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Determination of suitable irrigation schedule for optimum water use efficiency of wheat crop.

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Abstract
A field experiments was conducted during *rabi* seasons of 2014-2015 and 2015-2016 at the Agromet Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) The treatment comprised of four levels of irrigation schedule *Viz.,* I_1 (critical stages), I_2 (0.6 IW: CPE ratio), I_3 (0.8 IW: CPE ratio), and I_4 (1:0 IW: CPE ratio). The findings of present investigation indicated that the grain and straw yields as well as most of the growth and yield attributes of wheat were significantly influence due to different irrigation schedule. The results, further revealed that growth attributes such as plant height (cm), number of shoots m^{-2} and Leaf area index (LAI) were found significantly higher under I_1 (critical stages) treatment during both year 2014-15 and 2015-16. The total number of effective tillers m^{-2}, length of spike (cm), harvest index (%) and test weight (gm) were found higher under I_1 (critical stages) and I_4 (1.0 IW: CPE ratio) treatment during both years. The highest grain yield (52.3 and 52.2 q/ha) and straw yield (65.8 and 66.9 q/ha) recorded under I_1 (critical stages) treatment during the both years of 2014-15 and 2015-16. The lowest grain yield (51.2 and 51.9 q/ha) and straw yield (64.4 and 65.3 q/ha) was recorded under I_2 (0.6 IW: CPE ratio) during both years. The highest WUE (16.42 and 16.70 kg ha^{-1} mm^{-1}) was recorded under I2 (0.6 IW: CPE ratio) treatment and lowest (14.69 and 14.96 kg ha^{-1} mm^{-1}) under I_1 treatment.

Keywords: irrigation schedule, leaf area index, water use efficiency, grain yield, straw yield, harvest index.

Introduction
Wheat *(Triticum aestivum* L.*)* is one of the most important cereal crop in large number of countries in the world. It provides about 20% of total food calories for the human race. It is widely grown through the temperate zone and in some tropical and sub-tropical areas at higher elevation. The major wheat growing countries in the world are USSR, USA, China, India, Canada, Australia, France, Turkey and Pakistan. It ranks first (Anonymous, 2013) [2] in the world among the cereals both in respect of area (225.43 mha) and production (708.0 mt). Water is essential at every developmental phase starting from seed germination to plant maturation for harvesting the maximum potential yield of wheat. There is a positive correlation between grain yield and irrigation frequencies (Bajwa *et al.,* 1987) [3]. Availability of adequate amount of moisture at critical stages of plant growth not only optimizes the metabolic process in plant cell but also increases the effectiveness of the mineral nutrients applied to the crop (Bajwa *et al.,* 1993) [4]. Water deficit imposed after planting significantly reduces the plant growth and yield (Harold, 1986).Normal irrigations are essential for bumper crop production, but when there is scarcity of water, it becomes imperative to differentiate the critical growth stages of the crop where irrigation could be missed, without reducing the grain yield significantly (Timsina *et al.,* 1998) [16]. Irrigation missing at some critical growth stage sometime drastically reduces grain yield (Chauhan *et al.,* 2008) [7] due to lower test weight (Bajwa*et al.,* 1993) [4]. However, number of productive tillers per unit area remains unaffected (Rana, 1976) [12]. Similarly, over irrigation also sometimes tends to decrease grain yield instead of increasing yield (Kahlown and Azam, 2002) [8]. Among the various factors responsible for poor productivity of wheat, the irrigation scheduling is one of the major is play a vital role among them

Materials and Methods
Experimental site
The experimental site is located at the main campus of university on the left side of Faizabad

- Raibareilly road at a distance of 43 km away from Faizabad district headquarter.

Climate in brief

The local of experimental site lies between a latitude of $24^0$47' and $26^0$56' N and longitude of $82^0$12' and $83^0$98' E and an altitude of 113 m mean sea level, in the gangetic alluvium of eastern Uttar Pradesh. The Faizabad district falls in semi-arid zone, receiving a mean annual rainfall of about 1063 mm, out of which about 89 percent of the total rainfall is received during south-west monsoon (from June to September) with few showers (4%) in winter season. On the basis of average rainfall intensity during monsoon season it was that rainfall mostly occurred between July to September while mid-September onwards.

Experimental details

The PBW 343 cultivars of wheat was sown at 15th Nov. during the year 2014-15 and 2015-16 with recommended package of practices Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.).

Scheduling of irrigation

A fixed quantity of 60 mm of water was applied to the concerned experimental plots according to the irrigation schedules of the respective treatment. Irrespective of the treatments, uniform irrigation was given immediately after sowing to all the treatments for better establishment of the crop. The cumulative pan evaporation values were calculated from daily pan evaporation measured with the help of USWB class 'A' open pan evaporimeter installed at meteorological observatory, which was in the proximity of the experimental plot. A fixed depth of 60 mm irrigation water was applied to each treatment at irrigation based on IW: CPE ratio of 0.6, 0.8 and 1.0, respectively.

Plant height (cm)

Five plants were selected randomly in each plot and tagged for measuring height at different intervals. Height was measured at 30, 45, 60, 75, 90, 105 and 120 DAS with the help of meter scale from ground surface to the tip of the topmost leaf before heading and up to the base of the ear head after heading.

Number of shoots m^{-2}

The number of shoots were counted at 30, 45, 60, 75, 90, 105 and 120 DAS by placing quadrate at three places in each plot and the plants which come within the quadrate were averaged out to express shoots per square meter.

Leaf area index (LAI)

The leaf area was measured at 30, 45, 60, 75, 90, 105 and 120 DAS of the crop. The plants of 25 cm row length were taken and green leaves were separated to record their surface area by automatic leaf area meter. All the leaves were grouped into three viz., small, medium and large. Five leaves from each group were taken and their surface areas were measured. Areas of five leaves were multiplied with respective leaf numbers of a group and sum of all the three gave the total leaf area. For obtaining index, leaf area was divided by the ground area.

$$\text{LAI} = \frac{\text{Leaf area}}{\text{Ground area}}$$

1000-grain weight (g)

The samples were collected randomly from the cleaned grains of each plot and 1000-grains were counted and weighed in gram with the help of electronic balance.

Grain yield (qha^{-1})

After weighing the total biomass of each plots. The produce of each net plot was threshed separately and cleaned grain were air dried to maintain 12 per cent moisture. The grain yield was recorded in kg per plot and finally converted into quintal per hectare.

Straw yield (q ha^{-1})

The yield of straw was calculated by subtracting the grain yield from the total biological yield of the crop.

Harvest index (%)

The recovery of grains in the total harvested produce was considered as harvest index. It was calculated with the help of following formula.

$$HI\ (\%) = \frac{Economic\ yield}{Biological\ yield} \times 100$$

Water use efficiency (Kg ha^{-1} mm)

The response of seed yield per unit of irrigation water used at varying level of irrigation was worked out by dividing per hectare seed yield of wheat crop obtained under various treatment with the total water use (mm) of the respective treatment and it was recorded as crop water use efficiency (kg ha^{-1} mm) which was worked out by the following formula which is described by Michael (1978).

$$\text{WUE (Kg ha}^{-1}\text{ mm)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Water requirement (mm)}}$$

Result and discussion

Plant height

Plant height of wheat showed statistically significant variation due to moisture regime at 30,45,60,75,90,105 and at 120 DAS under the present trail (Table.1).The taller plant (18.3&18.2,32.6&32.5, 43.4&44.1,66.4&67.5, 88.5&90.0, 91.3&92.9, 95.3&96.9cm) was recorded from I_1(critical stages) at 30, 45, 60, 75, 90, 105 and 120 DAS both year 2014-15 and 2015-16 respectively and at par with I_4while the shorter plant (17.3&17.2, 28.5&28.4, 38.0&38.6, 56.6&57.6, 75.5&76.6, 79.8&81.2, 83.4&84.8) was recorded from I_2 (0.6 IW:CPE ratio). (Sharma *et al.* 1990) [14]

Number of shoots m^{-2}

Moisture regime varied significantly in terms of shoots m^{-2} of wheat at30, 45, 60, 75, 90, 105 and 120 DAS has been presented in Table 2. at 30, 45, 60, 75, 90, 105 and 120 DAS, the highest shoots m^{-2}viz. 205.7&206.2, 281.3&280.6, 316.1&321.4, 388.5&398.0, 470.55472.2, 467.45&469.5, 455.0&453.3 were recorded from I_1 (critical stages) and lowest number of shoots m^{-2} under the I_2 (0.6 IW: CPE ratio) during both year 2014-15 and 2015-16.In general the leaf area index increased with the advancement of the crop growth and reached to its maximum at 75 DAS and thereafter it decreased because of senescence of leaves. (Saren *et al.* 2004) [13]

Leaf area index (LAI)

Moisture regime in terms of leaf area index of wheat was presented in Table 3. at 30, 45, 60, 75, 90, 105 and 120 DAS (Moisture regime, date of sowing and variety had no significant influence on the leaf area index of wheat at 30 DAS. In general the leaf area index increased with the

advancement of the crop growth and reached to its maximum at 75 DAS and thereafter it decreased because of senescence of leaves. The I_1 moisture regime noticed significantly higher LAI (2.4 and 2.4) at 45 DAS, (4.0 and 4.1) at 60 DAS,(4.0 and 4.1) at 75 DAS, (4.1 and 4.2) at 90 DAS,(3.4 and 3.5) at 105 DAS, (2.0 and 2.1) at 120 DAS during the year 2014-15 and 2015-16, respectively over other moisture regime (Ahmad 2002) [1].

Effective tillers m^{-2}

Moisture regime varied significantly in terms of number of effective tillers m^{-2}of wheat are presented in Table 4.8 and Fig. 4.which revealed that the different moisture regime adopted under the study differed significantly for effective tillers m^{-2}. Highest number of effective tillers m^{-2} (445.4 and 452.9) were recorded with I_1 (critical stages) as compare to other irrigation level The increase in number of tillers might be due to enhanced vegetative growth, due to of beneficial role of water in maintaining cell turgidity, cell elongation and cell division and also meristmatic cell elongation in the axillary buds in turn trigged the various activities and increases the supply of photosynthets and thereby increase in number of tillers. The lowest number of effective tillers m^{-2} was found in I_2 (331.9 and 337.6) moisture regime, respectively during both of the year. (Khola *et al.* 1989) [10]

Spike length (cm)

The data of spike length as influenced by moisture regime of wheat presented in Table 4. It is evident from the results that the differences in spike length to different moisture regime were found significant. However, treatment I_1 (12.5 and 12.7cm) was recorded highest which was significantly superior over the I_2 and I_3, and found at par with I_4 irrigation level. (Karim (2011) [9].

Test weight (g)

The results showed that the moisture regime affected the test weight of wheat grain significantly (Table 4.). Significantly higher 1000-grain weight was recorded with I_1 (critical stage) as compared to I_2 and I_3 was and at par with the I_4 in both of the year. The data pertaining to grain yield was recorded and presented in Table 4. The statistical comparison of the results of grain yield revealed that differences in yield due to differences in the different irrigation treatments were found statistically significant. I_1 (critical stages) treatment yielded the highest (52.3 q/ha and 53.2 q/ha in the year 2014-15 and 2015-16 respectively) as compared to I_2, I_3 and I_4 treatment. However, I_1 and I_4 were found to be at par with each other in respect of their respective yields. The lowest grain yield with I_2 (45.8 and 46.5 q/ha) during the year 2014-15 and 2015-16, respectively. (Maliwal *et al*. (2000) [11].

Straw yield (t/ha)

Data pertaining to straw yield indicated that the moisture regimes had significant effect on the straw yield of wheat (Table 5.). Highest straw yield (65.8&66.9q/ha) was recorded in I_1 (critical satges) treatment and lowest (57.5&58.5q/ha) under I_2 treatment. Treatment I_1 and I_4 treatment were found to be at par with each other. (Brahma *et al.* 2006) [6].

Harvest index

The data on harvest index as influenced by different moisture regime, sowing date and varieties are presented in Table 5. Data indicated that moisture regime have been significant effect on the harvest index. Highest harvest index (45.4 and 46.2% during 2014-15 and 2015-16, respectively) was recorded under I_1 (critical stages) irrigation scheduling. However, lowest harvest index was observed in I_2 irrigation scheduling 39.70 and 40.4 during both of the years respectively. (Bastia and Rout 2000) [5]

Water Use Efficiency of Wheat

The water use efficiency (WUE) as presented in table 6. The water use efficiency was influenced due to different irrigation schedules. The highest water use efficiency (16.42 and 16.70 Kg ha^{-1} mm^{-1}) was recorded under treatment I2 (0.6 IW: CPE ratio) as compare to rest treatments during both of the years 2014-15 and 2015-16 respectively (Singh and Uttam 1993) [15].

Table 1: Effect of Irrigation level on plant height of wheat.

Treatments	Plant Height (cm)													
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime														
I_1 (Critical stages)	18.3	18.2	32.6	32.5	43.4	44.1	66.4	67.5	88.5	90.0	91.3	92.9	95.3	96.9
I_2 (0.6 IW : CPE)	17.3	17.2	28.5	28.4	38.0	38.6	56.6	57.6	75.5	76.7	79.8	81.2	83.4	84.8
I_3 (0.8 IW : CPE)	17.2	17.1	29.8	29.7	39.7	40.4	59.3	60.2	79.0	80.3	83.6	85.0	87.3	88.7
I_4 (1.0 IW : CPE)	17.5	17.9	31.3	32.1	41.7	42.3	62.2	63.1	83.0	86.1	87.8	91.2	91.7	95.2
SEm±	0.40	0.39	0.48	0.72	0.64	0.66	1.31	0.96	1.74	1.71	1.35	1.84	1.41	2.12
CD at 5%	NS	NS	1.66	2.48	2.21	2.27	4.52	3.32	6.03	5.93	4.66	6.36	4.86	7.35

Table 2: Effect of Irrigation level on Number of shoots of wheat.

Treatments	Number of Shoots (M-^{2})													
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime														
I_1 (Critical stages)	205.7	206.2	281.3	280.6	316.1	321.4	388.5	395.0	470.5	472.2	467.4	469.5	455.0	453.3

I_2 (0.6 IW: CPE)	194.2	194.8	246.0	245.2	276.4	281.2	339.7	345.5	401.1	402.6	398.4	400.2	387.9	386.5
I_3 (0.8 IW: CPE)	193.4	194.3	257.6	256.5	289.4	294.1	355.7	361.5	419.9	421.2	417.2	419.0	406.1	404.4
I_4 (1.0 IW: CPE)	202.3	197.1	270.5	277.3	304.0	315.6	373.6	387.8	441.1	452.0	438.2	440.1	426.5	433.9
SEm±	4.01	4.54	4.15	5.59	4.66	7.04	5.73	8.65	9.27	8.99	9.21	9.25	8.96	8.63
CD at 5%	NS	NS	14.35	19.34	16.12	24.36	19.81	29.94	32.07	31.11	31.85	32.00	31.01	29.86

Table-3: Effect of Irrigation level on leaf area index of wheat

Treatments	Leaf area index (LAI)													
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Irrigation level														
I_1 (Critical stages)	1.8	1.8	2.4	2.4	4.0	4.1	4.0	4.1	4.1	4.2	3.4	3.5	2.0	2.1
I_2 (0.6 IW: CPE)	1.7	1.7	2.1	2.1	3.5	3.6	3.4	3.5	3.5	3.6	2.9	3.0	1.7	1.7
I_3 (0.8 IW: CPE)	1.7	1.7	2.2	2.2	3.7	3.8	3.6	3.6	3.7	3.7	3.0	3.1	1.8	1.8
I_4 (1.0 IW: CPE)	1.7	1.7	2.3	2.4	3.9	3.9	3.7	3.9	3.9	3.9	3.2	3.3	1.9	2.0
SEm±	0.04	0.04	0.03	0.05	0.06	0.06	0.08	0.08	0.08	0.06	0.07	0.07	0.04	0.04
CD at 5%	NS	NS	0.12	0.17	0.21	0.20	0.27	0.27	0.28	0.20	0.23	0.23	0.14	0.14

Table 4: Effect of Irrigation level on yield attributes of wheat of wheat

Treatments	Effective Tillers m^{-2}		Length of Spike (cm)		Test Weight (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Irrigation level						
I_1 (Critical stages)	445.4	452.9	12.5	12.7	41.8	41.7
I_2 (0.6 IW : CPE)	331.9	337.6	10.5	10.7	35.2	35.1
I_3 (0.8 IW : CPE)	389.6	396.0	11.2	11.4	37.5	37.4
I_4 (1.0 IW : CPE)	430.0	436.1	11.9	12.4	39.8	39.9
SEm±	5.66	7.99	0.24	0.25	0.82	0.74
CD at 5%	19.59	27.64	0.85	0.86	2.83	2.55

Table 5: Effect of Irrigation level on grain, straw yield and harvest index of wheat of wheat

Treatments	Grain yield (q/ha)		Straw yield (q /ha)		Harvest index (%)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Irrigation level						
I_1 (Critical stage)	52.3	53.2	65.8	66.9	45.4	46.2
I_2 (0.6 IW : CPE)	45.8	46.5	57.5	58.5	39.7	40.4
I_3 (0.8 IW : CPE)	47.9	48.7	60.2	61.2	41.6	42.2
I_4 (1.0 IW : CPE)	51.2	51.9	64.4	65.3	44.4	45.0

Table 6 Water use efficiency (WUE) of wheat under different Irrigation level.

Irrigation Treatment	Yield (Kg ha^{-1})		Irrigation Water(mm)		WUE (Kg ha^{-1} mm^{-1})	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Irrigation level						
I_1 (Critical stages)	5289	5378	360	360	14.69	14.93
I_2 (0.6 IW : CPE)	3941	4009	240	240	16.42	16.70
I_3 (0.8 IW : CPE)	4627	4703	300	300	15.42	15.67
I_4 (1.0 IW : CPE)	5106	5179	360	360	14.18	14.38

Conclusion

Results from this study that the suitable irrigation schedule for wheat crop was found under I_1 (critical stages) treatment produced significantly the highest yield of wheat. Plant height, number of shoot, leaf area index, effective teller, grain yield, straw yield and harvest index was found significantly highest under I_1 (critical stages) treatment as compared to rest treatments. Highest water use efficiency was observed under I_2 (0.6 IW: CPE ratio) followed by I_3 (0.8 IW: CPE ratio), I_4 (1.0 IW: CPE ratio) and I_1 (critical stages) irrigation level.

References

1. Ahmad A. Effect of irrigation scheduling on the performance of wheat genotypes invertisols. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad. 2002.
2. Anonymous Progress Report 2012-2013. Directorate of Wheat Research, Karnal, India 2013, 1.
3. Bajwa *et al.* Effect of irrigation requirement and nitrogen rates on the yield and protein contents of wheat.*Pakistan* Journal of Agricultural Research. 1987; 8(3):325-329.

4. Bajwa *et al.* Influence of different irrigation regimes on the yield and yield components of wheat. Pakistan Journal of Agricultural Research. 1993; 14(4):361-365.
5. Bastia DK, Rout AK. Response of wheat (*Triticumaestivum*) cultivars to levels of fertilizers under limited irrigation. Indian. J. of Agron. 1993-2000; 46(4):670-673.
6. Brahma *et al.*, Effect of irrigation schedules, mulch and antitranspirant on growth, yield and economics of wheat. Karnataka J. Agric. Sci. 2006; 20(1):6-9.
7. Chauhan *et al.* Supplemental irrigation of wheat with saline water. Agricultural Water Management, 2008; 95: 253-258.
8. Kahlown Azam. Individual and combined effect of water logging and salinity on crop yields in the Indus basin. Journal of International Communication, Irrigation and Drainage, 2002; 51(4):329-338.
9. Karim M. Growth and Yeild Components of Wheat under Water Stress of Different Growth Stage. Bangladesh J. Agril. Res. 2011; 36(3):455-468.
10. Khola OPS, Rao DS, Ram Mohan, Singh H, Faroda AS. Response of late sown dwarf wheat to irrigation and fertility levels. Indian J. Agron. 1989; 34(1):114-116.
11. Maliwal GL, Patil JK, Kaswala RR, Patil ML, Bhatnagar R, Patil JC *et al.* scheduling of irrigation for wheat (*Triticumaestivum*) under restricted water supply in Narmada region. Indian Journal of Agricultural Sciences, 2000; 70(2):90-92.
12. Rana MZI, Growth and yield of wheat by early irrigation, M.Sc. Thesis, Department of Agronomy, University of Agriculture, Faisalabad, 1976.
13. Saren BK, Dey S, Mandal D. Effect of irrigation and sulphur on yield attributes productivity, consumptive use, and consumptive use efficiency of wheat (*Triticumaestivum* L.). Indian Journal of Agricultural Sciences. 2004; 74(5):257-261.
14. Sharma BD, Kar S, Cheema SS. Yield, water use and nitrogen uptake for different water and N levels in winter wheat. Fertilizer Research; 1990; 22(2):119-127.
15. Singh VPN, Uttam SK. Performance of wheat (*Triticumaestivum*) cultivars under limited irrigation and fertility management. Indian. J. of Agron. 1993; 38(3):386-388.
16. Timsina *et al.*, Cultivar, nitrogen and moisture effect on a rice wheat sequence, Experimental and stimulation., Agronomy Journal., 1998; 90(2):119-130.