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Effect of irrigation scheduling and hydrogel level on moisture extraction pattern and water use efficiency in wheat (*Triticum aestivum* L.)

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Abstract
In this research work "effect of irrigation scheduling and hydrogel level on moisture extraction pattern and water use efficiency in wheat (*Triticum aestivum* L.)". The experiment consisted of 12 treatment combinations comprised of four irrigation schedule and three hydrogel levels, tested on wheat cultivar Halna (K 7903) in split plot design with three replications. The results indicated that different irrigation schedule and hydrogel levels significantly influenced moisture extraction pattern and water use efficiency in wheat (*Triticum aestivum* L.). Among the various irrigation schedules, I3 (CRI + jointing + milking + dough) being at par with I4 (Irrigation at 0.6 IW/CPE) in water use efficiency. The similar trend was observed with the application of hydrogel @ 5.0 kg ha^{-1} compared to 2.5 kg ha^{-1} and control.

Keywords: Irrigation scheduling, hydrogel, moisture extraction pattern and water use efficiency

Introduction
Wheat (*Triticum aestivum* L.) is the single most important cereal crop, that has been considered as integral component of the food security system of several nations. The present situation is forcing the researchers to search for viable technology options to meet future water needs. Poor use efficiency of water is a serious bottleneck in realizing sustainable agricultural growth and food security for the future. Several agronomic practices have been developed and recommended to improve water productivity in crops. However, a holistic approach to evolve integrated solutions for multiple problems has been elusive. Irrigation scheduling, application of mulches, antitranspirant and hydrophilic polymer increase the duration of moisture availability with an increase in the amount of available moisture in the soil. Irrigation scheduling is one of the important managerial activities and affects the effective and efficient utilization of water by crops. It determines the process to decide when to irrigate the crops and how much water to apply. Hydrogel is three-dimensional, hydrophilic polymer, loosely cross-linked networks capable of imbibing large amounts of water or biological fluids. These synthetic polymers found in form of crystals and available under several trade names *viz*., Super Absorbent, Pusa Hydrogel *etc.* are collectively called hydrogel. Hydrogels have great potential in areas where opportunity for irrigation is limited and can increase the water availability during crop establishment. On weight basis it can absorb as high as 400 times its original weight (Kalhapure *et al.*, 2016) [1]. It enhances the crop productivity per unit available water and nutrients, particularly in moisture stress condition. Grain yield, nutrient uptake and water use efficiency improved in winter wheat when hydrogel was applied at the rate of 5kg/ha in sandy loam soil (Tyagi *et al.*, 2015) [2]. It improves physical properties of soil, seed germination, seedling emergence rate, root growth and density that help plants to prolonged moisture stress (Ekebafe *et al.*, 2011) [3]. Hydrogel reduces the leaching of herbicide, fertilizer and requirements of irrigation for crops. It also promotes early dense flowering and tillering and delay the permanent wilting point (Mehr and Kourosh, 2008) [4]. It optimizes agricultural production with minimizing yield loss due to water shortage and improving performance and sustainability of any irrigation system.

Among the several recognized criteria of irrigation scheduling in wheat, the critical stage approach is very familiar among the farmers as it needs no technical knowledge, skill and instruments. Under scarcity of water, four irrigation schedules at crown root initiation, tillering, flowering and milking stages recorded higher grain yield resulting in saving two irrigation for wheat (Kumar *et al.* 2015) [5].

Irrigation at jointing and anthesis improved grain yield by an average of 12.70 and 18.65% as compared with no irrigation in wheat (Zhang *et al.*, 2017) [6]. Wheat response to water stress from stem elongation to booting, followed by anthesis and grain- filling stages (Zhang *et al.*, 1999) [7]. Application of limited irrigation gets maximum yield and saves water compare to more irrigation schedules on wheat (Khokhar *et al.*, 2010) [8].

Material and Method

The experiment was conducted during the *Rabi* season of 2018-19 at the Agronomy Research Farm of the Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.). Geographically, the experimental site is at $26^0 47'$ N latitude and $82^0 12'$ E longitude and at an altitude of 113 meters above mean sea level. Total winter rainfall received during the crop period was 50.0 mm. The mean lowest temperature (3.5 ^{0}C) was recorded in the month of December whereas the maximum temperature (42.4 ^{0}C) was recorded in May. Relative humidity was highest (76.6%) in the month of February whereas it was lowest (45.5%) in May. The sunshine ranged from 3.6 to 9.9 hours. The results of soil analysis indicate that the experimental soil was silty loam in texture with a pH of 7.8. The soil of the experimental field was low in available nitrogen, medium in medium in phosphorus and high in potassium. On the whole the soil was moderate for the cultivation of wheat crop.

The experiment was laid out in Split Plot Design having three replications. There were 12 treatment combinations comprised of four irrigation schedule and three hydrogel levels. K 7903 (HALNA) is a wheat variety suitable for very late sown and irrigated conditions. The variety was released in 2002 by State Variety Release Committee. The potential yield of this variety is 31-35 q/ha. Fertilizer nitrogen, phosphorus and potassium were applied in the forms of urea, D.A.P. and muriate of potash @ 120, 60 and 40 Kg ha-1, respectively. Full dose of Phosphorus and Potassium and half dose of nitrogen was applied at the time of sowing and rest half dose of nitrogen was applied after first irrigation.

Soil moisture depletion pattern

Soil moisture depletion pattern from three layers *viz.* 0-15, 15-30 and 30-45 cm and 45-60 cm depths was calculated by using the formula given below. Moisture depleted from each layer was calculated by adding all the short period depletion from all the respective depths till the harvest of the crop and percentage depletion at various depths to the total was worked out.

$$\text{Soil Moisture depletion from i}^{th}\text{ layer (cm)} = \frac{\text{Mai-Mbi}}{100} \text{ x ASi x Di}$$

Where,

Mai= Moisture percentage after irrigation in ith layer Mbi= Moisture percentage before irrigation in ith layer Asi= Apparent specific gravity of ith layer (Mg/m3) Di= Depth of ith layer in cm

Consumptive use of water

It was calculated based on the direct soil moisture determinations:

Consumptive use of water (cm) = $\sum_{i=1}^{n}$ Total moisture depleted soil moisture contribution +ER

Water use efficiency (WUE)

This was computed from calculated kg of grain yield produced per hectare mm of water consumed in ET by the crop.

$$\text{WUE (Kg ha}^{-1}\text{cm)} = \frac{\text{Grain yield (Kg ha}^{-1}\text{)}}{\text{Total consumptive use of water (cm)}}$$

Result and Discussion

Soil moisture extraction

Moisture (69.17%) from upper (0-30 cm) soil layers as compared to I_1 (one irrigation at CRI) which extracted 55.16% only. The similar trend in moisture pattern depletion was observed in hydrogel application also. moisture (69.17%) from upper (0-30 cm) soil layers as compared to I_1 (one irrigation at CRI) which extracted 55.16% only. The similar trend in moisture pattern depletion was observed in hydrogel application also.

Table 1: Soil moisture extraction pattern (cm) as affected by various treatment combinations

Treatment combinations	Soil depth (cm)				Soil Moisture extraction (cm)
	0 to 15	15-30	30-45	45-60	
I_1H_0	8.42	7.94	6.82	6.69	29.87
I_1H_1	8.81	8.65	7.12	7.10	31.68
I_1H_2	9.14	9.02	7.62	6.90	32.68
I_2H_0	10.55	9.87	7.30	6.13	33.85
I_2H_1	11.78	10.14	6.96	6.10	34.98
I_2H_2	12.71	10.68	6.71	5.77	35.87
I_3H_0	13.00	11.96	7.49	4.66	37.11
I_3H_1	14.15	12.24	6.74	4.78	37.91
I_3H_2	15.26	13.01	7.10	4.71	40.08
I_4H_0	12.72	12.39	6.86	5.05	37.02
I_4H_1	13.82	12.69	6.88	5.01	38.4
I_4H_2	15.14	12.91	6.68	4.92	39.65

Consumptive use of water

There was continuous increase in consumptive use of water with increasing number of irrigation levels (Table 2). Mean highest consumptive use of water (38.37 cm) was found in I_3 (four irrigation at CRI, jointing, milking and dough stage) followed by I_4 (irrigation at 0.6 IW/CPE), I_2 (two irrigation at CRI and Jointing stage) and I_1 (one irrigation at CRI). The mean lowest consumptive use of water (31.41 cm) was found in I_1 (one irrigation at CRI). Similarly, mean consumptive use of water increased with increasing levels of hydrogel.

Table 2: Consumptive use of water (cm) as affected by various treatment combinations

Treatments	H_0	H_1	H_2	Mean
I_1	29.87	31.68	32.68	31.41
I_2	33.85	34.98	35.87	34.90
I_3	37.11	37.91	40.08	38.37
I_4	37.02	38.4	39.65	38.36
Mean	34.46	35.74	37.07	

Water use efficiency (WUE)

Data pertaining to water use efficiency as affected by various irrigation schedules and hydrogel levels are presented in Table 3. It is clear from the data that water use efficiency (WUE) was markedly influenced by different irrigation schedules and hydrogel levels. The highest water use efficiency (92.19 kg/ha/cm) was recorded under treatment I_3H_2 (four irrigation at CRI, jointing, milking and dough stage coupled with application of hydrogel @ 5.0 kg ha^{-1}) and lowest in I_1H_0 (one irrigation at CRI without hydrogel application). The mean data indicated that successive increase in irrigation level resulted into higher water use efficiency and similarly water use efficiency increased with increasing levels of hydrogel application.

Table 3: Water use efficiency (kg/ha/cm) as affected by various treatment combinations

Treatments	H_0	H_1	H_3	Mean
I_1	79.01	84.80	84.81	82.87
I_2	84.83	85.44	87.20	85.82
I_3	86.95	88.03	92.19	89.06
I_4	86.93	87.38	90.11	88.14
Mean	84.43	86.41	88.58	

Conclusion and Recommendations

Mean highest consumptive use of water (38.37 cm) was found in I_3 (four irrigation at CRI, jointing, milking and dough stage), mean highest consumptive use of water (38.37 cm) was found in I_3 (four irrigation at CRI, jointing, milking and dough stage) and the highest water use efficiency (92.19 kg/ha/cm) was recorded under treatment I_3H_2 (four irrigation at CRI, jointing, milking and dough stage coupled with application of hydrogel @ 5.0 kg ha^{-1}).

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