Revised Research Article

Assessing theeffect of irrigation levels and hydrogel on growth and yield of wheat (*Triticum aestivum* L.)

ABSTRACT

One of the most essential inputs for agriculture is water.Moisture stress at critical growth stages in wheat severely effects the growth and yield. Hydrogel (water-absorbing polymer) can keep the appropriate moisture level at the root zone depth and protects the crop from adverse effect 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, and water use efficiency of wheat. Results revealed that application of 3 irrigations recorded significantly maximum number of tillers per m^2 at 90 Days After Sowing 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.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, application of Nano hydrogel @ 20 kg ha^{-1} significantly increased WUE.

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

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 occupied second place after rice 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, representing 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). 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, yield, and WUE of wheat.

2. MATERIAL AND METHODS

A field experiment was conducted during Rabi season of 2020-21 at research farm Bihar Agricultural University, Sabour, Bhagalpur (situated between 25º50' N latitude and 87º19'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 organic carbon, nitrogen, and phosphorus, and medium in potassium. The experiment trial was laid out in split plot design with three irrigation levels as main plot treatments, viz. I_1- one irrigation at crown root initiation, I_2- two irrigations at CRI and boot leaf stage, I_3- three irrigations at CRI, late jointing and milking stage, andfive sub plot treatments with different hydrogels 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) replicated 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. Crop was harvested according to the treatment andsundried. 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 (Bisen *et al.* 2018):

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

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 bucket). Volume divided by time is taken equal to rate of water flow from the source to field (Othman et al. 2017).

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

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.
Calculated rate of water flow as 720 m^3/12 hrs. (each irrigation was given for 12hrs.) Converted it into ha.mm. (1 ha.mm = 10 m^3) as 72 ha mm. and used this for estimating WUE (kg/ha-mm).

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

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

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. However, the lowest number of tillers were in the control (No hydrogel).

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).

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 of Meena *et al.,* (2015), Ali et al. (2012).Ram pal (2019) and Abd-Eladl (2018).

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 to all other treatments and control (no hydrogel). The 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 CRIimproved 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.

REFERENCES

1. Abd-Eladl M. Integrated Management of Wheat under Dry Land Conditions. Journal of Soil Sciences and Agricultural Engineering Mansoura University.2018;9(12): 781 – 791.
2. Abhineet, Kumar R, Sudhakar S, Vishuddha N, Chaudhary V. Effect of restricted irrigation levels on yield attributes and yield of various varieties of wheat (Triticum aestivum L.). Journal of Pharmacognosy and Phytochemistry.2019;8(2): 122-125.
3. Ali B T, Hwary E and Yagoub O S. Effect of different irrigation intervals on wheat (Triticum aestivum L.) in semi-arid regions of Sudan. Journal of Science and Technology.2012;12(3): 75–83.
4. Anonymous. 2016. Economic survey of Bihar 2015-16. Government of Bihar.
5. Babel M S and Wahid S W. Freshwater Under Threat in South Asia. UNEP Report. United Nations Environment Programme (UNEP), 2008; p 29.
6. Bisen N, Singh SP, Singh RK, Prasad SK.Productivity, and water use efficiency of bread wheat (Triticum aestivum L.) as influenced by irrigation schedule, mulching and hydrogel in eastern Indo-Gangetic plains of India. Bangladesh Journal of Botany. 2018; 10(3): 2-9.
7. Bowman DC, Evans RY. Calcium inhibition of polyacrylamide gel hydration is partially reversible by potassium. Journal of Horticultural Sciences 1991;26(8): 1063–1065.
8. CGWB. 2014. Dynamic ground water resources of India (as on31st March 2011). In Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation, GOI, Faridabad.
9. FAO. 2016. FAO Statistical Yearbook. The Food and Agriculture Organization, Rome, Italy.
10. Kalhapure A, Rajeew KVP, Singh DS, Pandey. Hydrogels: a boon for increasing agricultural productivity in water-stressed environment. Current sciences.2016;111(11):1773-1779.
11. Kang S Z, Zhang L, Liang Y L, Hu X T, Cai H J and Gu B J. Effects of limited irrigation on yield and water use efficiency of winter wheat in the Loess Plateau of China. Agricultural Water Management.2002;5(5):203–16.
12. Kingra PK, Parminder SB, Singh SP. Effect of sowing dates, irrigation and mulching on growth and yield of wheat. Agricultural Research Journal.2018;55(2): 243-250.
13. Kukal S S, Singh Y, Jat M L and Sindhu H S. Improving water productivity of wheat-based cropping systems in south Asia for sustained productivity. Advances in Agronomy.2014;12(7):157–230.
14. Ladha J K, Yadvinder-Singh, Erenstein O and Hardy B. 2009. Integrated Crop and Resource Management in the Rice–Wheat Systems of South Asia. International Rice Research Institute, Los Banos, Philippines.
15. Meena RP, Sharma RK, Tripathi SC, Gill SC, Chhokar RS, Meena A, Sharma I. Influence of hydrogel, irrigation and nutrient levels on wheat productivity. Journal of Wheat Research. 2015;7(2):19-22.
16. Ministry of Agriculture and Farmers Welfare Department of Agriculture, cooperation and Farmers Welfare Directorate of Economics and Statistics fourth advance estimates of production of food grains for 2019-20.
17. Mubeen M. Ahmad A, Wajid A, Khaliq T, Sultana R S, Hussain S, Ali A, Ali H and Nasim W. Effect of growth stage-based irrigation schedules on biomass accumulation and resource use efficiency of wheat cultivars. American Journal of Plant Sciences. 2013;4:1435–42.
18. Othman A, Khairudhin WM, Othman J, Ghani MA.Water flow measuring methods in small hydropower for streams and rivers - A study.International Journal of Applied Engineering Research. 2017; 12(24): 14484-14489.
19. Ram pal. Evaluation of Pusa hydrogel for higher productivity of wheat in Bihar. Journal of AgriSearch. 2019;6(3): 131-133.
20. Tyagi V, Singh RK, Nagargade M. Effect of hydrogel, NPK and irrigation levels on yield, nutrient uptake and water use efficiency of wheat (Triticum aestivum L.). International Journals on Crops. 2015;16(4): 653-656.

21. Verma SK, Yadav AS. productivity, nutrient uptake and water use efficiency of wheat (Triticum aestivum L.) under different irrigation levels and fertility sources. Indian journal of ecology. 2010;37(1):13-17.