



## Wheat (*Triticum aestivum*) crop response to irrigation scheduling and super absorbent polymers

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### ABSTRACT

A field experiment was conducted at research farm of CCS Haryana Agricultural University, Hisar, Haryana during winter (*rabi*) season 2018–19 and 2019–20 with an objective to study the polymers with irrigation effect on wheat (*Triticum aestivum* L.) crop. The research was done in a split-plot design with four irrigation [(No irrigation (I<sub>0</sub>), One irrigation at CRI stage, crown root initiation stage; (I<sub>1</sub>), Two irrigation at CRI, Booting (I<sub>2</sub>), Three irrigation at CRI, Booting, milking (I<sub>3</sub>)] and three polymer treatments [(No polymers (P<sub>0</sub>), *Gondkatira* @5 kg/ha (P<sub>1</sub>), Pusa Hydrogel @2.5 kg/ha (P<sub>2</sub>)] in the main and subplot respectively. The wheat seed yield decreased by 11.90% from I<sub>3</sub> to I<sub>2</sub>, 17.12% from I<sub>3</sub> to I<sub>1</sub>, and 33.74% from I<sub>3</sub> to I<sub>0</sub>. The polymer treatment was used to increase the wheat seed yield. The yield was increased by 7.41% and 1.15% by application of hydrogel and *gondkatira* over no polymer. The minimum water productivity was registered under three irrigations. The application of *gondkatira* in wheat increased the water productivity by 8.09% while hydrogel 11.56%. Water stress or no irrigation has a lower  $F_v/F_m$  (Maximum quantum efficiency of PS II) (0.73) ratio than to no stress or three irrigations (0.75).

**Keywords:** Irrigation scheduling, Polymers, Wheat

Wheat (*Triticum aestivum* L.) known as "the cereal king" in India is a prime source of protein. India contributes 13.4% production from the 30.6 mha area with 98.40 mt production during 2017–18. Wheat productivity could be affected by seed quality, water table, soil health, insect-pest and diseases, and weather (Jat *et al.* 2014). Water scarcity for growing crops is the most important natural resource issue. In Indian conditions, irrigation for wheat crop is necessary to get high production but the groundwater table goes down day by day. Mazloom *et al.* (2020) reported a drop of up to 21% in wheat yield and up to 40% in maize yield owing to worldwide water scarcity. Water stress makes crops more vulnerable than those that grow in arid or semi-arid environments. Under this scenario, high crop production can only be achieved with a fair input application. The vertical practices, viz. irrigation scheduling, use of mulch, antitranspirants, and polymers, etc. can improve the moisture availability for a long duration. Shirazi *et al.* (2014) reported that limited irrigation at tillering and flowering gave higher yield and saved water. The soil treatment with hydrogel can accumulate two irrigations without reducing the wheat yield (Dar and Ram 2017).

From a farmer's point of view, irrigation scheduling was performed on a phenological basis in wheat crops. Super absorbents application in agriculture, a recent concept can help to reduce the problem of water stress. A hydrogel is semi-synthetic polymer made up of cellulose that gets swollen with water and releases gradually in the soil for a minimum period of one year. Grain yield of wheat, soybean, was increased due to hydrogel application (Roy *et al.* 2019). According to Nutan Kujur *et al.* (2022) in comparison to untreated soils, insertion of Pusa Hydrogel improved soil's capacity to hold and keep more moisture, with consistent and gradual release of soil moisture necessitating less and less frequent watering. Natural plant products also available and used in agriculture known as herbal hydrogel or *gondkatira*, reported that soil microbes are susceptible. So keeping these points in view the present study was conducted to evaluate the wheat crop with different irrigation and super absorbent polymers.

### MATERIALS AND METHODS

A study was carried out using split plot design in three replications at research farm of CCS Haryana Agricultural University, Hisar, Haryana (29°10'N, 75°46' E of 215 m asml) during, *rabi* season, 2018–19. The soil of the experimental field was sandy loam in the upper 30 cm layer. The field experiment was conducted in a split-plot design with four

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irrigations [No irrigation ( $I_0$ ), One irrigation at CRI stage, crown root initiation stage; ( $I_1$ ), Two irrigation at CRI, Booting ( $I_2$ ), Three irrigation at CRI, Booting, milking ( $I_3$ )] in main plots and three polymer treatments [No polymers ( $P_0$ ), *Gondkatira* @5 kg/ha ( $P_1$ ), Pusa Hydrogel @2.5 kg/ha ( $P_2$ )] in the subplot. Basal  $\frac{1}{2}$  N, full P & K was applied at sowing, and rest  $\frac{1}{2}$  N was top-dressed split into two equal doses, each first at CRI and flowering time.

**Canopy temperature (CT):** Canopy temperature was observed by a portable infrared thermometer (Model AG-42 Tele-temp corp. CA) between 12.00–2.00 PM from the four directions across the planted crop row. The canopy temperature readings were observed at 30–40°C from horizontal of a wheat canopy at the fixed 1.0 m distance from the crop canopy. The average of three readings was taken as a mean value of treatment in one replication.

**Leaf Relative Water Content:** RWC (Relative water content) of leaves of each treatment was determined in the topmost leaf between 9–10.00 A.M., calculated as (Shweta *et al.* 2021):

$$RWC = (FW-DW/TW-DW) \times 100$$

**Leaf water potential (LWP):** The leaf water potential was estimated with the help of pressure chamber in wheat crop. Measurement was taken between 9.00–10.00 A.M. under sunny and clear sky on the topmost wheat green leaf per experimental unit. The leaf at midrib, was cut by razor and was kept in the chamber with midrib exposed. The chamber was closed and slowly-slowly pressure was applied with nitrogen gas. The power to allow water to emerge on the cut surface determined the tension of the leaf when the balance pressure was measured as the possible leaf water (Shweta *et al.* 2021).

**SPAD value:** Chlorophyll content present in leaf was recorded at the anthesis stage of the crop by Chlorophyll Meter (SPAD-502). Such values were calculated based on the amount of light that the leaf is receiving in two regions with different wavelength range of chlorophyll absorption. The instrument takes readings through a non-destructive method and is based on quantification of light intensity absorbed by the sample.

**Chlorophyll fluorescence:** At the same time chlorophyll fluorescence parameters namely Fv/Fm was recorded with Chlorophyll Fluorescence Meter (Plant stress meter, Bio monitor, Sweden) at 12.00–2.00 P.M. in two uppermost fully expanded leaves. The leaves were kept for 30 min in dark by using cuvettes before measurement. The maximum quantum of PS II was observed by the Fv/Fm ratio.

**Optical Nitrogen Sensor:** An optical sensor device known as Green Seeker measures crop reflectance to calculate the normalized difference vegetation index (NDVI). The NDVI is the fraction of visible red and infrared radiation that is emitted from the field detected, passing across the canopy at 0.5–1.0 m above the plant. It can be said as

$$NDVI = (NIR-RED)/(NIR+RED)$$

**Water productivity:** The productivity of water is per

unit of water the crop uses. Productivity of water (WP) was calculated as:

$$WP = \text{Yield (kg/ha)}/\text{Water used (mm)}$$

**Protein content:** It was calculated by multiplying the amount of nitrogen in grain with a conversion factor of 6.25.

**Proline content:** Leaf segments (0.5 g) from each replication of each treatment were taken for proline estimation. Proline content of wheat leaves was observed following the colorimetric assay method (Bates *et al.* 1973). The proline content was calculated from a standard curve on a fresh weight basis as follows:

$$\text{Proline } (\mu\text{moles/g}) \text{ of fresh plant material} = \{ \text{proline } (\mu\text{g/ml}) \times (\text{toluene used ml})/115.5 \mu\text{g}/\mu\text{moles} \} / (\text{g sample}/5)$$

**Hectolitre weight:** Hectolitre weight was recorded by using a hectolitre weight instrument that uses a standard 100 ml container. Weighed grains and measured hectoliter weight in kg/hl.

**Sedimentation value:** The sedimentation value was estimated according to the process of DWE *et al.* (1979). A 6 g sample weight and a 20 min rest period were used.

**Phenol test:** The phenol reaction score was (Nathawat *et al.* 2016) measured by soaking around 100 grains overnight, under 1% Phenol solution. The grains were analyzed at a rating of 10, half an hour after draining the Phenol solution.

**Statistical analysis:** All the yield, yield attributes, water productivity, chlorophyll content, protein, and proline content in wheat were analyzed for two-way analysis of variance (ANOVA). OPSTAT at a 5% probability level was used to test the significance of mean value variations.

## RESULTS AND DISCUSSION

**Effect on yield and yield attributes of wheat:** Results revealed that the spike lengths, grains/spike, 1000-grain weight were significantly influenced by irrigation schedule and polymers. The maximum and minimum values of these yield attributes were reported in three irrigations and no irrigation, respectively. Grain yield in  $I_3$  was significantly higher over to other irrigation treatments. Irrigation ( $I_3$ ) produced a significantly higher economic yield of wheat in comparison to other irrigation treatments. The grain yield decreased by 11.90% from  $I_3$  to  $I_2$ , 17.12% from  $I_3$  to  $I_1$ , and 33.74% from  $I_3$  to  $I_0$  during the study (Table 1). Under limited water, crops grow constantly due to water-stressed and high evapotranspiration (ET). So without plenty amount of water, reach up to the satisfaction level of yield is complicated. The growth and yield attributes were answerable for lower wheat seed and straw yield (Dar *et al.* 2017).

The wheat yield assorted due to the polymer treatment executed. The highest and lower grain yield was recorded when applied hydrogel and no polymers respectively. The yield was increased by 7.41% and 1.15% by application of hydrogel and *gondkatira* over to no polymer might be due to the water availability for the early growth of seeds under dry conditions and, therefore, prevent associated delays in the emergence and prolong water availability supported by

Table 1 Effect of irrigation levels and polymers on yield and yield attributes of wheat

Treatment	Spike length (cm)	1000 grain weight (g)	Grains/spike	GY (kg/ha)	BY (kg/ha)	WUE (kg/ha-mm)
<i>Irrigation</i>						
I <sub>0</sub>	8.88	45.05	49.26	3136	16188	29.87
I <sub>1</sub>	8.94	45.94	52.28	3581	17014	19.90
I <sub>2</sub>	9.03	46.96	54.18	3748	17613	14.70
I <sub>3</sub>	9.21	47.31	57.23	4194	20160	12.71
CD (P=0.05)	0.11	1.30	2.79	505	1507	5.99
<i>Polymer</i>						
Control	8.87	45.358	49.83	3563	16145	18.42
<i>Gondkatira</i>	9.04	46.465	53.94	3604	17869	19.91
Hydrogel	9.14	47.121	55.94	3827	19218	20.55
CD (P=0.05)	0.11	0.662	3.02	NS	450	NS

Treatment details are given in Materials and Methods.

Mandal *et al.* (2015) and Shweta *et al.* (2022).

*Effect of irrigation and polymers on water productivity:*

The significantly higher water productivity was prefigured under no irrigation (I<sub>0</sub>), over to other irrigation treatments (Table 1). However minimum water productivity was registered under three irrigations (I<sub>3</sub>). The decline in water productivity under three irrigations because of the proportionate increase in grain yield was less than the increase in irrigation. With three irrigations, evaporation losses were more than the crop under no irrigation, causing less water productivity (Singh *et al.* 2015).

The effect of polymers was non-significant, however the application of hydrogel increased water productivity. The use of *gondkatira* in wheat enhanced by 8.09% and hydrogel increased water productivity by 11.56%. This might be due to polymers which increased the ability of soil to hold and retain more moisture with steady and gradual release of soil moisture (Nutankujur *et al.* 2022). That means an increase in grain yield by application of polymers, as polymers were helpful in the proper physiological process of a plant under water stress. Application of hydrogel and *gondkatira* could be an effective way for crop cultivation in the soils having low water holding capacity, where rain or irrigational water and fertilizer leached below the root zone within a short period of time, leading to poor water and fertilizer use efficiency by crops.

*Effect on plant water relation:* The plant water relation traits i.e. RWC, LWP, and CT were recorded at anthesis under different treatments (Table 2). RWC of leaves under no irrigation was significantly lower than one, two irrigations, and three irrigations however, canopy temperature and LWP were significantly higher under low irrigation frequencies. Three irrigations have significantly lower canopy temperature and on par with two irrigations. Cooler canopy might be due to efficient root-water status for long duration and continue transpiration process under water stress (Ferrante *et al.* 2012, Sharma and Kumar 2014). Plant water relations were increased by increasing the water

stress or reducing the irrigation frequencies.

The effect of polymers on plant water relations was not significantly affected than to control. However, the use of hydrogel recorded higher values of RWC, LWP, and CT over to control. More RWC of leaves results in the physiological process to continue efficiently under low moisture availability reported by Chen *et al.* (2012). Application of hydrogel and *gondkatira* could conserve water in itself and increase the water holding capacity of soil, ensuring more available water, thus, RWC content in leaves as well as plant growth and yield increased under water stress condition

*Effect on foliar SPAD value and photosynthesis activity:*

The effect of different irrigation treatments had non-significant effect concerning chlorophyll. However, three irrigations treatment have 6.11% higher SPAD value over to no irrigation (Table 2). This result was confirmed by (Singh

Table 2 Effect of irrigation and polymers on physiological parameters at physiological maturity

Treatment	CT (°C)	NDVI	FV/ FM	SPAD	LWP	RWC
<i>Irrigation</i>						
I <sub>0</sub>	18.8	0.67	0.73	44.2	21.5	62.5
I <sub>1</sub>	17.6	0.69	0.74	42.6	17.2	71.5
I <sub>2</sub>	16.5	0.70	0.74	44.4	15.6	74.4
I <sub>3</sub>	16.3	0.71	0.75	46.9	12.2	80.9
CD (P=0.05)	1.3	NS	NS	NS	2.1	8.5
<i>Polymer</i>						
Control	17.6	0.68	0.74	43.6	16.6	71.8
<i>Gondkatira</i>	16.8	0.69	0.74	44.1	16.5	72.6
Hydrogel	17.5	0.71	0.74	45.9	16.8	72.6
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Treatment details are given in Materials and Methods.

Table 3 Effect of irrigation and polymers on wheat quality parameters

Treatment	Protein	Proline ( $\mu\text{mole/g}$ DW)	Hectoliter weight (g)	Phenol test	Sedimentation Value
<i>Irrigation</i>					
I <sub>0</sub>	11.3	12.10	84.0	7.17	38.3
I <sub>1</sub>	11.2	9.60	84.2	7.00	40.5
I <sub>2</sub>	10.8	7.46	84.4	6.50	41.0
I <sub>3</sub>	10.3	4.18	84.8	6.50	41.8
CD (P=0.05)	NS	0.19	NS	NS	NS
<i>Polymers</i>					
Control	10.8	8.65	84.2	6.63	40.0
<i>Gondkatira</i>	10.9	8.21	84.3	6.73	39.4
Hydrogel	11	8.15	84.6	7.03	41.9
CD (P=0.05)	NS	0.17	NS	NS	NS

Treatment details are given in Materials and Methods.

*et al.* 2018). SPAD value and photosynthesis had positive relations and were also an indicator of photosynthetic activity (Zhang *et al.* 2014). High chlorophyll content indicates a low degree of photo-inhibition and reducing carbohydrate losses for grain development. Foliar leaf chlorophyll content of leaf is an indicator of the photosynthesis of plants. The differences in the chlorophyll of polymers are also not significant. However data (Table 2) showed that the use of hydrogel increased 5.28% and *gondkatira* increased the chlorophyll content by 1.15%.

Data (Table 2) revealed that NDVI was not significantly affected by both irrigation and with polymers. The results of the study demonstrated that the highest value of NDVI was recorded in three irrigations and the lowest value without irrigation. The values for NDVI increased by adding polymers, while *gondkatira* improved 1.47% and hydrogel increased NDVI values by 4.41%.

Chlorophyll fluorescence was seen as important for the evaluation of plant health and helpful in the detection of stress tolerance. Lichtenthaler *et al.* (2005) reported the ratio of fluorescence variable (Fv), and maximum fluorescence (Fm) have a significant correlation to water stress. From study revealed that irrigation treatment and application of polymers had a non-significant effect on  $F_v/F_m$  (Maximum quantum efficiency of PS II). Water stress or no irrigation has a lower (0.73) ratio than to no stress or three irrigations (0.75) (Table 2). Chlorophyll fluorescence worked as a non-destructive tool for screening of drought tolerance.

*Effect on quality:* Protein content was not significantly impacted in wheat grain, during experiment by irrigation treatments. No irrigation observed maximum (11.3%) and three irrigations observed minimum (10.3%) protein content. Application of polymers increased the protein content comparison to no polymer, however, differences were non-significant.

According to Maiti *et al.* (2000) proline contents

are indicator of water stress and increased under stress conditions. Different irrigation treatments significantly influenced proline content in the leaves as no irrigation was significantly higher in proline content (12.10  $\mu\text{mole/g}$  DW) and lowest (4.18  $\mu\text{mole/g}$  DW) proline content was with three irrigation locations (Table 3). Hectolitre weight, phenol check, and sedimentation value of treatments have not been significantly affected. Data indicates an increment in hectolitre weight and sedimentation and decreased phenol tests under three irrigation treatments. However, polymers have increased the hectolitre weight, the phenol test, and sedimentation values rather than control.

Based on our findings, we suggest that the application of hydrogel and *gondkatira* could be an effective drought mitigation strategy for field crop production in arid and semiarid regions of Haryana and the areas with similar ecologies.

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