Original Research Article

Assessing the ~~E~~effect of irrigation and hydrogel on growth and yield of wheat (*Triticumaestivum*L.)

ABSTRACT

One of the most essential inputs for agriculture is water~~.~~ ~~m~~Moisture stress at critical growth stages in wheat severely effects the growth and yield~~.~~ ~~of wheat.~~ Hydrogel (water-absorbing polymer) can keep the appropriate moisture level at the root zone depth and protects the crop from adverse effect ~~due to~~of moisture stress. The present trial was conducted during *rabi* season of 2020-21 to assess the performance of different hydrogels under different levels of irrigations on growth, yield, WUE of wheat. Results revealed that application of 3 irrigations recorded significantly maximum number of tillers per m^2 at 90 DAS and at harvest. The application of Nano hydrogel @ 20 kg ha^{-1} significantly increased the number of tillers per m^2 at 90 DAS and at harvest over control. Significantly maximum grain (26.1%) and straw (24.5%) yield were obtained with 3 irrigation levels over one irrigation~~.~~ ~~t~~The Nano hydrogel increased grain (33.6%) and straw (22.9%) yield significantly over control. Water use efficiency significantly improved with one irrigation over 3 irrigation levels~~.~~ ~~a~~Application of Nano hydrogel @ 20 kg ha^{-1} significantly increased WUE.

Keywords: ~~{~~hydrogel, moisture stress, irrigation, water-absorbing polymer, water use efficiency.~~}~~

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1. INTRODUCTION

Wheat is one of the most important cereals in human nutrition, and it is cultivated on huge scales around the world, covering 226 million hectares (mha) and 32 percent of total cereal cultivated land (FAO, 2006). ~~wheat~~ Wheat occupied second place after rice in ~~in~~ India. It is cultivated on an area of 29.8 million ha with the production of 107.59 million tones having productivity of 3.61tonnes ha^{-1} (Ministry of Agriculture and Farmers Welfare, 2019-20). One of the most important inputs for agricultural production is water. It allows for a higher productive potential from the land as well as a considerable response to applied agricultural inputs such as high-yielding cultivars and fertilizers, among other things (Kukal*et al.* 2014). In the context of rising population and competitive demands from agriculture, industry, and urbanites, water shortage is becoming a global concern (Babel and Wahid 2008). Groundwater is the primary source of irrigation in the country's wheat-growingregion, where the water table is dropping by about a metre per year, representings a major threat to the region (CGWB 2014). The major wheat-producing belts may not be able to sustain their wheat production in the future if the current level of water usage for wheat growing continues (Kang *et al.*2002). In 2014-15, Rohtas produced 8.4% of total state wheat production although covering only 6.7 percent of Bihar's land area. Between 2010 and 2015, Bihar's average yearly grain productivity increased by 5.65%. During the same period, rice productivity increased at an average annual rate of 18.99 percent, whereas wheat productivity increased at a negative rate of 7.44 percent (Anonymous 2016). Several technologies and agronomic approaches for increasing wheat water productivity have been developed and advocated. However, a comprehensive method for developing integrated solutions for many challenges has eluded researchers (Ladha*et al.* 2009).

The hydrogels have ability to absorb and retain water is up to 80-180 times its initial volume. (Bowman *et al*.1991). ~~h~~Hydrogels have ability to absorb 400 times of its original weight in terms of weight (Kalhapure*et al*. 2016). Grain yield, nutrient uptake and water-use efficiency improved in winter wheat when hydrogel was applied at the rate of 5 kg/ha in a sandy loam soil (Tyagi*et al.* 2015). Keeping the above points into consideration present experiment was conducted to assess the performance of different hydrogels under different levels of irrigations on growth, yieldand, WUE of wheat.

2. MATERIAL AND METHODS

A field experiment was conducted during Rabi season of 2020-21 at research farm of Bihar Agricultural University, Sabour, Bhagalpur (situated between 25°50' N latitude and 87°19'E longitude at an altitude of 52.73 meters above mean sea level) to assess the performance of different hydrogels under different levels of irrigations on growth, yield, WUE of wheat.The geographical location of experimental site comes under the middle Gangetic plain of Agro-climatic zone IIIA of southern East Bihar.The average annual rainfall of this locality is around 1100 mm. the soil of the experimental sit was sandy loam in texture and low in OC, ~~and~~ nitrogen~~,~~ and phosphorus, and medium in potassium. The experiment ~~trial~~ was laid out in split plot design with three irrigation levels viz. I_1- one irrigation at CRI, I_2- two irrigations at CRI and boot leaf stage, I_3- three irrigations at CRI, late jointing and milking stageas main plot treatments, ~~viz. I_1- one irrigation at CRI, I_2- two irrigations at CRI and boot leaf stage, I_3- three irrigations at CRI, late jointing and milking stage.~~ and~~F~~five sub plot treatments with different hydrogels ~~and control.~~viz.T_1- Eco sarovar hydrogel (7.5 kg ha^{-1}),T_2- Vedic hydrogel (7.5 kg ha^{-1}),T_3- Vaaridhar G1 hydrogel (2.5 kg ha^{-1}), T_4- Nano hydrogel (20 kg ha^{-1}),T_5- Control (No hydrogel)~~.~~ R~~r~~eplicated thrice.

Field was prepared by one deep ploughing, two cross harrowing and planking applied basal fertilizers and incorporated different hydrogels according to the layout of the field. Wheat variety HD-2967 was sown on the first week of December. Number of tillers per m^2 area was counted at different growth stages of the crop. After harvest, ~~of~~ the crop was sundried and taken the weight of harvested bundles according to the treatments then after winnowing, grain weight was measured at 12% grain moisture and recorded as grain yield in kg ha^{-1}. Straw yield in kg ha^{-1} calculated by subtracting biological yield and grain yield.

The water use efficiency (WUE) is expressed as the ratio of crop yield (Y) to the total amount of water used during entire growing period of crop. It was calculated by using following formula:

$$\text{Water use efficiency} = \frac{\text{Grain yield}}{\text{Total water used}}$$

Total water used was calculated through volumetric method measurement made by measuring the time required for the flow to fill a container of known volume (used 20 lit

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bucket). Volume divided by time is taken equal to rate of water flow from the source to field.

$$Q=\frac{\text{Volume of water (container known volume)}}{\text{Time required to fill (sec)}}\times 60$$

Where, Q- rate of water flow (m^3/min)
I was taken 20 lits (0.02 m^3) bucket. 1.2 sec was taken to fill the bucket. By using above formula measured rate of flow (m^3/min) as 1 m^3/sec.
Each irrigation was given for 12 hrs. according to this measured total amount of water in m^3 in each irrigation. It was calculated as 720 m^3 water used in each irrigation. Then after converted it into ha.mm. (1 ha.mm = 10 m^3) as 72 ha mm. and used this for estimating WUE (kg/ha-mm).

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3. RESULTS AND DISCUSSION

3.1Number of tillers per m^2

Significantly a greater number of tillers m^{-2} was recorded under three irrigations given at CRI, late jointing and milking stage. 326.41 and 306.42 tillers per m^2 were observed with I_3 at 90 DAS and at harvest, respectively.Regarding the effect of different hydrogels, significantly higher number of tillers m^{-2} was observed withNano hydrogel (20 kg ha^{-1}) at all growth stages. At 60 DAS the maximum number of tillers (40.49 more tiller m^{-2} than control) was recorded with Nano hydrogel. ~~,~~ HHowever, the lowest number of tillers were in the control (No hydrogel).
The application of three irrigations at CRI, late jointing and milking stage to wheat facilitates sufficient moisture for higher growth and development of the plants which enhanced photosynthetic efficiency leading to produce higher number of tillers per m^2. These findings accordance with those ofKingra*et al.* (2018), Mubeen *et al.* (2013) and Ali *et al.* (2012).

Table 1 Effect of irrigation and hydrogel on number of tillers per m^2

Treatments	Number of tillers m^{-2}			
	30 DAS	60 DAS	90 DAS	At harvest
Irrigation levels				
One irrigation at CRI	131.41	335.88	288.41	277.23
Two irrigations at CRI and boot leaf stage	131.24	331.49	307.66	286.26
Three irrigations at CRI, late jointing and milking stage	131.73	336.98	326.41	306.42
CD (P=0.05)	NS	NS	12.56	19.08
Hydrogels				
Eco sarovar hydrogel (7.5 kg ha^{-1})	131.85	334.54	311.61	293.54
Vedic hydrogel (7.5 kg ha^{-1})	131.76	335.91	314.94	296.15
Vaaridhar G1 hydrogel (2.5 kg ha^{-1})	130.49	325.07	290.18	271.60
Nano hydrogel (20 kg ha^{-1})	132.74	359.44	348.63	329.99
Control (no hydrogel)	130.46	318.95	272.12	250.22
CD (P=0.05)	NS	4.91	7.98	7.07
I × T	NS	NS	NS	NS

3.2 Grain yield (kg ha^{-1})

Results revealed that the grain yield increased significantly with three irrigations at CRI, late jointing, milking stage (I_3) over one irrigation (I_1) and two irrigations(I_2). The grain yield under three irrigations increased 26.11% and 8.58% than one irrigation (I_1) and two irrigations(I_2), respectively. Significantly the highest grain yield was obtained with Nano hydrogel which was significantly superior over all other treatments and control (no hydrogel). The grain yield under Nano hydrogel 33.56% increased than obtained under control (no hydrogel). Application of three irrigationsat CRI, late jointing, milking stage towheat facilitates sufficient moisture for higher growth and development and efficient utilization of water through Nano hydrogel enhanced photosyntheticefficiency by improving source-sink relationship of the plantsleading to higher growth of yield attributes reflected by higher grain yield of crop. These findings were in accordancewith those ofMeena*et al.,* (2015), Ali et al. (2012).Ram pal (2019) and Abd-Eladl (2018).

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3.3 Straw yield (kg ha^{-1})

The higher straw yield was produced with three irrigations given at CRI, late jointing, milking stage (I_3) which was significantly superior over one irrigation. The straw yield under three irrigations increased 24.46% and

9.20% than under one irrigation (I_1) and two irrigations(I_2), respectively. Maximum straw yield was produced with the Nano hydrogel which was significantly superior ~~than~~to all other treatments and control (no hydrogel). Tthe straw yield under Nano hydrogel increased 22.90% than under control (no hydrogel). This increment in straw yield was due to higher plant growth with sufficient water through Nano hydrogel and three irrigation levels leading to produce a greater number of tillers reflected in higher straw yield of the crop. These results are in conformity with the findings ofAbhineet*et al.* (2019) and Ram pal (2019).

Table 2 Effect of irrigation and hydrogel on grain yield and straw yield

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Irrigation levels		
One irrigation at CRI	3066.29	4654.28
Two irrigations at CRI and boot leaf stage	3561.22	5304.62
Three irrigations at CRI, late jointing and milking stage	3866.87	5792.87
CD (P=0.05)	353.45	430.35
Hydrogels		
Eco sarovar hydrogel (7.5 kg ha^{-1})	3561.00	5328.00
Vedic hydrogel (7.5 kg ha^{-1})	3620.40	5367.40
Vaaridhar G1 hydrogel (2.5 kg ha^{-1})	3310.41	5122.05
Nano hydrogel (20 kg ha^{-1})	4002.18	5753.84
Control (no hydrogel)	2996.64	4681.64
CD (P=0.05)	247.34	230.57
I × T	NS	NS

3.4 Water use efficiency (kg/ha-mm)

The water use efficiency (WUE) was decreased with increase in number of irrigations.

Among different levels of irrigation, one irrigation at CRI (I_1) was recorded significantly highest water use efficiency (42.59 kg/ha-mm) which was significantly superior over three irrigations given at CRI, late jointing, milking stage (I_3) and two irrigations given at CRI and boot leaf stage (I_2).

Among different hydrogels, Nano hydrogel recorded significantly highest water use efficiency (32.52kg/ha-mm) which was statistically superior over all other hydrogels and control (no hydrogel).These results are in close agreement with the results of earlier researchers like Verma*et al.* (2010) Abd-Eladl (2018) who stated the application of hydrogel resulted in higher WUE.

Table 3 Effect of irrigation and hydrogel on water use efficiency (kg/ha-mm)

Treatments	Water use efficiency(kg/ha-mm)
Irrigation levels	
One irrigation at CRI	42.59
Two irrigations at CRI and boot leaf stage	24.73
Three irrigations at CRI, late jointing and milking stage	17.90
CD (P=0.05)	3.28
Hydrogels	
Eco sarovar hydrogel (7.5 kg ha^{-1})	29.15
Vedic hydrogel (7.5 kg ha^{-1})	29.43
Vaaridhar G1 hydrogel (2.5 kg ha^{-1})	26.81
Nano hydrogel (20 kg ha^{-1})	32.52
Control (no hydrogel)	24.13
CD (P=0.05)	2.09
I × T	NS

4. CONCLUSION

The results of this study demonstrated that the cultivation of wheat under three irrigations at CRI, late jointing, milking stage resulted significantly greater number of tillers m^2, increase in grain and straw yield, however one irrigation at CRI was improved WUE and EWP. Likewise, application of Nano hydrogel@ 20 kg ha^{-1} resulted significantly a greater number of tillers per m^2, also improved WUE significantly over control. Nano hydrogel and 3 irrigations levels atCRI, late jointing, milking stage to wheat can be advocated as sustainable strategy for enhancing growth, productivity and WUE.

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