91	52.39	48.65	43.12	40.71	34.51	44.64
Bakhtawar	43.45	39.45	34.02	30.14	26.21	34.58
Inqlab-91	41.18	37.01	33.21	29.12	27.12	33.43
Iqbal	41.27	39.10	35.12	31.43	28.31	35.08
Johar-78	42.03	38.14	33.31	30.64	26.41	34.06
Khirman	52.31	49.01	45.22	41.21	35.56	45.25
Kiran-95	61.89	58.21	54.52	50.62	47.65*	54.57
Mangla	42.60	40.31	36.61	31.61	28.72	35.96
Marvi	52.25	51.35	48.43	43.11	40.12	47.02
Mehran-89	43.71	41.72	38.14	32.14	26.51	36.48
Pavon	45.60	42.61	39.61	34.21	30.61	38.52
Sarsabz	62.04	61.12	55.41	52.01	50.13**	56.08
Sindh-81	52.54	50.61	49.35	43.21	39.12	46.89
Soghat-90	42.58	39.12	36.58	31.12	27.14	35.31
Sonalika	43.87	41.09	36.45	32.45	29.15	36.83
T.J-83	53.81	52.11	48.56	43.15	40.11	47.52
WL-711	44.04	42.84	37.54	33.14	30.12	37.53
Yecora	45.22	43.34	40.88	36.45	30.18	39.33
Zardana	43.55	42.52	39.81	34.56	31.28	38.44
Z.A-77	45.96	43.21	40.26	37.58	30.15	39.53
RWM-9313	43.88	42.72	38.54	34.69	31.11	38.18
ESW-9525	53.05	51.01	49.65	45.43	40.19	48.08
SI-9590	45.68	40.01	35.86	31.56	29.14	36.42
ESW-9613	45.03	41.05	37.97	32.65	30.21	37.38
Mean	47.32	44.65	40.96	36.57	33.07	

$LSD_{(0.05)}$ for treatments = 1.63
$LSD_{(0.05)}$ for varieties = 4.05

Table 6. Effect of water stresses on 1000-grain weight of wheat varieties.

Varieties	T1	T2	T3	T4	T5	Mean
Abadgar-93	30.42	27.04	25.13	23.00	19.01	28.01
Anmol-91	36.20	35.12	33.41	30.67	22.75	32.23
Bakhtawar	28.70	25.07	23.66	20.26	16.03	23.72
Inqlab-91	27.50	25.64	23.67	20.16	15.56	23.49
Iqbal	28.35	26.17	24.04	20.01	17.25	24.94
Johar-78	29.40	28.04	25.14	21.00	16.67	26.97
Khirman	36.34	35.34	32.34	30.12	23.00	34.04
Kiran-95	38.58	37.58	34.58	31.03	28.45*	36.29
Mangla	32.67	29.36	27.53	25.00	19.00	28.91
Marvi	36.53	33.01	30.48	27.33	23.12	30.09
Mehran-89	30.60	28.27	25.91	21.03	18.67	24.95
Pavon	30.87	29.01	27.64	25.63	20.03	26.09
Sarsabz	45.13	44.03	41.24	37.65	32.07**	40.08
Sindh-81	37.41	35.74	32.23	27.03	24.67	34.27
Soghat-90	24.53	23.67	21.86	19.03	15.00	22.27
Sonalika	30.76	31.01	29.93	25.17	18.06	29.61
T.J-83	39.86	36.67	30.86	27.67	23.33	33.47
WL-711	30.30	30.16	28.07	23.00	18.67	28.56
Yecora	30.45	29.16	27.58	24.92	19.07	26.56
Zardana	30.60	28.09	26.67	22.58	17.34	25.81
Z.A-77	27.19	26.13	23.03	21.67	18.23	23.68
RWM-9313	28.03	25.63	20.63	17.33	14.67	22.11
ESW-9525	35.83	33.73	30.13	28.33	25.33	30.67
SI-9590	26.56	24.67	23.13	20.00	16.20	23.27
ESW-9613	29.08	28.07	24.03	20.46	15.45	24.34
Mean	32.06	30.41	28.63	26.42	23.67	

$LSD_{(0.05)}$ for treatments = 0.43
$LSD_{(0.05)}$ for varieties = 1.33

It might be concluded from the results of this study on wheat (*Triticum aestivum* L.) varieties for drought tolerance that water stress caused significant reduction in vegetative growth, yield and yield components of wheat varieties.

Since, parameters like plant height, spike length, spikelets per spike and 1000 grain weight were found to be influenced by increasing water stress. Besides reduction in these parameters, the varieties Sarsabz and Kiran-95 showed the highest yield as compared to other varieties in the field trial.

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