Research Article

Optimizing the Irrigation Water in Response to Growth and Yield of Wheat under Rainout Shelter Conditions

Shahid Hameed Khan Khalil[1*], Abdus Subhan[3], Ghani Akbar[1], Muhammad Asif[1], Zafar Islam[1], Adnan Shakeel[1] and Fawad Anwar[2]

[1]NARC-CEWRI, Pakistan Agricultural Research Council, Islamabad, Pakistan; [2]NARC-RRI, Pakistan Agricultural Research Council, Islamabad, Pakistan; [3]Soil and Environmental Sciences Department, Gomal University, D.I. Khan, Pakistan.

Abstract | The response of wheat to different irrigation regimes was studied in pot culture under rain shelter conditions at Arid Zone Research Center (AZRC), Dera Ismail Khan during 2014–15 and 2015–16. Irrigation was applied at different rates including control (only at sowing), 25, 50 and 75% of field capacity and conventional irrigation (300mm seasonal requirement) was used. In conventional irrigation methods, irrigation was used to maintain field capacity using 33kPa tension-meter reading during tillering, stem elongation, tillering and grain formation stages. It is clear from the experiment results that parameter of wheat growth including plant height, days to harvest, and number of tillers per plant and grain weight per ear were significantly changed by the application of different amounts of water (treatment) during the two years of the experiment. Conventional irrigation showed significantly higher values of growth parameters, but was comparable to the irrigation regime applied to 50 and 75% of the field capacity. Similarly, the use of different amounts of water significantly affected the yield and yield components of wheat. The thousand grain weight was recorded higher in pots receiving 25% irrigation water. Grain yield was found to be higher with the conventional irrigation method, which was statistically at par with the treatment that used 75% of field capacity irrigation water. The harvest index was recorded higher in the treatment that was irrigated at 50% field capacity. Conclusively, 50% of field capacity irrigation with water was an effective treatment and can be recommended for irrigated and water-scarce areas. Water scarce areas which receive less than 150mm annual rainfall.

Received | September 23, 2022; **Accepted** | December 17, 2022; **Published** | December 22, 2022
***Correspondence** | Shahid Hameed Khan Khalil, NARC-CEWRI, Pakistan Agricultural Research Council, Islamabad, Pakistan; **Email:** agri.engr.shahid@gmail.com
Citation | Khalil, S.H.K., A. Subhan, G. Akbar, M. Asif, Z. Islam, A. Shakeel and F. Anwar. 2022. Optimizing the irrigation water in response to growth and yield of wheat under rainout shelter conditions. *Pakistan Journal of Agricultural Research,* 35(4): 589-596.
DOI | https://dx.doi.org/10.17582/journal.pjar/2022/35.4.589.596
Keywords | Growth, Irrigation regime, Rainout shelter, Wheat, Yield

Introduction

Water availability at critical stages of crop growth is becoming more important in many parts of the world due to water scarcity and failures in the irrigation system (Igbadun *et al*., 2007). It has become a major problem in Pakistan as it directly affects crop yield. Pakistan has a well-established surface irrigation system, but due to mismanagement of water crop water requirements and leaching of harmful salts are still question marks. Although Pakistan has good quality irrigation water, fertile soil and favorable climatic conditions for most crops, the country's crop production is well below potential yield. Insufficient and inefficient use of water is one of the causes of low productivity. Water scarcity and poor management thus become the country's main constraints to crop yields. Wheat (*Triticum aestivum* L.) is a cereal crop which is grown in different parts of the world. It is a staple food in many countries around the world. In Pakistan, wheat was grown on an area of 9.2 m ha in 2016-17 (USDA, 2017). Irrigation water is essential from seed germination to plant maturity, but efficient, cost-effective and proper use at the critical crop stage requires special attention for optimal growth (Khan *et al*., 2004). Water stress at a critical stage of crop growth can significantly reduce grain yield, the greatest reduction being found at the anthesis stage (Jamal *et al*., 1996).

A number of studies have been conducted on deficit irrigation, but the trials were exposed to the precipitation, hence; this study was conducted to enhance growth and water productivity of wheat using different irrigation regimes under rainout shelter.

Materials and Methods

Description of the study site

To analyze the optimum dose of irrigation, an experiment was conducted under rainout shelter conditions at PARC-AZRC, D.I. Khan in 2014–15 and 2015–16. Per annum precipitation at the experimental area is about 300 mm, out of which 70% is received during monsoon season. Less than 100mm average precipitation is received during wheat season. The climate of the region is semi-arid. The weather data for the experimental site is given in Table 1.

Different soil samples were collected randomly from experimental site before commencement of experiment. Each sample was collected from 15-105cm soil. Multiple samples were analyzed by mixing the samples collected from the same depth. Pressure membrane plate apparatus was used to determine field capacity and permanent wilting point of each

Table 1: *Agro-meteorological data recorded for the months of December 2014-April 2015 and December 2015-April 2016 at Arid Zone Research Center, PARC, D.I. Khan.*

Month/Year		Temperature °C		Humidity %		Screen pan evaporation (mm/day)	Wind speed (km/day)	Rainfall (mm)
		Max	Mini	0800 hours	1400 hours			
December 2014	Total	623	144	2508	1595	30.00	66.17	-
	Average	20	5	81	51	1.00	2.00	-
January 2015	Total	576	153	2682	1935	26.62	66.81	28
	Average	19	5	87	62	0.86	2.16	-
February 2015	Total	616	225	2360	1267	55	74.04	27
	Average	22	8	84	45	1.96	2.64	-
March 2015	Total	792	362	2594	1811	2	87	85
	Average	26	12	84	58	-	3	-
April 2015	Total	980	539	2123	1331	146.05	648.25	43
	Average	32.67	17.97	70.77	44.37	4.87	21.61	8.60
December 2015	Total	22.23	5.68	76.81	75.65	1.41	1.57	4.00
	Average	689	176	2381	2345	43.77	48.64	4
January 2016	Total	20.48	4.71	81.13	76.42	1.16	1.82	2.00
	Average	635	146	2515	2369	35.95	56.38	4
February 2016	Total	24.86	5.79	62.34	63.48	2.36	2.19	0
	Average	721	168	1808	1841	68.4	63.64	0
March 2016	Total	29.10	6.71	62.94	53.52	2.42	0.97	19.00
	Average	902	208	1951	1659	75.1	29.98	95
April 2016	Total	34.40	7.53	55.00	39.60	3.42	2.54	0
	Average	1032	226	1650	1188	102.65	76.3	0

Table 2: *Chemical properties of soil and their standard procedures for analysis.*

S/No.	Parameter	Method	Depth (0-15cm)		Depth (15-30cm)	
			2014-2015	2015-2016	2014-2015	2015-2016
1	Soil pH	[20]	7.6	7.2	7.5	7.4
2	Available P	Olsen method [7]	7.1 ppm	8.3 ppm	6.2 ppm	6.6ppm
3	Available K	[18]	120ppm	128ppm	120ppm	122ppm
4	Soil OM	Walkley-Black method [26]	1.6%	1.8%	1.15%	1.12%
5	Nitrogen	Kjeldahl method [6]	0.04%	0.03%	0.02%	0.02%

Table 3: *Physical properties of soil.*

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	[1]FC (cm^3/cm^3)	[2]PWP (cm^3/cm^3)	Bulk density (g/cm^3)
15	56	24	19	0.232	0.114	1.51
30	67	18	15	0.206	0.109	1.55
45	72	15	13	0.191	0.099	1.55
60	68	18	15	0.206	0.109	1.55
75	68	15	18	0.214	0.120	1.56
90	68	20	13	0.199	0.099	1.52
105	70	15	15	0.203	0.109	1.56

[1]field capacity; [2]permanent wilting point.

soil layer at 33 and 1500 kPa, respectively (Richards and Weaver, 1943). Bouyoucos hydrometer method was used to estimate the texture of the soil (Bouyoucos, 1936). Standard procedures were followed to determine the chemical properties of the soil which are given in Table 2. Table 3 shows the physiochemical properties of soil.

There were 5 main blocks, one of each treatment using completely randomized design; and 20 sub blocks, one for each replicate. Depth of irrigation water received by each treatment i.e., control (T_0), 25% of FC (T_1), 50 % of FC (T_2), 75% of FC (T_3) and conventional method as used for wheat crop in the area (T_4). In conventional irrigation methods irrigation was applied to maintain the field capacity at various stages including tillers formation, booting and formation of grains. In T_0, T_1, T_2, T_3 and T_4 irrigation was applied at stages except the stem elongation stage. Irrigation water is not applied during stem elongation stage so as to restrict the vegetative growth and enhance the grains formation.

Before sowing, 50% total available water (TAW) (half the field capacity) was maintained in the top 30cm of soil during sowing for proper crop germination and emergence. The first irrigation was uniformly maintained at the beginning of the tillering phase in all experimental plots. Then each irrigation was applied according to the treatment. A time domain reflectometer (TDR) was used to determine soil moisture.

Twenty pots each having 30cm diameter and 60cm depth were used. Since the study was conducted in pots and the pot size for each treatment was same, thus the root growth parameters were neglected. Due to climate change the rain spell has shifted from October to end of November till Mid December and hence, the farming communities and scientists practice late sowing. Accordingly, wheat variety Hashim-2008 was sown during the month of December. The wheat growing season is November but due to climate change and erratic rainfalls, the farming community is switching to late sowing. In such practice the crop receives chilling temperature and significant precipitation. The day light during the crop period is adequate for yield and biomass. The crop was harvested in April end. Other cultural practices were held equal in all treatments.

The growth and yield parameters of the studied wheat included plant height, days to harvest, number of tillers per plant, number of grains per ear, grain weight per ear, thousand grain weight, total dry matter yield (kg ha^{-1}), grain yield (kg ha^{-1}), straw yield (kg ha-1) and harvest index (%).

Statistical analysis was performed using the procedure described in (Steel *et al*., 1997). Data from three replicates were used to normalize the data. The data was normalized for analysis purpose to carry out the linear regression. Analysis of variance (ANOVA) technique was used to analyze the recorded data of various parameters under completely randomized design. The effect of treatments in subsequent years was significant; therefore, experimental data from both years were analyzed separately. F-test was used to determine a significant effect of treatment in ANOVA, and treatment means were compared using Tukey's test at the 5% significance level.

Results and Discussion

Growth parameters of wheat as affected by the irrigation regime

Plant height: Plant height is one of the important growth parameters that contributes to both physiological functioning and crop growth. A significant effect on the height of wheat plants was observed during the two years study (Table 4). Plant height was found to be greater (52 cm) in pots that were irrigated in a conventional way (T_4). This was on par with treatments containing 50% FC water (T_2), 75% FC water (T_3) and the shortest plants were found in pots receiving 25% FC water (T1). In year 2, the tallest plants were 58 cm, 58 cm, 58 cm and 54 cm in pots receiving conventional irrigation (T_4), 75% FC water (T_3), 50% FC water (T_2) and 25% FC water (T_1), or the smallest plant height was found in the control (T_0), with a height of 43.75 cm.

Similar results were reported for the irrigation scheduling of wheat crops with a significantly taller plant in treatments where maximum irrigation was applied (Baloch *et al*., 2014). Short plants are caused by a lack of irrigation water, as growth stops (Gohari, 2012). Evapotranspiration data collected from the installed weather station was used to quantify the water use of wheat crop. Increasing water use increases plant height (Yuan *et al*., 2003). Similarly, plant height increases with the amount of irrigation (Alderfasi *et al*., 1999).

Days to heading

In the current study, applied water treatments showed a significant effect on days to heading of wheat during the experimental seasons (Table 4). In the first season, days to heading were found to be higher by 95 days in pots receiving 50% FC water (T_2). This was on par with the treatment receiving 75% FC water (T_3). The fewest days to item (92) were found in treatment T_1 comprising 25% applied water. In the experiment conducted during the second year, a resembling trend was found, with an ominously lengthier period of 104 days recorded in T_0, where no irrigation was applied after sowing. In the rest of the treatment, a minimum duration of 96 days was found.

Water stress results in an increased number of days at 50% course (Khakwani *et al*., 2012). Drought has been reported to increase the number of days to 50% by 4.78% (Bayoumi *et al*., 2008).

Number of tillers per plant

The irrigation regime used in the study showed a significant effect on the number of wheat tillers during both experimental years (Table 4). In the first year, it was found that the number of tillers was higher (3.0) in the conventional irrigation treatment (T_4). This was on par with the treatment receiving 50% irrigation (T_2). In the control treatment, the minimum number of tillers was found. In the next year of the experiment, the maximum number of shoots per plant^{-1} was found in the treatment with conventional irrigation (T_4) with a mean value of 2.75 shoots. The least cultivator was found in the control. A higher number of tillers per plant was observed in plots that received irrigation water with a three-week intervals period than those obtained irrigation water at four, five and six weeks intervals (Khan *et al*., 2007). They concluded that sufficient moisture available to the plant supports a higher number of tillers per plant. 90% of cultivators can be increased by irrigation (Elhani *et al*., 2007).

Number of grain per spike

Different irrigation regimes exhibited noteworthy result on number of ears of wheat in 2014-15 but insignificant in 2015-16 (Table 4). The highest number of per spike grains found was 31.00 in conventional irrigation treatment (T_4). The lowest number of per spike grains was found in the control.

A higher number of per spike wheat grains was observed in the irrigated treatments where irrigation was applied five times than those where irrigation was applied four times and three times (Bayoumi *et al*., 2008). Grain tip^{-1} was found higher where no water stress was applied (Akram, 2011).

Table 4: *Growth parameters of wheat as affected by the different irrigation regimes.*

Treatments	Plant height (cm)		Days to heading		No. of tillers per plant		Weight of grain spike^{-1}(g)	
	2014 – 15	2015 – 16	2014 – 15	2015 - 16	2014 – 15	2015 – 16	2014 – 15	2015 – 16
T_0: Control	41.50 ab	41.75 b	92.250 b	104.50 a	1.00 c	1.0 c	0.12 b	0.31 d
T_1:25% of FC	41.75 b	42.00 a	91.500 b	95.50 b	2.00 b	2.0 ab	0.29 ab	0.45 cd
T_2:50% of FC	49.00 a	49.50 a	94.750 a	95.50 b	2.50 ab	1.5 bc	0.455 a	0.61 bc
T_3:75% of FC	46.25 ab	46.75 a	93.000 ab	96.00 b	2.00 b	1.0 c	0.29 b	0.66 b
T_4: Conventional method	51.75 a	52.75 a	92.250 b	95.50 b	3.00 a	2.75 a	0.457a	0.867 a
LSD	10.49	4.2496	2.4481	1.9690	0.6290	0.7956	0.2 2	0.17

Means followed by different letter in a column are significantly different at 5% level of probability.

Table 5: *Yield parameters of wheat as affected by the different irrigation regimes.*

Treatments	1000 grain weight (gram)		Total dry matter (Kg ha^{-1})		Grain yield (Kg ha^{-1})		Harvest index (%)	
	2014 – 15	2015 – 16	2014 – 15	2015 - 16	2014 – 15	2015 – 16	2014 – 15	2015 – 16
T_0: Control	27.250 c	17.250 c	2474.0 d	2678.0 e	1117.50 e	1176.25 c	45.50 b	23.00c
T_1:25% of FC	34.675 a	30.750 b	3706.5 d	3044.5 d	1228.00 d	1303.25 b	33.25 c	42.75d
T_2:50% of FC	30.400 b	33.750 a	4998.5 c	5497.0 c	2438.8 c	2641.25 a	48.50 a	30.75bc
T_3:75% of FC	30.625 b	32.000 ab	6696.0 b	5575.0 b	3202.00 b	2625.00 a	48.00 a	33.00ab
T_4: Conventional method	29.675 b	31.750 ab	7478.3 a	5649.3 a	3575.00 a	2652.30 a	48.00 a	40.50a
LSD	1.9044	2.9901	80.201	46.585	11.046	37.128	0.9115	0.5799

Means followed by different letter in a column are significantly different at 5% level of probability. The growth and yield of drip- irrigated potato. Agric. Water Manage., 63: 153-167.

Weight of grain per spike

Ear weight is an important yield parameter that describes the economic yield obtained after harvesting the crop. The treatment applied to the pots showed a significant effect on the weight of wheat ear^{-1} grain during the two experimental years (Table 4). In the first year, the weight of grain ear^{-1} was found to be a maximum of 0.457 and 0.455 grams in treatments receiving conventional irrigation (T_4) and 50% FC irrigation water (T_2). The smallest value of ear^{-1} grain was found in the control (T_0). In the second season of the experiment, an almost analogous drift followed, with a pointedly higher ear^{-1} grain weight of 0.867 grams in treatments that were irrigated using the conventional method (T_4). The smallest value of ear^{-1} grain was found in the control (T_0). All the attributes that determine the yield, i.e., number of ears per running meter, ear length, number of ears^{-1}, number of ears^{-1} and test weight are significantly affected by different moisture regime (Singh *et al*., 2012).

Yield parameters of wheat as affected by the irrigation regime

Thousand grains weight: The weight of one thousand grains measured during the experiment indicated a substantial influence of the water schedule in the two years of study (Table 5). In the initial year, the highest thousand grain weight of 34.675 grams was recorded in the treatment receiving 25% irrigation water (T_1), followed by the treatment receiving 75% (T_3) and 50% (T_2) FC water with values of 30.625 and 30.40 grams. In the second year of the experiment, a significantly maximum weight of a thousand grains of 33.75 grams was found in the treatment receiving 50% FC water (T_2). In both years, the lowest value of the weight of one thousand grains was found in the control (T_0), with values of 27.25 and 17.25 grams.

Comparatively, 1000 grain weight of wheat was found highest when irrigation water was applied at four growth stages during stress (Maqsood *et al*., 2002). The thousand-grain weight was significantly increased because irrigation was applied at each growth stage of wheat (Sarwar *et al*., 2010).

Total dry matter yield

Total dry matter (TDM) is an important yield parameter that describes the amount of total biological material received after crop harvest. In the current study, the irrigation regimes indicated a momentous effect on wheat TDM during the two study years (Table 5). In the first year, the treatment with conventional irrigation rate (T_4) concluded a maximum of 7483.3 kg ha^{-1} TDM; followed by the rest of the treatments. The control treatment resulted in a minimum TDM value of 2474.0 kg ha^{-1}. The subsequent year of the study revealed resembling results. A significantly higher total dry matter of 5649.3 kg ha^{-1} was recorded in the treatment with the conventional dose of irrigation water T_4. The smallest value of TDM was found in the control, namely 2678.0 kg ha^{-1}. For all wheat genotypes, dry matter accumulation during plant growth decreased with increasing duration of terminal drought (Dalerie *et al*., 2010). Singh *et al*. (2012) also reported that all attributes that determine yield, i.e., number of ears per running meter, length of ear, number of ears, number of grains ear^{-1} and test weight were significantly affected due to different moisture regime.

Grain yield

Wheat grain yield in the current study showed a remarkable effect of irrigation regimes during the experimentation period (Table 5). During the initial year, a maximum grain yield of 3575.00 kg ha^{-1} was found when treated with conventional irrigation (T_4). The minimum value of grain yield observed in the control (T_0) was 1117.50 kg ha^{-1}. The subsequent year of the study revealed an almost same trend with a notably highest yield of 2652.00 kg ha^{-1} in the conventional irrigation treatment (T_4), 50% FC (T_2.) and 75% FC water (T_3), respectively. This was followed by treatment with control and 25% FC (T_1) with values of 1176.25 and 1303.25 kg ha^{-1}.

A higher yield of wheat is achieved by increasing the level of irrigation water (Wajid *et al*., 2002). A longer interval of six weeks also showed the lowest grain yield due to moisture (Khan *et al*., 2007).

Harvest index (%)

The harvest index (%) is an expression of yield parameter in terms of grains and the total biomass of the crop. The wheat yield index (%) varied significantly with irrigation regimes during the study period (Table 5). The maximum harvest index (48.50%) was obtained in the first study year with 50% irrigation water (T_2). This was followed by treatment receiving 75% irrigation water (T_3) and conventional irrigation (T_4), both with a value of 48.00%. The smallest harvest index value was found in the treatment where irrigation was supplied at 25% FC, with a value of 33.25%. In the subsequent study year, the maximum value of the harvest index was found in the treatment receiving irrigation water 25% FC (T_1) with a value of 42.75%. This was followed by treatment with classical irrigation (T_4) with a value of 40.50%. The smallest value of the harvest index was found in the T_0 control with a value of 23.0%.

The harvest index was recorded higher when irrigation water was applied during different stages of the crop and decreases due to water stress (Sarwar *et al*., 2010). Similarly, the Harvest Index was significantly reduced by the application of stress at different growth stages (Mekkei *et al*., 2014).

Conclusions and Recommendations

Conclusively, 50% of field capacity irrigation with water was an effective treatment and can be recommended for irrigated and water-scarce areas.

Novelty Statement

As far as the authors are aware, there is no similar research work carried out related, "Optimizing the Irrigation Water in Response to Growth and Yield of Wheat under Rainout Shelter Conditions".

Author's Contribution

Shahid Hameed Khan Khalil and Abdus Subhan: Overall management of the article as correspondence author addressed the peer reviews and incorporated desired changes.
Ghani Akbar: Supported in literature review.
Muhammad Asif: Supported in data collection and data compilation.

Conflict of interest

The authors have declared no conflict of interest.

References

Akram, M., 2011. Growth and yield components of wheat under water stress of different growth stages. Bangladesh J. Agri. Res., 36(3): 455-468. https://doi.org/10.3329/bjar.v36i3.9264

Alderfasi, A.A., M.O. Ghandorah and K.A. Moustafa. 1999. Evaluation of some wheat genotypes under drought stress in arid region of Saudi Arabia. Alexandria J. Agric. Res., 44: 209-217.

Baloch, S.U., L.I.U. Li-jun, M.N. Kandhroo, S. Fahad, S. Al-Sabiel, S.K. Baloch, and S.A. Badini. 2014. Effect of different irrigation schedules on the growth and yield performance of Wheat (*Triticumaestivum* L.) Varieties assessment in district Awaran (Balochistan). J. Biol. Agric. Healthc., 4(20): 5–17.

Bayoumi, T.Y., M.H. Eid and E.M. Metwali. 2008. Application of physiological and biochemical indices as a screening technique for drought tolerance in wheat genotypes. Afr. J. Biotech., 7: 2341-2352.

Bouyoucos, G.J., 1936. Directions for making mechanical analysis of soils by the hydrometer method. Soil Science, 4: 225–228. https://doi.org/10.1097/00010694-193609000-00007

Bremner, J.M., 1960. Determination of nitrogen in soil by the Kjeldahl method. J. Agric. Sci., 55: 11–33. https://doi.org/10.1017/S0021859600021572

Chapman, H.D. and P.F. Pratt. 1962. Methods of analysis for soils, plants and waters. Soil Sci., 93: 68. https://doi.org/10.1097/00010694-196201000-00015

Dalerie, S.M., R.S. Shareefi and S. Farzaneh. 2010. Evaluation of yield, dry matter accumulation and leaf area index in wheat genotypes as affected by terminal drought stress. Notulae Bot. Hortic. Agrobotanici Cluj-Napoca 38(1).

Elhani, S., V. Martos, Y. Rharrabti, C. Royo, and L.F. Garcı ´a del Moral. 2007. Contribution of main stem and tillers to durum wheat (*Triticumturgidum* L. var. durum) grain yield and its components grown in Mediterranean environments. Field Crops Res., 103: 25–35. https://doi.org/10.1016/j.fcr.2007.05.008

Gohari, A.A., 2012. Effect of soil water on plant height and root depth and some agronomic traits in common bean (*Phaseolus vulgaris*) under biological phosphorous fertilizer and irrigation management. Int. Res. J. Appl. Basic Sci., 3(4): 848-853.

Igbadun, H.E., A.K. Tarimo, B.A. Salim and H.F. Mahoo. 2007. Evaluation of selected crop water production functions for an irrigated maize crop. Agric. Water Manage., 94: 1-10. https://doi.org/10.1016/j.agwat.2007.07.006

Jamal, M., M.S. Nazir, S.H. Shah and A. Nazir. 1996. Varietal response of wheat to water stress at different growth stages and effect on grain yield, straw yield, harvest index and protein contents in grains. Rachis, 15(1-2): 38-45.

Khakwani, A.A., M.D. Dennett, M. Munir and M. Abid. 2012. Growth and yield response of wheat varieties to water stress at booting and anthesis stages of development. Pak. J. Bot., 44(3): 879-886.

Khan, M.J., T. Sarwar, A. Shahzadi and A. Malik. 2007. Effect of different irrigation schedules on water use and yield of wheat. Sarhad J. Agric., 23(4): 1061–1066.

Khan, M.R., M. Tahir and M.A. Ali. 2004. Effect of application time of last irrigation on wheat (*Triticumaestivum* L.) yield. Pak. J. Life Soc. Sci., 2(1): 59-61.

Singh, L.C., M. Singh and G.R. Singh 2012. Response of bed planted wheat (*Tritcum aestivum* L.) under the different moisture regime on water use and its efficiency. J. Chem. Pharm. Res., 4(11): 4941-4945.

Maqsood, M., A. Ali, Z. Aslam, M. Saeed and S. Ahmad. 2002. Effect of irrigation and nitrogen levels on grain yield and quality of wheat (*Triticum aestivum*). Int. J. Agric. Biol., 4(1): 164–165.

Mehlich, A., 1953. Determination of P, Ca, Mg, K, Na and NH4. North carolina soil test Div., (Mimeo 1953). pp. 23–89.

Mekkei, M.E.R. and A.M.A. El-Haggan-Eman. 2014. Effect of different irrigation regimes on grain yield and quality of some Egyptian bread wheat cultivars. J. Agric. Food Appl. Sci., 2(9): 275-282.

Nelson, D.W. and L. Sommers. 1982. Total carbon, organic carbon and organic matter. Methods soil Anal. Part 2. Agronomy, 9: 539–579. https://doi.org/10.2134/agronmonogr9.2.2ed.c29

Richards, L.A. and L.R. Weaver, 1943. Fifteen-atmosphere percentage as related to the permanent wilting percentage. Soil Sci., 56: 331–340. https://doi.org/10.1097/00010694-194311000-00002

Sarwar, N., M. Maqsood, K. Mubeen, M. Shehzad, M.S. Bhullar, R. Qamar and N. Akbar. 2010. Effect of different levels of irrigation on yield and yield components of wheat cultivars. Pak. J. Agric. Sci., 47(3): 371-374.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics: A biometrical approach 3rd ed. McGraw Hill

Book. Co. Inc. New York. pp. 400-428.
United States Department of Agriculture (USDA) Report on World Crop Data, 2017.
Wajid, A., A. Hussain, M. Maqsood, A. Ahmad and M. Awais. 2002. Influence of sowing date and irrigation levels on growth and grain yield of wheat. Pak. J. Agric. Sci., 39(1): 22-24.
Walkley, A. and I.A. Black. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29–38. https://doi.org/10.1097/00010694-193401000-00003
Yuan, B.Z., S. Nishiyama and Y. Kang. 2003. Effects of different irrigation regimes on the growth and yield of drip irrigated potato. Agric. Water Manage., 63: 153-167. https://doi.org/10.1016/S0378-3774(03)00174-4