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Short Communication

Growth analysis, micro-climatic parameters and productivity of wheat (*Triticum aestivum* L.) in relation to hydrogel under different irrigation regimes and nutrient levels

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Wheat (*Triticum aestivum* L.) is the world's most widely cultivated food crop. Besides staple food for human beings, wheat straw also serves as good source of feed for animals (Sarwar*et al.*, 2006). Wheat grain contains about 12% protein which is more than that in other cereals and is of special significance to maintain the good bread making quality due to the presence of a characteristic substance called 'gluten'. Water availability is one of the most important factors influencing the growth and productivity of wheat. Water requirement of wheat vary from 180-420 mm depending upon the duration of the crop. Thus, there is a sufficient scope to carry out what minimum amount of water should be applied to have maximum yield per unit of water applied. In addition to water, fertilizers constitute an integral part of improved crop production technology. Supply of adequate amounts of nutrients and its management is one of the most important factors in influencing the yield of not only wheat but other crops as well. The proper amount of fertilizer application is considered a key to the bumper crop production (Barthwal *et al.*, 2013). With rising cropping intensities in South Asia, nutrient management is a major issue being addressed by agricultural scientists for understanding any decline in yields. Leaching losses are completely associated with irrigation management. Though it is not possible to eliminate leaching losses completely while maintaining optimum crop productivity, proper irrigation schedule can keep the leaching losses to a minimum (Kumar *et al.*, 1995). Crop production systems that optimize yield, reduce losses and improve N uptake and water use efficiency are important in sustainable agriculture. Hydrogel is one of the most popular gel, used to increase infiltration rates in field agriculture, in addition to increasing water holding capacity for agricultural applications. The use of hydrophilic polymers to improve soil water and fertilizer retention properties and thus crop productivity is attracting considerable interest. Thus, there was need to study the effect of hydrogel on growth analysis and productivity in relation to fertilizers and irrigation levels.

The field experiment was conducted at the Punjab Agricultural University, Ludhiana (30^0 56′ N latitude and 75^o 52′ E longitude and at an altitude of 247 m above m.s.l), Punjab during *rabi* 2013-14. The soil type was deep alluvial loamy sand, TypicUstochrept, low in organic carbon (4.2 g C/kg at 0-15 cm), EC 0.12 dS/m normal in pH (pH 7.6), low in available N 183.4 kg/ha, medium in available P (13.8 kg/ha) and ammonium acetate extractable K (145.1). The rainfall of 177 mm was received during the wheat growing season. The experiment was conducted in a split plot design with four levels of irrigation at various physiological growth stages of wheat crop i.e. I_{0} - no irrigation, I_{2} - two irrigations at crown root initiation [CRI (20-25 DAS)] and boot stage (90-95 DAS), I_{3} - three irrigations at CRI, tillering (50-60 DAS) and milk stage (105-115 DAS) and I_{4} - four irrigations at CRI, tillering, boot stage and milk stage in main plots and six levels of nutrient and hydrogel doses (100% RDF without hydrogel, 100% RDF with 2.5 kg/ha hydrogel,100% RDF with 5.0 kg/ha hydrogel, 75% RDF without hydrogel,75% RDF with 2.5 kg/ha hydrogeland 75% RDF with 5.0 kg/ha hydrogel) in sub plots with three replications. Hydrogel developed by Indian Agricultural Research Institute (IARI), New Dehli was used and was applied with last ploughing before sowing of the wheat crop. The crop was sown on flat bed with row spacing of 20 cm. The recommended dose of fertilizers (RDF) of nitrogen in the form of urea (46% N) was used at the rate of 150 kg N/ha (3 split doses: 1/2 at sowing, 1/4 at I^{st} irrigation and 1/4 at 2^{nd} irrigation). Phosphorus (P_2O_5) at the rate of 62.5 kg/ha in the form of Di-ammonium phosphate (DAP- 18% N, 46 % P_2O_5) and Potassium (K_2O) at the rate of 30 kg/ha in the form of Muriate of Potash (MOP- 60 % K_2O) fertilizers were applied at the time of sowing. The data on yield was collected at harvest and presented as q/ha. PAR was measured at 30 days interval with SunScan Canopy

Analyser System between 12:00 noon and 2:00 pm. Crop growth rate (CGR), relative growth rate (CGR) and Photosynthetically active radiation interception (PARI) were calculated by using the following formulae.

$$CGR\ (gm^{-2}d^{-1}) = \frac{W_2 - W_1}{T_2 - T_1} \times 100$$

$$RGR\ (gm^{-2}d^{-1}) = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \times 100$$

$$PARI\ (\%) = \frac{\text{PAR at top of the canopy} - \text{PAR at bottom of canopy}}{\text{PAR at top of the canopy}} \times 100$$

where, W_1 and W_2 are the weight recorded at time T_1 and T_2 respectively.

NDVI was measured with Green Seeker Handheld Crop Sensor. Chlorophyll content was measured by a handheld chlorophyll meter and the data was converted to mg cm^{-2} using standard methods. Analysis of variance (ANOVA) was performed using CPCS 1 statistical software at a 0.05 level of probability used to test the significance of differences among treatment means.

CRG and RGR: The irrigation, nutrient and hydrogel levels showed significant effect on crop growth rate and relative growth rate of wheat crop. CGR at 30-60 & 60-90days after sowing (DAS) and RGR (60 &90 DAS) recorded under I_4 and I_3 were statistically at par with each other and were significantly higher than I_2 and I_0 treatment of irrigation (Table 1).

Table 1. Growth analysis and periodic micro-climatic observations of wheat (*Triticum aestivum* L.) in relation to hydrogel under different irrigation regimes and nutrient levels

Treatment	CGR ($gm^{-2}d^{-1}$)				RGR ($g\ g^{-1}d^{-1}$)				PAR interception (%)			
	30-60	60-90	90-120	120-Harvest	60	90	120	Harvest	30	60	90	120
Irrigation levels												
I_0	0.39	0.96	1.53	0.40	0.59	0.30	0.38	0.20	34.7	42.4	61.4	55.4
I_2	0.60	1.25	1.88	0.43	0.72	0.34	0.44	0.21	43.7	55.0	82.0	72.0
I_3	0.72	1.36	2.05	0.46	0.75	0.39	0.63	0.24	43.9	61.3	89.0	79.0
I_4	0.75	1.38	2.28	0.47	0.78	0.41	0.67	0.24	44.7	61.6	90.1	80.1
CD (p=0.05)	0.06	0.2	0.2	0.05	0.04	0.02	0.03	0.02	2.1	2.7	5.3	5.3
Nutrient and hydrogel levels												
$RDF_{100}H_0$	0.55	1.24	1.86	0.50	0.69	0.32	0.53	0.22	42.2	54.0	79.6	70.6
$RDF_{100}H_{2.5}$	0.65	1.28	2.01	0.52	0.72	0.36	0.57	0.27	42.9	57.1	83.0	74.0
$RDF_{100}H_5$	0.70	1.29	2.07	0.52	0.76	0.37	0.58	0.28	43.2	59.1	86.3	77.3
$RDF_{75}H_0$	0.49	1.04	1.63	0.39	0.60	0.30	0.42	0.18	37.3	46.2	67.9	58.9
$RDF_{75}H_{2.5}$	0.60	1.27	1.90	0.43	0.71	0.35	0.54	0.25	41.8	55.2	81.0	72.0
$RDF_{75}H_5$	0.70	1.30	2.15	0.53	0.77	0.38	0.58	0.28	43.2	58.9	86.1	77.1
CD(p=0.05)	0.06	0.02	0.20	0.04	0.04	0.02	0.03	0.02	1.4	2.0	3.7	3.7
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Similar results of CGR and RGR were recorded at 120 DAS and at harvest also. However CGR and RGR recorded at 90-120 and 120 DAS respectively, under I_4 treatment of irrigation was significantly better than all the other treatments. Among nutrition and hydrogel treatments,$RDF_{75}H_{5.0}$ recorded the highest CGR and RGR which was statistically at par with $RDF_{100}H_{5.0}$ and $RDF_{100}H_{2.5}$ and significantly better than all the other treatments. This could be the higher nutrient and moisture availability to wheat crop with increase in nutrient and hydrogel levels.

PARI and NDVI: PAR interception (Table 2) and NDVI (Table 1) were significantly higher with I_4 irrigation treatment than I_0 and I_2 treatments but was statistically at par with I_3treatment except at 30 days after sowing where I_4, I_3 and I_2 were statistically at par with each other and were significantly better than I_0. On the other hand at 60, 90 and 120 days after sowing nutrient and hydrogel levels $RDF_{100}H_{5.0}$ recorded the highest NDVI and PAR interception which was statistically at par with $RDF_{100}H_{2.5}$ and $RDF_{75}H_{5.0}$ and were significantly better than rest of the treatments. Irrespective of nutrient levels hydrogel also improved vigour of wheat crop. This can be due to increased growth under more moisture and nutrient availability which leads to more NDVI and PAR interception values.

Chlorophyll content: In terms of the chlorophyll of the leaves,I_0 treatment resulted in significantly better chlorophyll content of leaves than I_2, I_3 and I_4 treatments except at 30 days after sowing where chlorophyll content of leaves was statistically at par under I_3 and I_4 treatments but was lower than I_0 and I_2 treatment of irrigation (Table

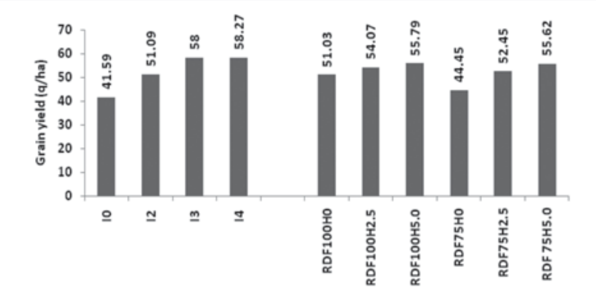
2). This can due to the fact that lower moisture availability restricts the plant height and tillering of crop which results in higher chlorophyll content. At 30 days after sowing $RDF_{100}H_0$ recorded significantly higher chlorophyll content. A progressive decrease in chlorophyll content was observed with increasing hydrogel levels. Similar results were recorded at 60, 90 and 120 days. The treatment $RDF_{75}H_0$ showed significantly lower chlorophyll content than other treatments. This can be due to the fact that hydrogel increased the soil moisture content and provides the favourable conditions for the crop growth.

Grain yield: In different irrigation treatments, there was a progressive increase in wheat grain yield with

Table 2. Periodic NDVI and chlorophyll of wheat (*Triticum aestivum* L.) in relation to hydrogel under different irrigation regimes and nutrient levels

Treatment	NDVI				Chlorophyll content (mg cm^{-2})			
	30	60	90	120	30	60	90	120
Irrigation levels								
I_0	0.40	0.61	0.72	0.71	0.396	0.450	0.434	0.414
I_2	0.46	0.74	0.85	0.83	0.367	0.415	0.397	0.376
I_3	0.46	0.80	0.88	0.87	0.334	0.385	0.368	0.348
I_4	0.46	0.80	0.89	0.88	0.337	0.372	0.357	0.337
CD (p=0.05)	0.02	0.06	0.03	0.04	0.003	0.002	0.002	0.002
Nutrient and hydrogel levels								
$RDF_{100}H_0$	0.45	0.72	0.82	0.81	0.381	0.428	0.414	0.394
$RDF_{100}H_{2.5}$	0.45	0.74	0.84	0.82	0.361	0.409	0.392	0.373
$RDF_{100}H_5$	0.46	0.77	0.87	0.86	0.350	0.399	0.380	0.358
$RDF_{75}H_0$	0.40	0.68	0.79	0.77	0.353	0.410	0.393	0.374
$RDF_{75}H_{2.5}$	0.45	0.74	0.83	0.82	0.355	0.397	0.380	0.360
$RDF_{75}H_5$	0.46	0.76	0.86	0.85	0.351	0.390	0.376	0.353
CD (p=0.05)	0.03	0.03	0.03	0.03	0.002	0.001	0.001	0.001
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

every increment in irrigation level with I_4 resulted in significantly higher yield than I_0 and I_2 treatments while, it was statistically at par with I_3 treatment of irrigation (Fig 1). This could be due to favourable moisture conditions under higher irrigation levels (8). $RDF_{100}H_{5.0}$ recorded the higher grain yield than $RDF_{100}H_0$, $RDF_{75}H_0$ and $RDF_{75}H_{2.5}$ and was statistically at par with $RDF_{100}H_{2.5}$ and $RDF_{75}H_{5.0}$. Application of 75% RDF resulted in significantly lower grain yield as compared to 100% RDF. Hydrogel @ 5 kg ha^{-1} along with 75% RDF recorded similar grain yield as that of 100% RDF. This might be due to fact that hydrogel improved the soil moisture conditions in addition to reducing the leaching losses of nutrients. Similar effect of hydrogel has also been reported by Rehman*et al.* (2011) on rice crop.



CD (p=0.05) 0.23 0.18

Fig. 1 Grain yield under different irrigations, fertilizer and hydrogel treatment

It is concluded from the study that under well distributed rainfall of about 170 mm during crop season, three irrigations can be applied to the wheat crop without decreasing the yield instead of four or five irrigations. Crop growth rate (CGR), relative growth rate (RGR), Photosynthetically active radiation (PAR) interception and Normalized Difference Vegetation Index (NDVI) recorded under I_3 or I_4 was higher than other irrigation levels. On the other hand decreasing the nutrient application by 25% decreased the yield of wheat. The results revealed that with the application of hydrogel at the rate of 5 kg/ha, nutrient application can be reduced by 25% without decreasing the yield of crop. Chlorophyll value results in decrease with increase in irrigation and nutrient levels.

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