INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)

http://www.innspub.net

Vol. 13, No. 1, p. 55-62, 2018

RESEARCH PAPER

OPEN ACCESS

Impact of full vs. deficit irrigations on various phenological stages of wheat

Adeel Aman, Muhammad Adnan*

Faculty of Agriculture, Department of Agronomy, Gomal University, Dera Ismail Khan, Pakistan

Article published on July 15, 2018

Key words: Wheat crop, Irrigation, Crop stages, Crop yield.

Abstract

In order to find out the most water critical stage of wheat crop, a pot experiment was carried out in a greenhouse at Faculty of Agriculture, Gomal University, Dera Ismail Khan, during 2016-2017. Randomized complete block (RCB) design with three repetitions was used for execution of the experiment. It was comprised of six treatments (irrigation regimes) which were assigned to pots measuring 53cm^2. The application of various irrigation frequencies significantly affected leaf area index, crop growth rate, net assimilation rate, chlorophyll contents, days to emergence, days to maturity, height, tillers and grains count, 1000-seed weight, gain and biological yield as well as harvest index. Among various treatments, the highest grain yield (3821kg ha^{-1}) was achieved when irrigation was applied at all phenological stages. It was followed by the treatment received no irrigation at heading stage (3227.7kg ha^{-1}). The lowest yield (993.7kg ha^{-1}) was, however, recorded in treatment where irrigation was applied at three weeks after seedling emergence. Therefore, it can be inferred from this experiment that seedling, tillering and grain formation are the most sensitive and critical moisture stress stages for obtaining higher yield of wheat under Agro-climatic conditions of Dera Ismail Khan.

* **Corresponding Author:** Muhammad Adnan ✉ adnanagri12@gmail.com

Introduction

Wheat is the leading cereal crop of Pakistan. Nationally, the average area allocated for its cultivation is 9180 thousand hectares with 25.478 million tons production. (Anonymous, 2015). In Asia, Pakistan ranks 4th among the largest producers while it is the 11th most wheat producing country of the world. Wheat is the most basic calorie and protein source and one of the most important crops in the world. In Pakistan, the average wheat yield is low (2500kg ha^{-1}) due to many biotic and abiotic stresses. For example, irrigation stress at different phenological stages of wheat has been reported to have variable effect on wheat growth, development and yield. If irrigation stress is applied on tillering stage, it results in less number of tillers. It has also been reported that pollination is reduced at anthesis due to water stress resulting in reduced number of seeds and eventually low seed yield (Ashraf, 1998). Similarly, water stress at grain formation stage results in shrinkled grains etc.

For crop production, scarcity of water is considered a major abiotic stress in such regions (Passioura, 2007; Edhaie *et al.*, 2011). It is estimated that about 33 million hectares of the world's wheat cultivated lands face moisture stress (Rajaram *et al.*, 2001). Kazemeini and Edalat (2011) reported that water stress is the leading cause of low wheat yield especially in the dry regions (Geerts and Raes, 2009).

Although Pakistan has reasonable water resources but due to poor management strategies, the available water is insufficient to meet the crop requirements. This moisture deficit not only affects plant growth but also results in low harvests leading to financial loss to the farmers. In areas where irrigation water is available, growers do not provide optimum water requirements due to lack of appropriate knowledge (Khan *et al.*, 2007).

Since the availability of water is limited therefore it seems unfeasible to irrigate the whole irrigatable land area at once. Under such circumstances, efforts should be made to reduce the depth of water applied for bringing more land under irrigation (Salemi *et al.*, 2011). Such an approach of deficit irrigation eventually increases net return for water applied and maximizes water productivity (English, 2005).

Application of irrigation water at critical growth stages of wheat is essential to ensure better crop stand and higher yield. Wajid *et al.* (2002) recorded highest grain yield by giving irrigation at all growth stages. It is clear from the previous research work that economical and timely application of water to crops is necessary to increase water use efficiency of field crops on sustainable basis. Keeping that in view, the present research work was initiated to determine the most critical growth stages of wheat plants for water sensitivity. To avoid the most critical growth stage from water stress for sound grain yield.

Materials and methods

This experiment on the 'Impact of full vs. deficit irrigations on various phenological stages of wheat' was conducted at Faculty of Agriculture, gomal university, Dera Ismail Khan, Pakistan.

Experimental material

For this experiment pots were used, each pot was filled with 20 kg soil. The crop was sown by dibbling method. Eight seed were sown in each pot.

Methodology

Randomized complete block design with three repeats was used for the execution of experiment. Eight seed were sown in each pot. After germination, 4 seedlings were kept in each pot while the rest were thinned-out two weeks after germination. Urea, di-Ammonium phosphate and potassium sulfate were used at150-120-90kg ha^{-1} (2.05-2.35-1.7g pot^{-1}) in all pots. Phosphorous (P) and potash (K) were applied at the time of sowing with half dose of nitrogen (N) while rest of the N was top dressed 21 days after seedling emergence. A mixture of 300g sand + 90g farm yard manure was also applied in each pot. The detail of treatments is given as under:

T_1 = Irrigation three weeks after seedling emergence (Just one irrigation after seedling emergence)

T_2 = No irrigation at tillering stage (recommended 5 irrigations except tillering stage).

T_3 = No irrigation at booting stage (recommended 5 irrigations except booting stage)

T_4 = No irrigation at heading stage (recommended 5 irrigations except heading stage)

T_5 = No irrigation at grain formation stage (recommended 5 irrigations except grain formation stage)

T_6 = Irrigation throughout growing season (recommended 6 irrigations)

Statistical analysis

Data collected and recorded during the study period was subjected to statistical analysis using analysis of variance technique (Steel *et al*., 1997) while least significant difference (LSD) test was used to check the differences among treatment means at 5% probability level. Analysis was performed through "Statistix 8.1" software.

Results and discussion

Leaf area index

Data on leaf area index (LAI) as affected by full vs. deficit irrigations (Table-1) indicated that drought imposed at different crop growth stages significantly reduced LAI as compared to that of fully irrigated plants (Appendix-1-2). Among various treatments, maximum LAI (0.22) was recorded at 42 DAS whereas LAI recorded at 84 DAS was maximum (0.68) in T_6 where the crop was irrigated throughout growing season followed by T_5 (no irrigation at grain formation stage), T_3 (no irrigation at booting stage) and T_4 (no irrigation at heading stage) which produced LAI of 0.21, 0.21, and 0.20 which were statistically at par with each other. LAI after 84 DAS also indicated almost the same trend which produced value of 0.65 next to maximum LAI while the minimum was 0.28 followed by T_2 (no irrigation at tillering stage) which gave LAI of 0.41. Minimum LAI (0.20 and 0.28) was recorded when crop was irrigated three weeks after seedling emergence (T_1). Moisture plays an important role in formation and expansion of leaves. The number of leaves and their area is essential for efficient interception of sunlight to enhance the process of photosynthesis and net production of assimilates. Therefore, LAI is an important factor which indicates the net photosynthesis occurring in the plants that finally contributes towards the final yield. The higher LAI was recorded in plants where irrigation was applied throughout the growing season. It was due to availability of sufficient moisture at all critical growth stages while the reverse was true in plants where single irrigation was applied three weeks after seedling emergence and no further moisture was available to crop plants during later growth stages till maturity. Leaf area index is the main physiological determinant of crop yield. It is related to photosynthesis and transpiration, and to a certain extent, to the above-ground biomass of the stand and yield (Kang *et al.* 2005). Qadir *et al.* (1999) reported that water stress during vegetative growth causes reduction in LAI. Likewise, reduced cell enlargement, poor growth and photosynthetic activity are main causes of lower leaf area index in crop plants.

Table 1. Effect of full vs. deficit irrigations on leaf area index of wheat.

Treatments	Leaf area index	
	42-DAS	84-DAS
T_1 Irrigation three weeks after seedling emergence	0.19 c	0.28 e
T_2 No irrigation at tillering stage	0.20 c	0.41 d
T_3 No irrigation at booting stage	0.21 b	0.42 d
T_4 No irrigation at heading stage	0.20 b	0.49 c
T_5 No irrigation at grain formation stage	0.21 b	0.65 b
T_6 Irrigation throughout growing season	0.22 a	0.68 a
$LSD_{0.05}$	0.001	0.01

Means are significant at 5% probability level.

Crop growth rate (g m^{-2} day^{-1})

Data pertaining to crop growth rate as affected by full vs. deficit irrigations are presented in Table-2 while ANOVA is given in Appendix-3. Among various treatments, maximum CGR (6.90) was obtained where irrigation was applied throughout growing season followed by T_5 (no irrigation at grain formation stage) which produced crop growth rate of 6.36g m^{-2} day^{-1}. Irrigation three weeks after seedling emergence had minimum CGR (2.17) followed by T_2 (no irrigation at tillering stage) which recorded 3.62g m^{-2} day^{-1} CGR.

The continuous moisture supply throughout the growth period helped in increasing the vegetative growth at rapid pace while the plants received irrigation three weeks after seedling emergence (T_1) remained under high moisture stress throughout the vegetative growth period and thereby recorded lower crop growth rate. Availability of moisture is indispensable for optimum physiological and biochemical processes occurring inside the plant. Maximum crop growth rate was recorded with season long application of irrigation. It was due to the reason that the crop did not face moisture stress at any critical growth stage from emergence till maturity.

Table 2. Effect of full vs. deficit irrigations on crop growth rate (g m^{-2} day^{-1}) of wheat.

Treatments	Crop growth rate
T_1 Irrigation three weeks after seedling emergence	2.17 f
T_2 No irrigation at tillering stage	3.62 e
T_3 No irrigation at booting stage	4.36 d
T_4 No irrigation at heading stage	5.19 c
T_5 No irrigation at grain formation stage	6.36 b
T_6 Irrigation throughout growing season	6.90 a
$LSD_{0.05}$	0.32

Means are significant at 5% probability level.

Net assimilation rate (mg m^{-2} day^{-1})

NAR is an important physiological parameter for the assessment of total dry matter production by crop plants. Data related to net assimilation rate is given in Table-3 with ANOVA in Appendix-4. As far as the effect of various treatments is concerned, irrigation water applied during the entire crop growth period surpassed all other treatments with net assimilation rate of 12.09mg m^{-2} day^{-1} except that recorded in T_5 (no irrigation at grain formation stage) which produced statistically at par NAR of 11.55mg m^{-2} day^{-1}. A significant reduction in NAR was observed by skipping irrigation supply at grain formation, heading, booting and tillering stages, respectively. Among treatments, minimum NAR (9.45mg m^{-2} day^{-1}) was recorded by irrigating crop three weeks after seedling emergence (T_1) followed by T_2 (no irrigation at tillering stage) which gave NAR of 10.35mg m^{-2} day^{-1}. Water plays an imperative role in physiological processes occurring inside a plant, particularly photosynthesis being the primary input for production and accumulation of dry matter. Optimum quantity of water applied to a crop at all the critical growth stages ensures efficient utilization of nutrients and ultimately maximum dry matter production. The same reason may be attributed to the maximum net assimilation rate obtained through irrigating the wheat plants during their entire life cycle.

Table 3. Effect of full vs. deficit irrigations on net assimilation rate (mg m^{-2} day^{-1}) of wheat.

Treatments	Net assimilation rate
T_1 Irrigation three weeks after seedling emergence	9.45 e
T_2 No irrigation at tillering stage	10.35 d
T_3 No irrigation at booting stage	10.80 cd
T_4 No irrigation at heading stage	11.31 bc
T_5 No irrigation at grain formation stage	11.55 ab
T_6 Irrigation throughout growing season	12.09 a
$LSD_{0.05}$	0.60

Means are significant at 5% probability level.

Chlorophyll contents (μg cm^{-2})

The data pertaining to chlorophyll contents recorded at 42 and 84 DAS is expressed in Table-4 and ANOVA is given in Appendix 5-6. Chlorophyll contents (54.27μ g cm^{-2}) at 42 DAS was found significantly higher when crop was irrigated throughout growing season while minimum (41.23μg cm^{-2}) was recorded by applying irrigation three weeks after seedling emergence (T_1).

The data related to chlorophyll contents 84 DAS indicated that all the treatments produced statistically at par chlorophyll contents while the lowest chlorophyll contents of 35.74μg cm^{-2} was recorded in T_1 (irrigation three weeks after seedling emergence).

For efficient crop growth, ample moisture is essential for the formation and expansion of leaves. Water keeps the cells turgid and enhances the plants capability to stand upright and bear more branches and leaves.

More number of leaves eventually ensures higher sun light interception by green leaf area and thus more food production.

Table 4. Effect of full vs. deficit irrigations on chlorophyll contents (μg cm^{-2}) of wheat.

Treatments	Chlorophyll contents	
	42-DAS	84-DAS
T_1 Irrigation three weeks after seedling emergence	41.23 e	35.74 b
T_2 No irrigation at tillering stage	52.33 c	49.47 a
T_3 No irrigation at booting stage	48.97 d	50.44 a
T_4 No irrigation at heading stage	53.40 b	51.53 a
T_5 No irrigation at grain formation stage	53.42 b	48.83 a
T_6 Irrigation throughout growing season	54.27 a	49.30 a
$LSD_{0.05}$	0.49	2.70

Means are significant at 5% probability level.

Days to emergence

Details on data concerning days to emergence are given in Table-5 and Appendix-7. It is revealed that days to emergence were non-significantly affected by full vs. deficit irrigations. However, maximum numerical value (4.67) was recorded in treatment with skipped irrigation at tillering while minimum days (3.67) to emergence were recorded by irrigating crop three weeks after seedling emergence, skipping irrigation at booting stage, and at heading stage. Such a minimal difference among the mean values was probably due to variable seed size and moisture content at the time of sowing or could be due to variable sowing depth which might have caused delay in seedling emergence.

Table 5. Effect of full vs. deficit irrigations on days to emergence of wheat.

Treatments	Days to emergence
T_1 Irrigation three weeks after seedling emergence	3.67 ^{NS}
T_2 No irrigation at tillering stage	4.67
T_3 No irrigation at booting stage	3.67
T_4 No irrigation at heading stage	3.67
T_5 No irrigation at grain formation stage	4.33
T_6 Irrigation throughout growing season	4.00

NS = Non-significant.

Days to maturity

Number of days to maturity (Table-6 and Appendix-8) showed that maximum days (131.03) to maturity was taken by plants irrigated throughout growing season (T_6) followed by T_4 (no irrigation at heading stage) and T_3 (no irrigation at booting stage) which took 123.48 and 122.52 days to maturity, respectively. While minimum days (117.08) were recorded in plants where irrigation was applied three weeks after seedling emergence (T_1 irrigation three weeks after seedling emergence) followed by T_2 (no irrigation at tillering stage) and T_5 (no irrigation at grain formation stage) with 119.68 and 118.85 days to maturity, respectively. Similarly, plants which were not irrigated at tillering stage matured earlier as compared to other treatments under study. The maximum days to maturity in T_6 (irrigation throughout the growing season) might be due more vegetative growth because of ample water supply at all the growth stages. While the minimum days to maturity in water deficit treatments caused the plants to attain reproductive phase (maturity) earlier.

Table 6. Effect of full vs. deficit irrigations on days to maturity of wheat.

Treatments	Days to maturity
T_1 Irrigation three weeks after seedling emergence	117.08 d
T_2 No irrigation at tillering stage	119.68 c
T_3 No irrigation at booting stage	122.52 b
T_4 No irrigation at heading stage	123.48 b
T_5 No irrigation at grain formation stage	118.85 c
T_6 Irrigation throughout growing season	131.03 a
$LSD_{0.05}$	1.11

Means are significant at 5% probability level.

Plant Height (cm)

Data on height of wheat plants are given in Table-7 with ANOVA in Appendix-9. Among various treatments, tallest plants of 81.28 cm were recorded by irrigating crop throughout growing season (T_6) followed by T_5 (no irrigation at grain formation stage) which produced statistically at par plants of 80.52 cm. Plants irrigated three weeks after seedling emergence (T_1) attained the lowest height of 62.51cm followed by the plants (77.29 cm) where irrigation was skipped at tillering stage (T_2).

The tallest plants in treatments where irrigation was applied throughout the vegetative as well as reproductive stage eventually helped in cell division and elongation along with hormones production and their translocation to sites where active division (apical meristem) was taking place. Availability of sufficient moisture is essential for cell elongation and enlargement. This is because the plants show sensitivity to moisture content for attaining height, as lack of water reduces cell enlargement and results in stunted plant growth (Qadir *et al.* 1999). Inamullah *et al.* (1999) also reported that water stress conditions showed reduced plant height. Malik and Hassan (2002) and Haikel and Melegy (2005) reported that irrigation boosts cell elongation, cell division and consequently increases growth.

Table 7. Effect of full vs. deficit irrigations on plant height at maturity (cm) of wheat.

Treatments	Plant height at maturity
T_1 Irrigation three weeks after seedling emergence	62.51 d
T_2 No irrigation at tillering stage	77.29 c
T_3 No irrigation at booting stage	79.09 b
T_4 No irrigation at heading stage	79.09 b
T_5 No irrigation at grain formation stage	80.52 ab
T_6 Irrigation throughout growing season	81.28 a
$LSD_{0.05}$	1.57

Means are significant at 5% probability level.

Number of tillers (pot^{-1})

Number of tillers is one of the major yield contributing parameters. Data related to tillers' count are given in Table-8 with ANOVA in Appendix-10. Results showed highest tillers (8.67) were recorded with irrigating crop throughout growing season which was, however, statistically at par with all other treatments. The minimum number of tillers (4.00) was recorded in T_1 (irrigation three weeks after seedling emergence) followed by T_2 (no irrigation at tillering stage) which produced 6.00 tillers per pot. These results indicated that water stress at early vegetative growth stages (tillering and spike initiation) have drastically affected tillers production even after moisture supply at advanced growth stages. Lack of irrigation at any growth stage drastically reduces the growth and development of a plant. Bajwa *et al.* (1993) observed significant effect of varying levels of irrigations on the number of tillers. Awad *et al.* (2000) noted greater tillers' survival with frequent irrigations. Similarly, Musaddique *et al.* (2000) reported that maximum number of tillers in wheat was obtained in treatment where maximum number of irrigation was applied. Kabir *et al.* (2009) also noted that no irrigation reduced the number of tillers.

Table 8. Effect of full vs. deficit irrigations on number of tillers (pot^{-1}) of wheat.

Treatments	Number of tillers
T_1 Irrigation three weeks after seedling emergence	4.00 c
T_2 No irrigation at tillering stage	6.00 b
T_3 No irrigation at booting stage	8.00 a
T_4 No irrigation at heading stage	8.33 a
T_5 No irrigation at grain formation stage	8.33 a
T_6 Irrigation throughout growing season	8.67 a
$LSD_{0.05}$	1.08

Means are significant at 5% probability level.

Number of grains (spike^{-1})

Results on grains' count are presented in Table-9 while ANOVA is given in Appendix-11. As revealed from the mean values, irrigating crop throughout growing season increased the number of grains (50.33 spike^{-1}). It was followed by 45.01, 43.53, 42.86 and 42.69 grains recorded when irrigation was skipped at grain formation stage, booting stage, heading stage and tillering stage, respectively. Minimum number of grains (29.00 spike^{-1}) was recorded by irrigating crop three weeks after seedling emergence. Adequate quantity of moisture in the soil hastens the translocation of nutrients inside the plant body, thus helps in the transportation of nutrient elements from source to the sink.

Uninterrupted water supply throughout growing season maintains this flow of nutrients in the plant body, thereby increases the chances of grain formation by ensuring constant provision of nutrients. Qadir *et al.* (1999) and Khanzada *et al.* (2001) reported that water stress throughout vegetative and reproductive stages caused a significant reduction in number of grains per spike in wheat. Similarly, Awad *et al.* (2000) recorded maximum number of grains in treatments where increased moisture was available.

Table 9. Effect of full vs. deficit irrigations on number of grains (spike^{-1}) of wheat.

Treatments	Number of grains
T_1 Irrigation three weeks after seedling emergence	29.00 c
T_2 No irrigation at tillering stage	42.69 b
T_3 No irrigation at booting stage	43.53 b
T_4 No irrigation at heading stage	42.86 b
T_5 No irrigation at grain formation stage	45.01 b
T_6 Irrigation throughout growing season	50.33 a
$LSD_{0.05}$	3.59

Means are significant at 5% probability level.

References

Anonymous. 2015. Economic Survey of Pakistan. Finance Division, Government of Pakistan.

Ashraf MY. 1998. Yield and yield components response of wheat (*Triticum aestivum* L.) genotypes grown under different soil water deficit conditions. Acta Agronomica Hungarica **46(1),** 45-51.

Awad AM, El-Zaher H, Moustafa MA, Sayed MA, Osman AM. 2000. Wheat production on sandy soils using different fertilization methods and irrigation regimes. Alexandria Journal of Agricultural Research **45(1),** 35-61.

Bajwa MA, Chaudhry MH, Abdus S. 1993. Influence of different irrigation regimes on yield and yield components in wheat. Pakistan Journal of Agricultural Research **14(4),** 361-365.

Chander SS, Singh TK. 2008. Selection criteria for drought tolerance in spring wheat (*Triticum aestivum* L.). Series: Coping with wheat in a changing environment abiotic stress. The 11th International Wheat Genetics Symposium (Appels, R., R. Eastwood, E. Lagudah, P. Langridge and M. Mackay Eds. Lynne, Sydney University Press.

English M. 2005. Deficit irrigation. Analytical framework. Journal of Irrigation and Drainage Engineering **116(3),** 399-412.

Galavi M, Moghaddam HA. 2012. Influence of deficit irrigation during growth stages on water use efficiency (wue) and production of wheat cultivars under field conditions. International Research Journal of Applied and Basic Sciences **3(10),** 2071-2078.

Geerts S, Raes D. 2009. Deficit irrigation as an on-farm strategy to maximize crop water productivity in dry areas. Agricultural Water Management **96(9),** 1275-1284.

Haikel MA, El-Melegy AM. 2005. Effect of irrigation requirements, seeding rates and biomineral fertilizer on wheat productivity in newly reclaimed soil under sprinkler irrigation system. Journal of Productivity and Development **10(1),** 113-134.

Hussain A, Ghaudhry MR, Wajad A, Ahmed A, Rafiq M, Ibrahim M, Goheer AR. 2004. Influence of water stress on growth, yield and radiation use efficiency of various wheat cultivars. International Journal of Agriculture and Biology **6,** 1074-1079.

Inamullah ZA, Swati A, Siraj D. 1999. Evaluation of lines for drought tolerance in wheat (*Triticum aestivum* L.). Scientific Khyber **12(2),** 39-48.

Iqbal M, Ahmed K, Ahmad I, Sadiq M, Ashraf MY. 1999. Yield and yield components of durum wheat as influenced by water stress at various growth stages. Pakistan Journal of Biological Sciences (Pakistan) **2,** 11-14.

Jamal M, Nazir MS, Shah SH, Ahmed N. 1996. Varietal response of wheat to waters tress at different growth stages. III. Effect on grain yield, straw yield, harvest index and protein content in grain. Barley and Wheat Newsletter, Rachis **15(1-2),** 38-45.

Kang S, Zhang L, Liang Y, Hu X, Cai H, Gu B. 2002. Effects of limited irrigation on yield and water use efficiency of winter wheat in the Loess Plateau of China. Agricultural Water Management **55(3),** 203-216.

Kang Y, Wang QG, Liu HJ. 2005. Winter wheat canopy interception and its influence factors under sprinkler irrigation. Agricultural Water Management **74(3),** 189-199.

Kazemeini SA, Edalat M. 2011. Effect of deficit irrigation at different growth stages on wheat growth and yield. Journal of Life Sciences **5,** 35-38.

Khan AJ, Azam F, Ali A, Tariq M, Amin M. 2005. Inter-relationship and path coefficient nalysis for biometric traits in drought tolerant wheat (*Triticum aestivum* L.). Asian Journal of Plant Sciences **4(5),** 540-543.

Khan MJ, Sarwar T, Shahzadi A, Malik A. 2007). Effect of different irrigation schedules on water use and yield of wheat. Sarhad Journal of Agriculture **23(4),** 1061-1066.

Khanzada BS, Ala A, Yasin AM, Shirazi MU, Alam SM, Ansari RAM, Khan MA. 2001. Effect of water stress on yield and yield components of different Guar (*Cyamopsis tetragonaloba* L.) genotypes. Pakistan Journal of Biological Sciences **4(4),** 371-374.

Malik MA, Hassan F. 2002. Response of wheat genotypes on suppression of weeds under rainfed conditions. Pakistan Journal Agriculture Agricultural Engineering Veterinary Sciences **18(1),** 18-22.

Mirzaei A, Naseri R, Soleimani R. 2011. Response of different growth stages of wheat to moisture tension in a semiarid land. World Applied Science Journal **12(1),** 83-89.

Musaddique M, Hussain A, Wajid SA, Ahmad A. 2000. Growth, yield and components of yield of different genotypes of wheat. International Journal of Agriculture and Biology **2,** 242-244.

Pannu RK, Singh P, Singh DP, Chaudhary BD, Sangwan VP, Sharma HC. 1996. Ground water-table limits the irrigation requirement of tall and dwarf wheats (*Triticum aestivum* L.). Indian Journal of Agronomy **41(4),** 568-572.

Passioura J. 2007. The drought environment: physical, biological and agricultural perspectives. Journal of experimental botany **58(2),** 113-117.

Qadir G, Saeed M, Cheerna MA. 1999. Effect of water stress on growth and yield performance of four wheat cultivars. Pakistan Journal of Biological Sciences **1,** 236-239.

Riaz R, Chowdhry MA. 2003. Genetic analysis of some economic traits of wheat under drought condition. Asian Journal of Plant Sciences **2(10),** 790-796.

Ryan J, Estefan G, Rashid A. 2001. Soil and plant analysis laboratory manual, International center for Agricultural Research in the Dry Areas (ICARDA). Aleppo, Syria.

Salemi H, Soom MAM, Lee TS, Yousaf MK, Ahmad D. 2011. Effects of deficit irrigation on water productivity and maize yields in arid regions of Iran. Journal of Tropical Agricultural Science **34(2),** 207-216.

Steel RGD, Torrie JH, Dickey DA. 1997). Principles and procedures of statistics: a biometrical approach., 3rd Edn. McGraw-Hill, Inc. Book Co. N.Y. (USA.).

Van Den Boogaard R, Veneklaas EJ, Peacock JM, Lambers H. 1996. Yield and water use of wheat (*Triticum aestivum* L.) in a Mediterranean environment: cultivar differences and sowing density effects. Plant and Soil **181(2),** 251-262.

Wajid A, Hussain A, Maqsood M, Ahmad A, Awais M. 2002. Influence of sowing date and irrigation levels on growth and grain yield of wheat. Pakistan Journal of Agriculture Sciences **39(1),** 22-24.