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Effect of different varieties and Irrigation scheduling on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
The particulars of experimental material used and techniques adopted during the course of investigation entitled "Effect of different varieties and Irrigation Scheduling on Growth and Yield of Wheat (*Triticum aestivum* L.)". Field experiment was carried out during Rabi season of 2021-22 at Agricultural Research Farm of Faculty of Agriculture sciences and allied Industries Rama University, Mandhana Kanpur (U.P). The experiment was laid out in Factorial Randomized block design with three replications keeping three irrigation scheduling 0.6 IW/CPE, 0.9 IW/CPE and 1.2 IW/CPE with combination four varieties HD-2285, NW-1067, Kundan and U. Halna. Results revealed that among the practices treatment combination 1.2 IW/CPE irrigation scheduling and variety U. Halna proved as superior than other treatments with respect to higher crop growth and yield attributes whereas plant height, leaf area index, length of spike, grain per spike, test weight of 1000 grain grain and straw yield. Maximum gross return and cost of cultivation was found with 1.2 IW/CPE irrigation scheduling and variety U. Halna treatment combination. While maximum net return was found with treatment combination 1.2 IW/CPE irrigation scheduling and variety U. Halna. Maximum B:C ratio was obtained in combination of 1.2 IW/CPE irrigation scheduling and variety U. Halna. The planting was done on 4th december 2021. Amoung the various treatment combination 1.2 IW/CPE irrigation scheduling and variety U. Halna recorded highest B:C ratio and yield.

Keywords: Different varieties and irrigation scheduling, *Triticum aestivum*, yield of wheat

1. Introduction
Wheat is one of the most important cereal crop of India as well as in many parts of the world. It shares a major portion in food security mission of the country. Wheat is very adaptable crop and is grown under the wide range of soil and climatic conditions. In India it is grown mostly in plains as well as in mountainous region of North and South India. India is second largest producer of wheat after China. Major wheat growing states in India, Uttar Pradesh ranks first in both area and production, while Punjab ranks first in productivity (Agriculture census 2015-16). In Uttar Pradesh, the crop occupies an area of 9.65 million hectares and production of 26.87 million tonnes with an average productivity of 2786 kg/ha whereas, in India it is cultivated on an area of 29.58 million ha with the production of 99.70 million tones having productivity of 3.37 tonnes ha^{-1} (Anonymous, 2020).

Wheat crop needs sufficient available water to achieve optimum yields, quality and adequate grain-protein content. In recent years, the water storage has gradually decreased in our country mainly due to the annual increasing irrigation and dry climate. Therefore, a better understanding of the water balance is essential for exploring water saving measures. One of the most important aspects of water balance is number of irrigation to the crop, which is a key factor to determine proper water usage to improve water use efficiency in irrigated agriculture. Wheat is highly sensitive to water stress during the crown root initiation (CRI) and flowering but over irrigation may lead to heavy vegetative growth and shortening of reproductive period and decrease in the final yield. Thus, timing the length of irrigation interval with the stages of crop growth might bring about a reduction in the number of irrigation and results in an economic crop yield. Irrigation scheduling is one of the important crop management activities and influences the effective and efficient utilization of water by crops. It simply implies when to irrigate the crop and how much water to apply. It optimizes agricultural production with minimizing yield loss due to water shortage and improving performance and sustainability of any irrigation system through conserving water. Water is needed mainly to meet the evapotranspiration requirements. Evapotranspiration depends on climate.

2. Growth Studies

2.1. Initial plant population

A perusal of data (Table-1) showed that initial plant population recorded at 15 DAS was not influenced significantly due to various irrigation schedules and wheat varieties.

2.2. Plant height (cm)

The data pertaining to plant height was recorded at various growth stages i.e., 45, 65, 85 DAS and at harvest as influenced by different moisture regimes and wheat varieties is summarized in Table-1.

Plant height increases progressively with increase in age up to 85 days with a slight decline thereafter. The abrupt increase in height from 45 to 85 DAS shows grand growth period of the crop.

The different treatments of irrigation scheduling could not influence the plant height at 45 DAS. The plant height recorded at 65 DAS, 85 DAS, and at harvest was influenced significantly with increasing the irrigation schedules from three to six irrigations. The tallest plants were observed under 1.2 IW/CPE ratio (I_3) which was at par with 0.9 IW/CPE ratio (I_2) but showed significant superiority over 0.6 IW/CPE ratio (I_1). Similar results have been reported by Singh *et al.* (2003) [22], Brahma *et al*. (2007) [2], Kabir *et al*. (2010) [5] and Aslam *et al.* (2014) [1].

Variety Unnat Halna (V_4) produced tallest plant as compared to other a n d recorded12.36, 83.66, 94.78 and 97.41cm plant at 45,65, 85 DAS and at harvest of crop, respectively, which was at par with Kundan (V_3) and was found to be significantly superior over rest of the cultivar at all the stages. Wheat variety HD-2285 (V_1) produced significantly dwarf plants than other varieties and recorded 10.40, 79.81, 86.74 and 90.55 cm height at 45, 65, 85 DAS and at harvest of the crop respectively. These results are in accordance with Jat and Singh (2004) [4], Kulhari *et al.* (2000) [7].

Table 1: Plant height (cm) at different growth stages as influenced by different irrigation schedules and varieties of wheat

Treatments	Initial Plant population (m^{-2}) 15 DAS	Plant height (cm)			
		45 DAS	65 DAS	85 DAS	At harvest
A. Irrigations schedules					
0.6 IW/CPE	121.33	11.61	80.09	81.16	84.86
0.9 IW/CPE	121.25	11.72	82.87	86.26	94.18
1.2 IW/CPE	122.25	11.77	84.73	95.23	102.30
SEm ±	0.62	0.11	0.43	0.65	0.84
CD at 5%	NS	NS	1.28	2.00	2.48
B. Varieties					
HD-2285	122.00	10.40	79.81	86.74	90.55
NW-1067	120.33	11.80	83.21	87.01	93.18
Kundan	122.11	12.25	83.56	88.69	93.98
U. Halna	122.00	12.36	83.66	94.78	97.41
SEm ±	0.72	0.13	0.50	0.43	0.97
CD at 5%	NS	0.38	1.48	1.33	2.87

2.3. Leaf Area Index (LAI)

The data on leaf are index (LAI) recorded at 3 phenological growth stages *i.e*. 45, 65 and 85 DAS as influenced by different irrigation scheduling and wheat varieties are summarized in Table-2.

In general, the leaf area index increases with advancement of the crop growth and reaches to its maximum at 85 DAS and decline thereafter due to senescence of leaves.

The perusal of the data reveals that the irrigation scheduling affected the LAI significantly at all growth stages. Irrigation scheduling at I_3 (1.2 IW/CPE ratio) recorded significantly maximum leaf area at 45 DAS (3.52), 65 DAS (4.73) and 85 DAS (2.84) as compared to I_1 (0.6 IW/CPE ratio), however being at par with I_2 (0.9 IW/CPE ratio). These results corroborate the findings of Rehman *et al*., (2000) [16], Wajid *et al.*, (2002) [27] and Kumar and Pannu (2012) [8].

Data on LAI was significantly affected by varieties at all the stages of crop. V_4 (U. Halna) noticed significantly higher LAI at 45 DAS (3.55), 65 DAS (4.51) and 85 DAS (2.70) as compared to rest of the varieties, however being at par with V_3 (Kundan). The lowest value of LAI was recorded with variety V_1 (HD-2285). The results are in agreement to those of Srinivas (2002) [24] and Singh *et al.* (2010) [19].

Table 2: Leaf Area Index (LAI) at different growth stages as influenced by different irrigation schedules and varieties of wheat

Treatment	Leaf area index		
	45 DAS	65 DAS	85 DAS
(A) Irrigation schedules			
0.6 IW/CPE	3.18	3.93	2.35
0.9 IW/CPE	3.34	4.36	2.61
1.2 IW/CPE	3.52	4.73	2.84
SEm ±	0.03	0.05	0.02
CD at 5%	0.10	0.15	0.08
(B) Varieties			
HD-2285	3.15	4.19	2.51
NW-1067	3.28	4.31	2.58
Kundan	3.41	4.35	2.61
U. Halna	3.55	4.51	2.70
SEm ±	0.03	0.06	0.03
CD at 5%	0.11	0.17	0.09

3. Yield attributes

3.1. Effective tillers per m^{-2}

Data in Table-3 indicates that effective tillers per m^{-2} of wheat increased progressively with increasing irrigation from three to six. The higher effective tillers per m^{-2} (375.42) was recorded under treatment I_3 (1.2 IW/CPE ratio) being at par with treatment I_2 (0.9 IW/CPE ratio) but gave significantly higher effective tillers per m^{-2} over I_1 treatment (0.6 IW/CPE ratio). These results are in accordance to those of Parihar and Tiwari (2003) [15], Dhaka *et al.* (2006) [3] and Nayak *et al.* (2015) [14].

In case of varieties, the maximum effective tillers per m^{-2} (357.48) was recorded with V_4 (U. Halna) which was at par with V_3 (Kundan) but significantly superior over rest of the treatments. Mishra *et al*. (2003) [11] and Singh and Singh (2006) [20] reported similar results.

3.2. Length of spike (cm)

Data in Table-3 indicates that spike length of wheat increased progressively with increasing irrigation from three to six. The higher length of spike (10.10 cm) was recorded under treatment I_3 (1.2 IW/CPE ratio) being at par with treatment I_2 (0.9 IW/CPE ratio) but gave significantly higher spike length over I_1 treatment (0.6 IW/CPE ratio). These results are in accordance to those of Parihar and Tiwari (2003) [15], Dhaka *et al.* (2006) [3] and Nayak *et al.* (2015) [14].

In case of varieties, the maximum length of spike (9.62 cm) was recorded with V_4 (U. Halna) which was at par with V_3 (Kundan) but significantly superior over rest of the treatments. Mishra *et al*. (2003) [11] and Singh and Singh (2006) [20] reported similar results.

3.3. Number of grains spike^{-1}

An examination of data showed (Table-3) that irrigation scheduling treatments caused significant variation in number of grains spike^{-1}. The maximum number of grains spike^{-1} (50.45) was recorded with treatment I_3 (1.2 IW/CPE ratio) which was at par with treatment I_2 (0.9 IW/CPE ratio) but found significantly superior over I_1 treatment (0.6 IW/CPE ratio). These results are in accordance to those of Parihar and Tiwari (2003) [15], Dhaka *et al.* (2006) [3] and Nayak *et al.* (2015) [14].

Table 3: Yield attributes as influenced by different irrigation schedules and varieties of wheat

Treatments	Effective tillers/m^{-2}	Spike Length (cm)	No. of grains spike^{-1}	Grain weight /spike^{-1}	Test weight (g)
A. Irrigation schedules					
0.6 IW/CPE	311.43	8.40	41.89	2.05	38.57
0.9 IW/CPE	345.70	9.30	46.42	2.27	39.06
1.2 IW/CPE	375.42	10.10	50.45	2.47	39.41
SEm ±	2.90	0.04	0.41	0.02	0.06
CD at 5%	8.52	0.12	1.22	0.08	0.18
B. Varieties					
HD-2285	332.30	8.96	44.72	2.19	38.43
NW-1067	341.95	9.20	45.96	2.25	38.59
Kundan	345.00	9.28	46.32	2.27	39.21
U. Halna	357.48	9.62	48.01	2.35	39.82
SEm ±	3.35	0.05	0.48	0.03	0.07
CD at 5%	9.84	0.14	1.41	0.09	0.21

Perusal of data presented in Table-3 reveals that among four wheat varieties, U. Halna proved statistical superiority over other varieties. The maximum number of grains/ spike (48.01) was recorded with V_4 (U. Halna), which was significantly superior to V_3 (Kundan), V_2 (NW-1067) and V_1 (HD-2285). However, the lowest number of grains spike^{-1} was recorded with V_1 (HD-2285). Mishra *et al*. (2003) [11] and Singh and Singh (2006) [20] reported similar results.

3.4. Grain weight / spike^{-1}

A perusal of data presented in Table-3 showed that different irrigation schedule had significant effect on the Grain weight / spike^{-1}. Maximum Grain weight / spike^{-1} (2.47g) was noted under I_3 (1.2 IW/CPE ratio) and minimum Grain weight / spike^{-1} (2.05g) under I_1 (0.6 IW/CPE ratio). These results are in accordance to those of Parihar and Tiwari (2003) [15], Dhaka *et al.* (2006) [3] and Nayak *et al.* (2015) [14].

It is clear from data (Table-3) that Grain weight / spike^{-1} was significantly affected by various wheat varieties. The highest Grain weight /spike^{-1} (2.35 g) was recorded under V_4 treatment (U. Halna) and minimum Grain weight / spike^{-1} (2.27 g) under V_3 (Kundan). Mishra *et al*. (2003) [11] and Singh and Singh (2006) [20] reported similar results.

3.5. Test weight (g)

A perusal of data presented in Table-3 showed that different irrigation schedule had significant effect on the test weight. Maximum test weight (39.41g) was noted under I_3 (1.2 IW/CPE ratio) and minimum test weight (38.57g) under I_1 (0.6 IW/CPE ratio). These results are in accordance to those of Parihar and Tiwari (2003) [15], Dhaka *et al.* (2006) [3] and Nayak *et al.* (2015) [14].

It is clear from data (Table-3) that test weight was significantly affected by various wheat varieties. The highest test weight (39.82g) was recorded under V_4 treatment (U. Halna) and minimum test weight (38.43g) under V_1 (HD-2285). Mishra *et al.* (2003) [11] and Singh and Singh (2006) [20] reported similar results.

4. Yield

4.1. Grain yield (q ha^{-1})

Data in the Table-4 revealed that grain yield was affected significantly due to different irrigation scheduling and varieties.

Significantly higher grain yield (44.73 q ha^{-1}) was recorded with I_3 (1.2 IW/CPE ratio) which was at par with I_2 (0.9 IW/CPE ratio) but produced significantly higher grain yield. The lowest grain yield (37.11 q ha^{-1}) was found with I_1 (0.6 IW/CPE ratio). These results are in line with those reported by Soni and Leharia (1999) [23], Thakur *et al.* (2000) [25], Parihar and Tiwari (2003) [15], and Singh *et al.* (2018) [21].

Data (Table-4) further revealed that among four wheat varieties, maximum grain yield (42.60 q ha^{-1}) was obtained under V_4 (U. Halna) and minimum grain yield (39.60 q ha^{-1}) under V_1 (HD-2285). The marked variation in yield parameters due to varietal differences was also observed by Nainwal and Singh (2000) [13], Sardana (2001) [17] and Mahajan *et al.* (2018) [9].

4.2. Straw yield (q ha^{-1})

The data recorded on straw yield (q ha^{-1}) has been summarized in Table-4. Alike grain yield, straw yield also exhibited similar trend. It is clear from the data presented in table that the straw yield is significantly influenced by irrigation scheduling. The maximum straw yield (73.67 q ha^{-1}) was obtained under I_3 (1.2 IW/CPE ratio) being at par with I_2 (0.9 IW/CPE ratio) but was significantly superior over I_1 (0.6 IW/CPE ratio). These results are in line with those reported by Soni and Leharia (1999) [23], Thakur *et al.* (2000) [25], Parihar and Tiwari (2003) [15], and Singh *et al.* (2018) [21].
However, in varieties, maximum straw yield (69.81 q ha^{-1}) was found with V_4 (U. Halna) which was significantly superior over V_2 (NW-1067), V_3 (Kundan) and V_1 (HD-2285). The marked variation in yield parameters due to varietal differences was also observed by Nainwal and Singh (2000) [13], Sardana (2001) [17] and Mahajan *et al.* (2018) [9].

4.3. Biological yield (q ha^{-1})

Data in Table-4 revealed that different treatments of irrigation scheduling were found to significantly influence the biological yield of wheat. The highest biological yield (118.41q ha^{-1}) was recorded under I_3 (1.2 IW/CPE ratio) which was at par with I_2 (0.9 IW/CPE ratio) but Produced significantly higher biological yield over I_1 (0.6 IW/CPE ratio) during the course of investigation.
Variety V_4 (U. Halna) produced significantly higher biological yield of 112.41 q ha^{-1} as compared to rest of the varieties under testing. Variety V_3 (Kundan) produced significantly higher biological yield (108.89 q ha^{-1}) over variety V_2 (NW-1067) and V_1 (HD-2285) which recorded the lowest biological yield (105.92 q ha^{-1}) among all the varieties.

4.4. Harvest index (%)

Harvest index data as affected by different irrigation level and varieties is given in Table-4 clearly revealed that harvest index was affected significantly by different irrigation schedule and varieties. The maximum value of harvest index (37.77 %) was observed with I_3 (1.2 IW/CPE ratio) and lowest (37.46%) with I_1 (0.6 IW/CPE ratio). The results were in close with Mehta *et al.* (2010) [10].
The maximum value of harvest index (37.88%) was recorded in V_4 (Unnat Halna) and minimum (37.37%) with V_1 (HD-2285).

Table 4: Grain, straw, biological yield (q ha^{-1}) and harvest index (%) as influenced by different irrigation schedules and varieties of wheat

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
A. Irrigation schedules				
0.6 IW/CPE	37.11	61.93	98.63	37.46
0.9 IW/CPE	41.18	68.22	109.41	37.64
1.2 IW/CPE	44.73	73.67	118.41	37.77
SEm ±	0.41	0.51	1.00	0.03
CD at 5%	1.22	1.50	2.93	0.10
B. Varieties				
HD-2285	39.60	66.32	105.92	37.37
NW-1067	40.75	67.85	108.05	37.51
Kundan	41.10	67.79	108.89	37.73
U. Halna	42.60	69.81	112.41	37.88
SEm ±	0.48	0.59	1.15	0.04
CD at 5%	1.41	1.73	3.39	0.12

5. Economics

The data based on input-out analysis, the cost of cultivation, gross return, net return and net return per rupee invested as influenced by different treatment combinations are presented in Table-5, were workout to highlight the economic feasibility of the various treatments.

Table 5: Economics of the different treatment combinations

Treatment combination	Total cost of cultivation (₹ ha^{-1})	Gross income (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
I_1V_1	56325	80548	24223	1.43:1
I_1V_2	56372	81755	25383	1.45:1
I_1V_3	56435	82123	25688	1.45:1
$I_1 V_4$	57472	83698	26226	1.45:1
I_2V_1	57815	84826	27011	1.46:1
I_2V_2	57862	86034	28172	1.48:1
$I_2 V_3$	57925	86401	28476	1.49:1
$I_2 V_4$	58962	87976	29014	1.49:1
I_3V_1	59012	88554	29542	1.50:1
$I_3 V_2$	59059	89761	30702	1.51:1
$I_3 V_3$	59122	90129	31007	1.52:1
$I_3 V_4$	60159	91704	31545	1.52:1

The maximum cost of cultivation (₹60159 ha^{-1}) incurred with irrigation at 1.2 IW/CPE ratio (I_3). This was mainly due to higher cost of application of irrigation water. Irrigation scheduling at 0.6 IW/CPE ratio (I_1) resulted in lowest cost of cultivation (₹56325 ha^{-1}).

Highest net return (₹31545 ha^{-1}) and B: C ratio (1.52) was obtained under wheat variety Unnat Halna along with irrigation scheduling at 1.2 IW/CPE ratio. This might be due to the increase in grain and straw yield because of the frequent irrigations applied in combination with high yield variety. Kibe and Singh (2003) [6], Sarkar *et al.* (2015) [18], Mukherjee (2012) [12] and Verma *et al.* (2016) [26] also noted similar results.

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