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Studies on water requirement of different wheat genotypes grown under irrigation (*Triticum aestivum* L.)

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Abstract
In the *rabi* season of 2019-2020, research entitled "Studies on water requirement of different wheat genotypes grown under irrigation (*Triticum aestivum* L.)" was carried out at the farm of Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra). The treatments entailed of 15 treatment combinations comprised of three irrigation levels i.e., two irrigation (CRI, Flowering), four irrigation (CRI, Tillering, Flowering and Milk stage), six irrigation (CRI, Tillering, Jointing, Flowering, Milk and Dough stage) and five wheat genotypes *viz.*, AKAW-4627, AKAW-4832, WSM 109-4, PDKV SARDAR, and PDKV WASHIM. Three replications of a factorial randomized block design were used to set up the experiment. The soil had a pH of 7.64, was clayey, and had 212.72, 22.27 and 368.45 kg ha^{-1} of readily available N, P and K.
Consumptive use of water was highest in six irrigation that were irrigated frequently. Maximum water productivity and water use efficiency were observed under two irrigations (CRI, Flowering) with genotype AKAW-4627. Under six irrigation scenarios, the genotype AKAW-4627 produced the highest gross monetary returns, net monetary returns, and benefit cost ratio (CRI, Tillering, Jointing, Flowering, Milk and Dough stage).

Keywords: Irrigation levels, water productivity, water requirement, water use efficiency, wheat genotypes

Introduction
The crucial component for the cultivation of crops is water. Throughout their lifetimes, plants require it frequently and in considerable quantities. It has a significant influence on a variety of metabolic processes, counting growth and development, photosynthesis, flowering, maturation, reproduction, grain filling, grain maturity, harvesting, and yield. Both its scarcity and abundance have an effect on a plant's growth and production as well as its yield and quality. Increased agricultural production and productivity are largely dependent on water availability. "The irrigation plays a vital role in growth and development of wheat particularly in semi-arid conditions for better crop yield. Farmers are forced to pump the more groundwater, owing to the limited canal water supply, to fulfil the crop water needs which will increase the cost of production and lowers the groundwater table" (Mekonnen *et al*., 2016) [3]. "Therefore, the scheduling and evaluating the optimum water requirements of the crop by the deficit irrigation are of the great concern in semi-arid tropics to save water and its cost" (Pereira *et al.*, 2002; Ul-Allah *et al*., 2015 and Wakchaure *et al.*, 2016) [5, 7, 8]. Since irrigation water is a limited resource, water use optimization is critical to water resource management. It allows for more efficient use of all other production variables, resulting in higher yields per unit area and time. Because of the high variability and inadequacy of rainfall in India, irrigation has been described as a critical factor in agriculture. Irrigation is more important in the cultivation of high yielding wheat varieties because the weather remains dry throughout the crop's growing season (October to April). The judicious application of water necessitates urgent attention will, which can only be achieved by adhering to any technical basis for water application to crops. Critical crop growth stage approach for irrigation scheduling is one such technical approach, especially in the area of water shortage. In irrigated areas, wheat crops need 6 watering, depending on the amount of rainfall. Therefore, there is an urgent need to reduce water requirements by improving irrigation water use efficiency in changing climate conditions.

Materials and Methods

The field trial entitled "Studies on water requirement of different wheat genotypes grown under irrigation (*Triticum aestivum* L.)" was conducted on clayey soil at the farm of Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *rabi* season of 2019-2020. Three replications of a factorial randomized block design were used to set up the experiment. The soil had a pH of 7.64, was clayey, and had 212.72, 22.27 and 368.45 kg ha^{-1} of readily available N, P and K consisting of fifteen treatment combinations. Three irrigations I1 (2 Irrigation at CRI, Flowering), I2 (4 Irrigation at CRI, Tillering, Flowering, Milk stage) and I3 (6 Irrigation at CRI, Tillering, Jointing, Flowering, Milk and Dough stage) and five genotypes *viz.*, AKAW- 4627, AKAW- 4832, WSM 109-4, AKAW-4210-6 (PDKV SARDAR) and WSM- 1472 (PDKV WASHIM) were tested. Gross plot size was 2.40 m x 6 m and Net plot size was 2 m x 5 m.

Soil samples were drawn with the help of screw auger from the depth of 15 and 30 cm. In all treatments soil samples were collected before and after each irrigation. Then samples were transferred immediately to aluminium boxes and covered with lid to avoid sun heating in field. The moisture percent was worked out with gravimetric method.

Consumptive use of water was determined by adding (i) potential evapotranspiration during 24-48 hours (depending upon the season) immediately after each irrigation. (ii) soil moisture utilized from the profile.

(iii) effective rainfall and (iv) ground water utilization. Computation was done as under

$$Cu = \sum_{K=1}^{N} Ek \times 0.8 + \sum_{i=1}^{n} \frac{M1i - M2i}{100} \times Asi \times Di + ER + GWC$$

Where,

Cu = Consumptive use of water (mm)

Ek = actual evaporation for the period of one to two days (immediately after Kth Irrigation) from the standard USWB class A open pan evaporimeter.

N = number of time interval

M1i = moisture percent after 1-2 days since irrigation

M2i = moisture percent on the day just before next irrigation

n = number of soil layers

Asi = bulk density of the ith layer

Di = soil depth (mm) of the ith layer

ER = effective rainfall (mm)

GWC = ground water contribution, if any

Water use efficiency in different irrigation treatments was premeditated based on grain yield and straw yield and consumptive use of water for the entire season for different treatments. Yield per mm of water utilized was computed from the average yield in the given treatment. Water productivity is the income obtained from per m3 of water. Water productivity was calculated by using the following formula.

$$\text{Water productivity (₹ m}^{-3}) = \frac{\text{Gross monetary returns}}{\text{Total applied water}}$$

Results and Discussion

Soil moisture content (%)

Overall status of soil moisture at the depth of 0-30 cm is placed at Table No. 1.

Effect of irrigation levels

The soil moisture content due to number of irrigations was observed to be significant after 2nd irrigation (tillering stage), before and after 3rd irrigation (jointing stage), before 4th irrigation (flowering stage), after 5th irrigation (milk stage), before and after 6th irrigation (dough stage). Data analysis reveals that maximum soil moisture was held with six irrigation [13] which was statistically at par with I2 (four irrigation) at after 2nd irrigation (tillering stage), before 3rd irrigation (jointing stage), after 5th irrigation (milk stage) and before 6th irrigation (dough stage). While minimum soil moisture was held with two irrigations [11]. This might be due to increase in number of irrigations, the resultant soil moisture content increased.

Effect of genotypes

The figures on soil moisture content were not significantly influenced by various genotypes. The soil moisture status of all genotypes was statistically similar.

Consumptive use of water (mm)

Data on consumptive use of water (mm) as influenced by various irrigation treatments are presented in Table No. 2.

Effect of irrigation levels

A marked decrease in consumptive use of water was observed with corresponding decrease in number of irrigations from six to two. Maximum consumptive use of water (480.29 mm) was obtained with six irrigation [13] and minimum consumptive use of water (237.12 mm) with two irrigation [11]. These findings are consistent with those of Singh *et al*. (2010) [6] and Ahmad, Afzal (2016) [1] who found that increased irrigation frequency was accompanied with higher consumptive water usage.

c) Water productivity (₹ m-3) and Water use efficiency (kg ha^{-1} mm^{-1})

Different irrigation levels and genotypes significantly affected the water productivity (₹ m-3) and water use efficiency (kg ha^{-1} mm^{-1}) as reported in Table No. 3.

Effect of irrigation levels

The maximum water productivity (41.25 ₹ m-3) was obtained from plots irrigated with two irrigation [11] followed by water productivity (26.07 ₹ m-3) obtained from four irrigation [12]. Lowest water productivity (20.05 ₹ m-3) was obtained from plots irrigated with six irrigation [13]. This might be due to better yield with less water consumption which leads to higher water use efficiency and thus more income per unit volume of water.

The water use efficiency was found significantly highest (11.34 kg ha^{-1} mm^{-1}) in two irrigation [11] followed by I2- four irrigation (9.67 kg ha^{-1} mm^{-1}) and I3- six irrigation (7.32 kg ha^{-1} mm^{-1}). The lowest consumptive use of water (237.12 mm), which illustrates the efficient use of water at lower irrigation frequencies, was primarily responsible for the I1 (two irrigation) irrigation schedule's excellent water use efficiency. Due to larger losses of water from surface soil (480.29 mm) in the often irrigated (I3 - six irrigation) condition, the water usage efficiency was lower. Similar results were confirmed via Mishra and Tripathi (2010) [4] and Kumar *et al.* (2016) [2] that WUE reduced with increased in

number of irrigations.

Effect of genotypes

The water productivity and water use efficiency due to genotypes was observed to be significant. Genotype AKAW-4627 and PDKV SARDAR recorded highest water productivity (44.59 ₹ m-3 and 43.32 ₹ m-3) and water use efficiency (14.22 kg ha^{-1} mm^{-1} and 13.79 kg ha^{-1} mm^{-1} respectively) over all other genotypes. However, these two treatments were at par among each other.

Interaction effect

Water productivity and Water use efficiency showed significant effect under interaction of irrigation schedule and genotypes are presented in Table 4 and 5.

Genotype G1 (AKAW-4627) recorded maximum water productivity (55.80 ₹ m-3) at two irrigation which was at par with combination of two irrigation with genotype PDKV SARDAR (54.52 ₹ m-3) and significantly higher to rest of the treatment combinations. All the genotypes were reported well to decreased irrigation.

The maximum water use efficiency (15.77 kg ha^{-1} mm^{-1}) was found in the genotype AKAW-4627 combined with two irrigation applied at CRI and flowering stages, which was at par with combination of two irrigation with genotype PDKV SARDAR (15.45 kg ha^{-1} mm^{-1}).

Table 1: Effect of various levels of irrigation and genotypes on soil moisture content (%)

Treatments	Soil moisture content (0-30 cm)											
Factor A- Irrigation levels	**Before CRI**	**After CRI**	**Before Tillering**	**After Tillering**	**Before Jointing**	**After Jointing**	**Before Flowering**	**After Flowering**	**Before Milk stage**	**After Milk stage**	**Before Dough stage**	**After Dough stage**
I1- 2 Irrigation (CRI, Flowering)	29.40	34.20	28.75	28.39	24.12	23.29	20.44	31.85	26.01	25.89	19.64	19.31
I2- 4 Irrigation (CRI, Tillering, Flowering, Milk stage)	30.20	34.38	28.93	33.85	27.66	26.79	24.16	32.98	27.58	32.81	25.28	24.30
I3- 6 Irrigation (CRI, Tillering, Jointing, Flowering, Milk and Dough stage)	30.76	34.64	29.26	34.19	28.48	33.44	28.51	33.52	28.11	33.36	26.67	32.79
S.E. (m) ±	0.59	0.48	0.51	0.55	0.71	0.68	0.61	0.55	0.75	0.64	0.60	0.62
C.D at 5%	NS	NS	NS	1.59	2.06	1.97	1.78	NS	NS	1.87	1.74	1.80
Factor B- Genotypes												
G1- AKAW-4627	30.22	34.49	29.32	31.60	26.64	25.60	22.86	33.32	27.78	30.04	23.44	22.53
G2- AKAW-4832	29.45	34.21	28.58	30.94	25.21	24.55	21.75	31.87	26.32	28.56	22.22	21.57
G3- WSM 109-4	29.21	33.93	28.17	30.60	25.09	24.27	21.72	31.75	25.38	28.26	21.47	21.07
G4- PDKV SARDAR	29.99	34.43	29.18	31.43	26.29	25.57	22.77	32.92	27.47	30.00	23.02	22.38
G5- PDKV WASHIM	30.12	34.40	28.95	31.05	26.21	25.21	22.39	32.22	27.03	29.90	22.14	21.47
S.E. (m) ±	0.77	0.62	0.66	0.71	0.91	0.87	0.79	0.71	0.97	0.83	0.77	0.80
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (IXG)												
S.E. (m) ±	1.33	1.07	1.14	1.23	1.59	1.52	1.38	1.24	1.68	1.45	1.34	1.38
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Consumptive use of water (mm) as affected by levels of irrigation

Treatments	Consumptive use of water (mm)
I1- 2 Irrigation (CRI, Flowering)	237.12
I2- 4 Irrigation (CRI, Tillering, Flowering, Milk stage)	324.37
I3- 6 Irrigation (CRI, Tillering, Jointing, Flowering, Milk and Dough stage)	480.29

Table 3: Water use efficiency (kg ha^{-1} mm^{-1}) and water productivity (₹ m-3) as affected by various levels of irrigation and genotypes

Treatments	Water use efficiency (kg ha^{-1} mm^{-1})	Water productivity (₹ m-3)
Factor A- Irrigation levels		
I1- 2 Irrigation (CRI, Flowering)	11.34	41.25
I2- 4 Irrigation (CRI, Tillering, Flowering, Milk stage)	9.67	26.07
I3- 6 Irrigation (CRI, Tillering, Jointing, Flowering, Milk and Dough stage)	7.32	20.05
S.E. (m) ±	0.13	0.35
C.D at 5%	0.38	1.02
Factor B- Genotypes		
G1- AKAW-4627	14.22	44.59
G2- AKAW-4832	9.31	29.97
G3- WSM 109-4	7.38	24.53
G4- PDKV SARDAR	13.79	43.32
G5- PDKV WASHIM	7.82	25.90
S.E. (m) ±	0.17	0.46
C.D. at 5%	0.49	1.32
Interaction (IxG)		
S.E. (m) ±	0.30	0.79
C.D. at 5%	0.85	2.29
GM	9.44	29.13

Table 4: Water productivity (₹ m-3) as influenced by interaction of various levels of irrigation and genotypes

Treatments	Genotypes					Mean 'A'
	AKAW-4627	AKAW-4832	WSM 109-4	PDKV SARDAR	PDKV WASHIM	
I1- 2 Irrigation (CRI, Flowering)	55.80	34.40	30.52	54.52	30.99	41.25
I2- 4 Irrigation (CRI, Tillering, Flowering, Milk stage)	33.37	25.53	18.55	32.12	20.81	26.07
I3- 6 Irrigation (CRI, Tillering, Jointing, Flowering, Milk and Dough stage)	25.95	19.38	14.77	23.29	16.89	20.05
Mean 'B'	44.59	29.97	24.53	43.32	25.90	
SE (m) ±	0.79					
C.D. at 5%	2.29					

Table 5: Water use efficiency (kg ha^{-1} mm^{-1}) as influenced by interaction of various levels of irrigation and genotypes

Treatments	Genotypes					Mean
	AKAW-4627	AKAW-4832	WSM 109-4	PDKV SARDAR	PDKV WASHIM	'A'
I1- 2 Irrigation (CRI, Flowering)	15.77	9.18	8.15	15.45	8.15	11.34
I2- 4 Irrigation (CRI, Tillering, Flowering, Milk stage)	12.68	9.44	6.61	12.14	7.49	9.67
I3- 6 Irrigation (CRI, Tillering, Jointing, Flowering, Milk and Dough stage)	9.68	7.07	5.16	8.62	6.10	7.32
Mean 'B'	14.22	9.31	7.38	13.79	7.82	
SE (m) ±				0.30		
C.D. at 5%				0.85		

Conclusion

Maximum water productivity and water use efficiency were recorded under two irrigations (CRI, Flowering) with genotype AKAW-4627.

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