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GROWTH AND YIELD COMPARISONS OF FOUR COMMERCIAL WHEAT VARIETIES TO IRRIGATION FREQUENCIES

Nisar Ahmed Soomro*, Abdul Fatah Soomro**, Hamz Ali Samo* and Muhammad Siddique Depar***

ABSTRACT:- To examine the comparative response of wheat varieties to different irrigation regimes, four varieties namely, Kiran, Imdad-2005, TJ-83 and T.D-1 were supplied with 3 (IR_1), 4 (IR_2) and 5 (IR_3) irrigations during the entire cropping season. The crop given 5 irrigations resulted in 88.71% germination, 82.77 cm plant height, 10.88 tillers plant^{-1}, 266.74 tillers m^{-2}, 59.41 grains spike^{-1}, 60.50 g 1000-seed weight and 5862.25 kg grain yield ha^{-1}. The crop irrigated four times, showed bit adverse effects on growth and yield traits over 5 irrigations with 84.77% germination, 79.16 cm plant height, 10.07 tillers plant^{-1}, 254.91 tillers m^{-2}, 51.91 grains spike^{-1}, 57.60 g 1000-seed weight and 5230.75 kg grain yield ha^{-1}; while the plots given 3 irrigations showed lowest values for all the parameters. In varieties, Imdad-2005 maximizes its performance with 90.81% germination, 88.33 cm plant height, 10.29 tillers plant^{-1}, 273.10 tillers m^{-2}, 54.99 grains spike^{-1}, 58.40 g 1000-seed weight and 5804.66 kg grain yield ha^{-1}. However, varieties TJ-83, Kiran and T.D-1 ranked 2nd, 3rd and 4th in all the growth traits examined in this study. It was concluded that the differences in grain yield between the crop receiving five and four irrigations were statistically non-significant; which suggested that judicious application of four irrigations will be adequate to produce higher economic grain yield ha^{-1}.

Key Words: Wheat; Varieties; Irrigation Regimes; Growth; Grain Yield; Agronomic Characters; Yield Components; Pakistan.

INTRODUCTION

Triticum aestivum is a hexaploid wheat cultivated worldwide and considered as the principal source of human diet. It occupied prominent position among cereals, particularly in the Asia and more specifically in the south Asian regions. Wheat supplies 68% calories and protein in the diet (Shewry, 2009). The daily diet of people in Pakistan is mainly based on wheat (Farzi and Bigloo, 2010). Importance of wheat in Pakistan can be noted from the fact that agricultural policies are formulated focusing this crop; 60% of daily diet of common man is based on wheat with average per capita consumption of 125 kg (Khan and Habib, 2003). Being the leading food grain of Pakistan, wheat occupies the largest area under single crop and contributes 10% to the value added in agriculture and 2.1% to GDP. Area under wheat has decreased to 9180

** Social Sciences Research Institute, Tandojam, Pakistan.*
*** National Sugar and Tropical Horticulture Research Institute, Thatta, Pakistan.*
**** Arid Zone Research Institute, Umerkot Pakistan.*
Corresponding author: fatahsoomro@ymail.com

thousand hectares in 2014-15 from last year's area of 9199 thousand hectares which shows a decrease of 0.2%. The production of wheat stood at 25.478 mt during 2014-15, showing a decrease of 1.9% over the last year's production of 25.979 mt (GoP, 2015).

Pakistan is known to be the most important country where wheat is cultivated extensively in its all ecological conditions and included in world top ten wheat producing countries (Khan et al., 2002), but the average yields are much lower than other major wheat growing countries including China, USA, India etc. (Arain et al., 2005). Among major causes of relatively poor grain yields in wheat, variety specific irrigation management has considerable role to influence the productivity, because Pakistan is at the verge of water scarcity. The water availability for wheat season 2014-15 was 33.1 MAF which was 9.1% lesser than the normal irrigation water availability of 36.4 MAF (GoP, 2015). Hence, it is imperative to cultivate wheat varieties with less water requirement and the wheat varieties already under cultivation should be examined carefully for their proper water requirement. Wheat plants appeared to be most sensitive to water stress during tillering, heading and milk-ripe stages (Ahmed and Badar, 2004). Irrigation stress during reproductive stage reduced seed yield (Dhaka et al., 2007), reduced crop growth traits including crop growth rate, leaf area index and net assimilation rate (Jazy et al., 2007). Excessive irrigation at the milk-ripe stage mostly led to lodging and in silt clay loam soil compared to clayey soil (Tripathi et al., 1989; Waraich et al., 2007). The production ability of wheat in relation to irrigation has been investigated by many research workers. Khatun et al. (2007) reported yield increase with the increase of irrigation frequency. Alderfasi et al. (1999) observed a significant increase of plant height, fertile tillering 1000 kernel weight and grain and biological yields with increased amount of irrigation. Dawood and Kheiralla (1994) and Bankar et al. (2008) observed that five irrigations at crown root initiation, tillering, jointing, flowering and milking stages, led to the highest yield. Bunyolo (2000) found that water use by wheat increased with shorter irrigation intervals; while Munyindaa and Bunyoloa (2000) applied irrigations at tillering either on a weekly, every two weeks, or every three weeks basis and obtained maximum yields with weekly irrigation. Haj et al. (2005) studied effects of irrigation regimes on wheat and reported significant differences regarding these parameters due to irrigation regimes. Significant effects of the water regime were found on all measured traits by Ibrahim et al. (2007) and number of grain per spike, 1000-grain weight, the gains were highest when the crop was irrigated five times at 25 days interval, rather than four times at 30 days intervals. In view of the facts stated above, comparative response of different commercial wheat varieties to various irrigation regimes was investigated under agro-ecological conditions of Hyderabad district, Sindh (Pakistan).

MATERIALS AND METHOD

The experiment was conducted in the fields of Agronomy Section, Agriculture Research Institute,

Tandojam during *rabi* 2012-13 under four replicated randomized complete block design having net plot size of 3m × 5m ($15m^2$). The experimental plot was well worked following all the recommended ploughing practices for land preparation. The seed of wheat varieties was obtained with the courtesy of agronomist, and the experiment was performed at Agriculture Research Institute, Tandojam. Nitrogen was applied @ 120 kg N ha^{-1} in the form of urea and DAP. Urea was applied in three splits, first at the time of sowing, second at the 1^{st} irrigation and the remaining at the 2^{nd} irrigation. Phosphorus was applied @ 75 kg P_2O_5 ha^{-1} in the form of DAP once all at the time of sowing. The number of irrigations was applied according to the experimental plan and the weedicides were also applied. For recording observations on various agronomical traits, five plants in each plot were selected at random and labelled. After completion of observations on growth parameters, and when crop matures, the labelled plants were harvested manually and tied in small bundles, and were shifted to threshing yard. Threshing was performed manually; the grains were collected carefully to count and record. The data thus collected were subjected to statistical analysis using MSTAT-C. The LSD test was applied to compare treatments superiority, where necessary (Russel and Eisensmith, 1983).

RESULTS AND DISCUSSION

Plant Height (cm)

The analysis of variance demonstrated a significant ($P<0.05$) effect of irrigation levels and varieties on plant height; while the effect of irrigation × variety interaction on this parameter was non-significant ($P>0.05$). The plant height was maximum (82.77cm) in plots irrigated five times, followed by plant height of 77.16 cm when crop was irrigated four times; while the crop receiving three irrigations resulted in lowest plant height of 77.68 cm, respectively. Among varieties, Imdad-2005 produced plants of maximum height (88.33 cm); while varieties TJ-83 and Kiran exhibited average plant height of 82.25 cm and 79.66 cm, respectively. However, the minimum plant height of 69.25 cm was recorded from dwarf variety, T.D-1. Among interactions, the interactive effect of 5 irrigations × Imdad-2005 resulted in maximum plant height of 90.22 cm; while the interaction 3 irrigations × T.D-1 resulted in lowest plant height of 66.33 cm. These results indicated that plant height vary from variety to variety. Moreover, genetically variety Imdad-2005 grows taller than other varieties tested regardless the number of irrigations; while genetically variety T.D-1 is dwarf as indicated from its name (T.D-1= Triple Dwarf). The LSD test indicated non-significant differences in plant height between 4 and 5 irrigations as well as between varieties, Imdad-2005 and TJ-83. Hence, four irrigation frequencies would be adequate to fulfil the crop water requirements as an optimum irrigation level. Haj et al. (2005) studied effects of irrigation regimes on wheat and reported significant differences regarding growth parameters including plant height due to irrigation regimes (Table 1).

Table 1. Plant height (cm), tillers plant^{-1} and tillers m^{-2} of wheat varieties as influenced by various irrigation levels

Irrigations	Variety				Mean for Irrigations
	Imdad-2005	TJ-83	Kiran	TD-1	
Plant height (cm)					
03	86.55	81.10	76.77	66.33	77.68 [b]
04	88.22	82.00	77.77	68.66	79.16 [a]
05	90.22	83.66	84.44	72.77	82.77 [a]
Mean for varieties	88.33 [a]	82.25 [a]	79.66 [b]	69.25 [c]	
LSD 0.05: Varieties(V)=4.6084, Irrigation levels(I) 3.9910, I×V=(ns)					
Tillers plant^{-1}					
03	8.88	8.44	7.88	7.55	8.18 [b]
04	10.33	10.10	10.00	9.88	10.07 [a]
05	11.66	10.77	10.66	10.44	10.88 [a]
Mean for varieties	10.29	9.77	9.51	9.29	
LSD 0.05: Varieties (V) (ns), Irrigation levels (I) =1.398, I×V=(ns)					
Tillers m^{-2}					
03	259.66	240.00	227.66	223.00	237.58 [b]
04	271.00	258.66	247.33	242.66	254.91 [a]
05	288.66	270.00	255.00	253.33	266.74 [a]
Mean for varieties	273.10	256.22	243.33	239.66	
LSD 0.05: Varieties(V)=(ns), Irrigation levels(I) =23.307,I×V=(ns)					

Tillers Plant^{-1}

The number of tillers plant^{-1} of wheat was significantly ($P<0.05$) affected by irrigation frequencies; while the effect of varieties and interaction between irrigation frequencies and varieties on tillers plant^{-1} was non-significant ($P>0.05$). The number of tillers plant^{-1} was highest (10.88) in plots given five irrigations; followed by four irrigations and three irrigations which resulted in average 10.07 and 8.18 tillers plant^{-1}, respectively. In varieties, the number of tillers plant^{-1} was highest (10.29) in commercial variety Imdad-2005, followed by varieties TJ-83 and Kiran with 9.77 and 9.51 average number of tillers plant^{-1}, respectively. However, the lowest number of tillers plant^{-1} (9.29) was recorded in plots sown with variety T.D-1. The interaction of variety Imdad-2005 × 5 irrigations resulted in maximum number of tillers (11.66) plant^{-1}, while the interaction of variety T.D-1 × 3 irrigations resulted in the lowest number of tillers (7.55) plant^{-1}. It was noted that increasing irrigation level resulted in an increased number of tillers plant^{-1}, while regardless the irrigation frequencies, variety Imdad-2005 surpassed all the tested varieties for this parameter. The LSD test indicated that the differences in tillers plant^{-1} of wheat under five and four irrigations were statistically non-

significant (P>0.05), and significant (P<0.05) when compared with rest of the irrigation levels. Alderfasi et al. (1999) also found similar results and reported that tillers in wheat increased with increased amount of irrigation (Table 1).

Number of Tillers m^{-2}

Number of tillers m^{-2} of wheat was significantly (P<0.05) affected by number of irrigations applied; while the effect of varieties and interaction between number of irrigations and varieties on tillers m^{-2} was non-significant (P>0.05). The number of tillers m^{-2} was maximum (266.74) in crop irrigated five times throughout growing season; while the number of tillers decreased to 254.91 and 237.58 m^{-2} when the crop was irrigated 4 and 3 times, respectively. In varieties, the number of tillers m^{-2} was highest (273.10) in promising variety Imdad-2005, followed by TJ-83 and Kiran with 256.22 and 243.33 tillers m^{-2}, respectively. The minimum tillers m^{-2} (239.33) was observed in variety T.D-1. The interactive effect indicates that interaction of variety Imdad-2005 × 5 irrigations resulted in maximum number of tillers (288.66 $m^{-2)}$, while the interaction of variety T.D-1 × 3 irrigations resulted in the lowest number of tillers (223.00) m^{-2}. The results further showed that tillers m^{-2} increased considerably with increasing number of irrigations. However, statistically (as suggested by LSD test) the differences in tillers m^{-2} between four and five irrigations were non-significant, which suggested four irrigations as an optimum level for this trait. Among varieties, Imdad-2005 was relatively superior in tillering capacity as compared to rest of the varieties tested in this study. Kabir et al. (2009) and Alderfasi et al. (1999) also demonstrated the effect of irrigation on wheat and reported significant increase in plant height, tillers, seed index, grain yield and biological yield with increased amount of irrigation (Table 1).

Number of Grains $Spike^{-1}$

These were significantly (P<0.05) influenced by irrigation levels; while the effect of varieties and interaction of "variety × irrigation level" on grains $spike^{-1}$ was non-significant (P>0.05) statistically. Grains $spike^{-1}$ were significantly highest (59.41) in crop supplied with five irrigations, while the grains $spike^{-1}$ adversely affected and reduced to 51.91 when the crop was irrigated four times in a season; while the minimum number of grains (44.66) $spike^{-1}$ was recorded in crop given three irrigations. In case of varieties, the maximum number of grains (54.99) $spike^{-1}$ was counted in crop sown with promising variety Imdad-2005, followed by TJ-83 and Kiran with 53.55 and 50.22 grains $spike^{-1}$, respectively. However, the lowest number of grains (49.22) $spike^{-1}$ was observed in crop sown with variety T.D-1. The interaction studies indicated that variety Imdad-2005 × 5 irrigations resulted in maximum number of grains (62.66) $spike^{-1}$, while the minimum number of grains (42.33) $spike^{-1}$ was recorded in the interaction of variety T.D-1 × 3 irrigations. The LSD test indicated a linear significant (P<0.05) difference for the number of grains $spike^{-1}$ between each irrigation level. Moreover, varieties Imdad-2005 and TJ-84 were almost equal in producing

grains spike^{-1} but considerably higher than varieties Kiran and T.D-1. Kabir et al. (2009) examined the effect of irrigation level on the performance of wheat using different levels of irrigations and reported that higher irrigation levels gave better results in all the parameters including grains spike^{-1} and ultimately better yields. Shao et al. (2009) suggested that deficit irrigation applications given to crops in several small amounts were no better than applying them in relatively large quantities (Table 2).

1000- grain Weight (g).

The analysis of variance demonstrated significant effect ($P<0.05$) of irrigation levels on 1000-grain weight; while the effect of varieties and variety × irrigation level interaction on this trait was statistically non-significant ($P>0.05$). The 1000-grain weight was maximum (60.50g) in plots irrigated five times, while the crop receiving four irrigations and three irrigations gave 1000-grain weight of 57.60 g and 50.80 g, respectively. In varieties, maximum 1000-grain weight (58.40 g) was recorded in variety Imdad-2005, followed by varieties TJ-83 and Kiran with 56.20 g and 55.60 g average 1000-grain weight, respectively. However, the minimum 1000-grain weight (54.90 g) was noted in wheat variety T.D-1. The interaction studies showed that variety Imdad-2005 × 5 irrigations resulted in maximum 1000-grain

Table 2. Grains spike^{-1}, 1000-grains weight (g) and grain yield (kg ha^{-1}) of wheat varieties as influenced by various irrigation levels

Irrigation	Variety				Mean for irrigations
	Imdad-2005	TJ-83	Kiran	TD-1	
Grains spike^{-1}					
03	46.66	46.00	43.66	42.33	44.66 ^{c}
04	55.66	53.00	50.00	49.00	51.91 ^{b}
05	62.66	61.66	57.00	56.33	59.41 ^{a}
Mean for varieties	54.99	53.55	50.22	49.22	
LSD 0.05: Varieties(V)=(ns), Irrigation levels(I)=6.7766, I×V=(ns)					
1000-grains weight (g)					
03	54.90	50.20	49.50	48.80	50.80 ^{b}
04	58.20	57.80	57.20	57.20	57.60 ^{a}
05	62.10	60.80	60.30	58.80	60.50 ^{a}
Mean for varieties	58.40	56.20	55.60	54.90	
LSD 0.05: Varieties(V)=(ns), Irrigation levels(I)=3.6466, I×V=(ns)					
Grain yield (kg ha^{-1})					
03	5350.00	4655.00	4550.00	4444.00	4749.75 ^{b}
04	5838.00	5232.00	5032.00	4821.00	5230.75 ^{a}
05	6226.00	6020.00	5703.00	5500.00	5862.25 ^{a}
Mean for varieties	5804.66	5302.33	5095.00	4921.66	
LSD 0.05: Varieties(V)=(ns), Irrigation levels(I) = 785.49, I×V = (ns)					

weight (62.10 g), while the minimum 1000-grain weight (48.80 g) was recorded in the interaction of variety T.D-1 × 3 irrigations. The LSD test indicated that the differences in 1000-grain weight between four and five irrigations was non-significant (P>0.05) and significant (P<0.05) when compared with the crop receiving 3 irrigations. Variety Imdad-2005 maintained its superiority surpassing all tested varieties for this trait. These results are in accordance with those of Abd El-Gawad et al. (1994) who found that increasing irrigation level increased thousand kernel weight. Significant effects of the water regime were found on all measured traits by Ibrahim et al. (2007) and the studies carried out by Khan et al. (2007); Lin et al. (2007) and Shao et al. (2009) indicated that at least four to five irrigations are needed for obtaining desired results in wheat (Table 2).

Grain Yield (ha^{-1})

Grain yield per unit area is mostly influenced by its contributing traits and all research efforts are centralized to achieve higher grain yield ha^{-1}. There was significant (P<0.05) effect of irrigation levels on grain yield, while the effect of varieties as well as variety × irrigation level interaction on grain yield was non-significant (P>0.05). The highest grain yield (5862.25 kg ha^{-1}) was achieved from the crop given five irrigations throughout its growing season, followed by four irrigations where 5230.75 kg ha^{-1} grain yield was achieved. However, the lowest grain yield (4749.75 kg ha^{-1}) was obtained from the crop receiving three irrigations. The varietal effect indicates that the maximum grain yield (5804.66 kg ha^{-1}) was produced by commercial variety Imdad-2005, followed by varieties TJ-83 and Kiran giving average grain yield of 5302.33 and 5095.00 kg ha^{-1}, respectively. However, the variety T.D-1 produced lowest grain yield of 4921.66 kg ha^{-1}. The interactive effect indicates that interaction of variety Imdad-2005 × 5 irrigations resulted in maximum grain yield (6226 kg ha^{-1}), while the minimum grain yield (4444 kg ha^{-1}) was recorded in the interaction of variety T.D-1 × 3 irrigations. The LSD test indicated differences in grain yield between five and four irrigations were non-significant (P>0.05) and significant (P<0.05) when compared with the yield under 3 irrigations. These findings also conform with the results of Khatun et al. (2007) who reported that the wheat yield increase with the increased irrigation level. In another study on the same aspects, Bunyolo (2000) found that significant improvement in wheat yields with increasing irrigation level. Similar results have also been reported by Abro (2012), who reported that four irrigations would be enough if applied at the proper growth stage. Different irrigation regime had a pronounced effect on phonological stages.

The results indicated that irrigation levels has direct effect on vegetative and reproductive periods; water stress at the time of elongation and before booting stages results in early flowering compared to normal irrigation levels. Saleem et al. (2007) and Mohammed (2013) reported that increasing drought stress decreased days to heading and days to maturity.

Mekkei and Haggan (2014) reported skipping irrigations highly

reduced number of tillers m^{-2} and was associated with skipping the 2nd and 3rd irrigation. However, skipping the 4th and 5th irrigation had low reduction in number of tillers m^{-2} compared with other irrigation levels.

These results are in agreements with the findings of Mohammed (2013), Zarien et al. (2014) and Aslam et al. (2014) The recent studies carried out by Rajper (2012) and Mubeen et al. (2013) have also supported the findings of the present study, and reported that four irrigations would be enough, if these irrigations are judiciously applied in wheat (Table 1).

It could be concluded that skipping irrigation at various growth stages significantly decreased plant height, number of tillers m^2, number of spikes m^2, spike length, 1000 grain weight, biological yield and harvest index compared with normal irrigations. It was depicted from the study that skipping the 4th or 5th irrigation led to high reduction in all the yield traits. It was also observed from the findings that significant differences were observed in yield and yield attributing traits among different wheat varieties. Ultimately, it was suggested after prevailing results that judicious application of four irrigations will be adequate to produce higher economic grain yield ha^{-1} from wheat crop.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Mr. Nisar Ahmed Soomro	Conceived the idea, Wrote abstract, Methodology, Data collection
2.	Dr. Abdul Fatah Soomro	Conclusion, Technical input at every step
3.	Mr. Hamza Ali Samo	Data entry in SPSS and analysis
4.	Mr. Muhammad Siddique Depar	Introduction, References

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