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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (1): 236-239, 1999 Research Article

Effect of Water Stress on Growth and Yield Performance of Four Wheat Cultivars

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Abstract
Effect of water stress on growth and yield performance of four wheat cultivars viz. Pasban-90, Barani-83, Punjab-85 and Rohtas-90 was studied at University of Agriculture, Faisalabad, Water stress during reproductive development decreased grain yield ha of wheat compared with control through reduction in number of fertile tillers m^{-2} and grains per spike and 1000-grain weight but did not differ significantly from water stress during the vegetative development. Rohtas-90 produced higher grain yield than Barani-83 both under normal and water stress conditions but was statistically at par with Pasban-90 and Punjab-85. The result suggested that water stress during vegetative and reproductive development is equally injurious to wheat and adequate water supply throughout crop development is essential to harvest its maximum biological potential.

Introduction
Water stress at any of the developmental stages of wheat (*Triticum aestivum* L.) causes a significant reduction in its grain yield (Hochman, 1982). However, the magnitude of adverse effect depends upon wheat variety and stage of crop subjected to water stress.

Water is essential at every stage of plant growth, from seed germination to plant maturation, but sensitivity of wheat to water stress increases as the plant growth progresses and reaches the maximum during early dough stage (Human *et al.*, 1981). However, water stress during vegetative growth stages limits leaf and tiller development of winter wheat, while water stress during jointing increases ratio of senescence and decreases number of spikelets per head (Musick and Dusek, 1980), while boot stage have been found to reduce grain yield (Hochman, 1982). Wheat planting in the irrigated areas of Punjab commences in October and continuous as late as January. Most of the crop is harvested in April and May. During this spam of time there is no regular rainfall except a few scattered showers. Consequently the normal growth and development of wheat crop primarily hinges upon available irrigation water. Since there is a dearth of irrigation water during the wheat growing period, it is imperative that the available water be used most economically and efficiently. To achieve this objective, a conclusive information regarding the wheat developmental stages that are highly sensitive to water stress is required. Similarly wheat varieties that perform relatively better under water stress must be selected. This was therefore, planned to evaluate the growth and yield response of four wheat varieties viz. Pasban-90, Punjab-85 and Barani-83 to water stress during their vegetative and reproductive growth.

Materials and Methods
The experiment was conducted at the agronomic research area, University of Agriculture, Faisalabad. Four wheat varieties Pasban-90, Barani-83, Punjab-85 and Rohtas-90 was sown on a well prepared moist seed bed in split-plot design with four replications on a net plot size of 2×3 m. Treatments comprised three water stress stages, i.e., no water stress (Control); water stress during vegetative development and water stress during reproductive development. Crop was sown in 25 cm rows spaces with a single row hand drill. For each variety seed rate was 100 kg ha^{-1}. Water was imposed by with holding application of irrigation water at the above mentioned wheat development stages and a 30×30 cm drain was dug around each plot to avoid possible lateral movement of water between the adjacent plots and to drain out rainfall water immediately. A basal dose of NPK at 130 kg N, 115 kg P_2O_5 and 65 kg K_2O ha^{-1} was applied by broadcast at the time of seed bed preparation. All other agronomic practices were kept normal and uniform for all the treatments. Observation were recorded on different agro-biological parameters including grain protein content of wheat. All observation were recorded using the standard procedures. The data collected were analyzed by using the Fisher's analysis of variance techniques and differences among treatments means were compared significance by using the LSD test at $p = 0.05$ (Steel and Torrie, 1981).

Results and Discussion
Leaf Area (LA) plays a key role in plant development because it indicates the size of as similatory system that contributes directly to plant productivity. Both the individual and interactive effects of water stress and varieties on leaf area m^{-2} land area of wheat were significant. Wheat variety Punjab-85 grown without any exposure to water stress (WS_1V_3) produced the maximum LA m^{-2} (2.6 m) but did not differ significantly from the treatment combinations WS_1V_1, WS_1V_2, WS_1V_4, WS_3V_2 and WS_3V_3, while Pasban-90 subjected to water stress throughout vegetative growth WS_2V_1 produced the minimum LA m^{-2} (1.59 m^2) and statistically at par with $W5_3V_1$ and WS_3V_4. The results suggest that water stress at any development stage is detrimental to LA M^{-2}. However, magnitude of such adverse effect varies with the development stage at which wheat is subjected to water stress and the variety (Table 1).

Table 1: Grain yield and yield components, grain protein content, leaf area and plant height of four wheat varieties as affected by water stress during vegetative and reproductive development. Leaf area was recorded at boot stage, other components were measured at harvest.

Treatment	Leaf area (m^2)	Plant height (cm)	No. of fertile tillers at per spike	No. of spikelets	No. of grains per spike	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest index (%)	Grain content (%)
A. Water stress									
WS_1	2.39a	88.0a	271.0a	20.70a	48.4a	43.2a	3.25	43.5a	10.8
$W5_2$	1.99b	84.5b	259.0b	20.0b	41.9b	42.4a	3.13ab	40.1b	10.8
WS_3	2.13b	79.7c	270.0b	19.9b	40.0b	39.3b	2.96b	39.7b	11.1^{NS}
B. Variety									
V_1 = Pasban-90	1.93b	80.4b	274.0b	20.2b	49.8a	40.7	3.28b	41.8a	10.0b
V_2 = Barani-83	2.24a	102.3a	238.0d	22.3a	40.9bc	43.5	2.59d	38.5b	11.7a
V_3 = Punjab-85	2.33a	79.2b	266.0c	19.4b	39.2c	41.9	3.02c	41.2a	11.6a
V_4 = Rohtas-90	2.17a	73.3c	290.0a	19.2b	43.8b	40.7^{NS}	3.55a	42.9a	10.3b
C. Treatment combination									
WS_1V_1	2.25abc	86.4	275.0b	20.8	54.0	43.9	3.48ab	45.1	10.2
WS_1V_2	2.23abc	106.3	244.0d	23.0	46.3	45.0	2.60d	39.9	11.4
WS_1V_3	2.60a	81.4	271.0b	19.8	44.0	41.7	3.19abcd	43.6	11.4
WS_1V_4	2.38abc	77.9	294.0a	19.6	49.3	42.9	3.73a	45.4	10.1
WS_2V_1	1.59e	82.2	270.0c	20.1	49.3	38.9	3.23abcd	40.6	10.1
WS_2V_2	1.99bcd	103.8	227.0e	22.3	42.3	44.2	2.67cd	37.1	11.1
WS_2V_3	2.06bcd	78.1	251.0b	19.0	35.3	44.3	3.02abcd	41.0	11.6
WS_2V_4	2.30abc	73.9	287.0a	18.8	40.8	41.6	3.58ab	41.5	10.4
WS_3V_1	1.95cde	72.7	276.0b	19.3	46.3	39.2	3.12abcd	39.8	10.5
WS_3V_2	2.41ab	96.9	241.0d	21.8	34.3	41.3	2.50d	38.6	12.7
WS_3V_3	2.31abc	78.1	275.0b	19.5	38.3	39.5	2.85bcd	38.9	12.0
WS_3V_4	1.84de	71.1^{NS}	287.0a	19.3^{NS}	41.3^{NS}	37.4^{NS}	3.35abc	40.5^{NS}	10.4^{NS}

WS, = No water stress; WS, = water stress during vegetative development; WS_3 = Water stress during reproductive development; Means not sharing the same letters differs significantly from one another at $p<0.05$; NS = Non-significant

Plant height: Individual effect of water stress and variety on plant height of wheat was significant but theft interactive effect was non-significant. Water stress significantly educed plant height. The minimum plant height of 79.7 cm was recorded when crop was subject to water stress throughout reproductive growth, preceded by the crop exposed to water stress during the vegetative development. Monayeri *et al*. (1984) reported that plant height is sensitive to moisture regime which may be attributed to the reduction in cell enlargement. Wheat varieties also significantly differed from one another is plant height due to the differences in their genetic make up. Barani-83 Produced the tallest plants (102.3 cm) against the Rohtas)0 that had the shortest plants (73.3). Pasban-90 and Punjab-85 had equal plant height and occupied the middle position.

Number of fertile tillers m^{-2}: Both the individual and interactive effect of water stress and variety on the number of fertile tillers m^{-2} were significant. Rohtas-90 grown with egular irrigation water supply (WS_1V_4) produced the naximum number of fertile tillers m^{-2} (294) but did not lifter significantly from WS_2V_4 and WS_3V_4. By contrast, Barani-83 subjected to water stress throughout vegetative growth (WS_2V_2) produced the minimum (227) preceded by the treatment combination WS_1V_2 and WS_3V_2. The result suggest the Punjab-85 and Rohtas-90 are less sensitive to water stress during vegetative development, while Pasban90 and Barani-83 are very sensitive. Reduction in number of fertile tillers per m2 of wheat in response to water stress has also been reported by Rajki (1982) and Blum and Pnuel (1990).

Number of spikelets per spike: Water stress treatments reduced the number of spikelets per spike significantly. Water stress during vegetative or reproductive development had an equal suppressive effect on number of spikelets per spike.

Shalaby *et al*. (1988) has also reported that water stress at crown-root initiation or late tillering stages in wheat causes significant reduction in number of spikelets per spike. Wheat varieties also differed significantly from on another in number of spikelets per spike. Barani-83 produced significantly more number of spikelets per spike (22.3) than Pasban-90 (20.0), Punjab-85 (19.4) and Rohtas-90 (19.2). However, the later three cuitivars did not differ significantly from one another. The effects of treatments combination of water stress and varieties on spikelets per spike of wheat were non significant. Different number of spikelets per spike in different varieties seems to be due to their varying genetic make-up.

Number of grains per spike: Sink capacity of a wheat variety depends upon the number of grains per spike and grain weight per spike, both of which contribute to the grain yield. Individual effect of water stress and variety on number of grains per spike was significant, while their interactive effect was non-significant. Water stress throughout vegetative or reproductive development caused a significant reduction in number of grains per spike compared with control. However, both water stress treatments were significantly equal to each other. Tompkins *et al*. (1991) reported significant suppressive effect of water stress on number of grains per spike. Wheat varieties also produced significahtly different number of grains per spike. Pasban-90 produced significantly more number of grains per spike (49.8), followed by Rohtas-90 (43.8), Barani-83 (40.9) and Punjab-85 (39.2), respectively. However, different between Barani-83 and Rohtas-90 or Barani-83 and Punjab-85 was non-significant.

1000-grain weight: Water stress throughout reproductive development caused the maximum reduction in 1000-grain weight of wheat. While water stress during the vegetative development did not effect the 1000-grain weight adversely as it was statistically on a par with control crop. This reduction in 100-grain weight might be attributed to a decrease in the supply of assimilates to the grains which leads to curtailing the duration of grain filling phase. Similar results were reported by Rajki (1982). Wheat varieties and treatments, combination did not differ significantly from one another in 1000-grain weight of wheat.

Grain yield per hectare: Water stress during reproductive development reduced grain yield ha^{-1} of what significantly compared with control but was statistically equal to water stress during the vegetative development. Although the later stress treatment reduced grain yield by 3.81 percent compared with that of control, yet these two treatments did not differ significantly from each other. Reduction in grain yield under water stress condition is ascribed to less number of tillers m^{-2} and grain per spike and less 1000-grain weight. Sinha *et al*. (1986) and Tompkins *et al*. (1991) reported low grain yield due to drought stress conditions ascribed to less number of tillers m-2 and grain per spike and less 1000-grain weight. Sinha *et al*. (1986) and Tompkins *et al*. (1991) reported low grain yield due to drought stress. All the four wheat varieties also differed significantly from one another in grain yield ha^{-1}. Rohtas-90 produced the maximum grain yield of 3.55 t ha^{-1}, followed by Pasban-90, Punjab-85 and Barani-83 that produced yield of 3.28, 3.02 and 2.50 t ha^{-1} respectively. Such differences in grain yield are primarily ascribed to differential tillering potential of four wheat varieties. Interactive effect of water stress and variety on grain yield of wheat was also significant. Rohtas-90 grown without water stress (WS_1V_4) produced the maximum grain yield (3.73 t ha^{-1}) but did differ significantly from the treatment combinations WS WS_1V_3, WS_2V_1, WS_2V_3, WS_2V_4, WS_2V_1 and $W5_2V_4$. On contrary, Barani-83 subjected to water stress during reproductive development (WS_3V_3) gave the maximum grain yield (2.50 t ha^{-1}) but was statistically at par with treatment combinations WS_1V_2, WS_1V_3, WS_2V_1, WS_2V_1 WS_2V_1 and WS_3V_3. Above results suggest that regard of water stress Rohtas-90 was the best grain producer statistically at par with Pasban-90 and Punjab-85 contrary, Barani-83 exhibited the lowest grain potential. Water stress during vegetative or reproduce development seems to be equally injurious in all varieties under study except Punjab-85 that is apparer more sensitive to water stress during its reproduce development.

Harvest index: The physiological of a cereal plan· partition dry matter between its grain and other parts be evaluated from its harvest index. Water stress due vegetative or reproductive development reduced the hary index of wheat significantly compared with control but not differ significantly from each other. Shalaby *et al*. (1988) also reported that water stress at late tillering flowering decrease the harvest index of wheat. Wheat Barani-83 exhibited significantly lower harvest index the Rohtas-90, Pasban-90 and Punjab-85 that were statistic on a par with one another. Lower harvest index in Barani is ascribed to its more vegetative growth than other the varieties as is evident from its more straw yield and the plants. The differences among various treatment combinations were non significant.

Grain protein content: Various water stress treatments non-significant effect on protein content of wheat ranged between 10.80 to 11.14 percent. Monayeri *et al*. (1984) reported non-significant effect of water stress protein content of wheat grains. While Tompkins *et al*. (1991) found lower proteins yields due to drought stress despite their higher protein concentration. Wheat variety differed significantly in grain protein content. Barani-83 Punjab-85 produced significantly higher grain protein content than Pasban-90 and Rohtas-90. However, the former or two latter varieties did not differ significant grain protein content that varied from 10.1 to 12.7 cent.

References

Blum, A. and Y. Pnuel, 1990. Physiological attributes associated with drought resistance of wheat cultivars in a Mediterranean environment. Aust. J. Agric. Res., 41: 799-810.

Hochman, Z., 1982. Effect of water stress with phasic development on yield of wheat grown in a semi-arid environment. Field Crops Res., 5: 55-67.

Human, J.J., M.J.M. Spawer and L.P. Debrugn, 1981. The drought sensitivity of wheat in different growing stages. Crop Prod., 10: 65-68.

Monayeri, M.O., A.N. Higazi, N.H. Ezzat, H.M. Saleem and S.N. Tohoun, 1984. Growth and yield of some wheat and barley varieties grown under different moisture levels. Ann. Agric. Sci. Mushtohor, 20: 231-243.

Musick, J.T. and D.A. Dusek, 1980. Planting date and mater deficit effects on development and yield of irrigated winter wheat. Agron. J., 72: 45-52.

Rajki, E., 1982. Drought-sensitive phases in the development of wheat and the possibility of testing drought resistance in the phytotron. Cereal Res. Commun., 10: 213-221.

Shalaby, E.M., H.M. Abdel-Rahim, M.G. Mosaad and M.M. Masoud, 1988. Effect of watering regime on morpho-physiological traits and harvest index and its components of wheat. Assiut. J. Agric. Sci., 19: 195-207.

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 Crops Res., 13: 289-299.

Steel, R.G. and J.H. Torrie, 1981. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Edn., McGraw Hill Book Co., New York.

Tompkins, D.K., D.B. Fowler and A.T. Wright, 1991. Water use by no-till winter wheat influence of seed rate and row spacing. Agron. J., 83: 766-769.