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Efficacy of hydrogel and chitosan on wheat (*Triticum aestivum* L.) Growth and yield under deficit irrigation level

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Abstract
In India natural sources of water for irrigation is rainfall or by using artificial resources. Apart from that now rainfall pattern leading to unpredictable changes due to climate change and global warming. Based on experimentation at New Delhi, India has reported that a 1ºc rise in temperature throughout the growing period will reduce wheat production by 5 million tonnes. Wheat is most sensitive to drought stress. Water stress at this stage is substantially impact on yield. Due to increase in rate of transpiration that will rise demand. To cope up with coming situation the experiment was conducted at Central Agricultural field, Sam Higginbottom University of Agriculture, Technology & Sciences, U.P on wheat variety (HD-2967). Hydrogel and Chitosan were taken under different concentration to evaluate the effect of hydrogel and chitosan on growth and yield of wheat under water deficit condition as hydrogel can retain large quantity of water and chitosan can reduce transpirational loss of water. Hydrogel (100 %, 75 %, 50 % and 25 %) and Chitosan (100 %, 75 % and 50 %) with twenty-one treatments and three replications along with control were laid out in randomized block design. Growth and yield parameters were observed. Result on crop growth and yield under water deficit condition was observed. Treatment T_9 (100 % HG and 100 % CHT) showed best results, however T_{10} was statistically at par with T_9, while T_{11} was found non-significant with T_0.

Keywords: pusa hydrogel, chitosan, water scarcity, growth, yield

Introduction
Water is becoming increasingly scarce worldwide. Aridity and droughts are the natural causes for scarcity. Agriculture is therefore forced to find new approaches to cope with water scarcity but adopting sustainable water use issues. Climate impacts and adaptation strategies are increasingly becoming major areas of scientific concern, e.g. impacts on the production of crops such as maize, wheat and rice (Howden and Leary, 1997) [12].

Although population growth is generally expected to slow in the coming decades, median forecasts typically assume that the world population will grow close to another 50% above the recent milestone of 7 billion people.

Drought is a normal recurrent feature of Climate & occurs in all climatic regiones and is usually characterized in terms of its spatial extension, intensity & duration (Rizwana *et al.,*) Drought is generally considered to be occurring when the principle monsoon, i.e. southwest monsoon & north cost monsoon, fail or are deficient or scanty. (GOI, 2000) [28].

Wheat (*Triticum aestivum* L) is the most extensively grown cereal crop in the world, covering about 237 million hectares annually, accounting for a total of 420 million tonnes and for at least one-fifth of man's calorie intake.

The position of wheat is crucial in daily food consumption due to its absolute baking performance in contrast to all other cereals (Dewettinck *et al.*, 2008) [4] and is the best source for feeding humans (Mesbah, 2009) [25]. Due to water stress, wheat yield, as well as the quality of wheat, is affected (Moharram and Habib, 2011). So, the time has come to improve water availability on one hand, and on the other to evolve wheat varieties that can withstand water stress without compromising quality. To cope with water scarcity two different technologies have been used like-water saving or water retention capacity and reducing transpiration through formation waxy coating layer on the leaf surface.

These problems require the use of an integrated approach that includes agronomic water-saving techniques, and appropriate management practices (Yu *et al.*, 2011) [38]. The use of water absorbing polymers (i.e., hydrogels) or superabsorbent polymers (SAPs) such as polyacrylates cross-linked with polyacrylamides (PAM) can effectively improve the top soil's ability to store water available for plant growth and production (Yu *et al*., 2011), and reduce seepage of water, and fertilizer and heavy metal leaching down the soil profile (Qu and Varennes, 2009) [31].

Hydrogel is a semi-synthetic, cross linked, derivatized cellulose-graft-anionic polyacrylate super absorbent polymer. (Success Story, 2012) [35]. Optimized absorption release ratio under load (AUL) Gradual biodegradability without formation of toxic products HG -neutrality after swelling in water (Success Story, 2012) [35].

A balance between leaf HG photosynthesis and transpiration can be achieved by adjusting the stomatal behaviour to the optimal status using exogenous substances (Antitranspirants), which lead to an increase in water use efficiency (WUE) at the leaf level. Application methods using antitranspirants have been proposed to reduce water loss and enhance the water status of plants. (Lipe and Wendt, 2008) [23].

Chitosan is an antitranspirant compound that has proved to be effective in many crops. Can help to preserve water resources use in agriculture (Bittelli *et al*., 2001) [3]. Under chitosan application plant reacts to water deficit with a rapid, abscisic acid (ABA)-mediated closure of stomata bringing down rate of transpiration (Pospisilova *et al*., 2003) [29]. They include both film-forming and stomata closing compounds, able to increase the leaf resistance to water vapor loss. (Tambussi and Bort, 2007) [6].

Materials and Methods

Present study was conducted in central agricultural field of SHUATS, located at 25.570 N latitude, 81.510 E longitude and 98 m altitude above the mean sea level. As per the purpose of study experiment was conducted based on surface irrigation to create water deficit condition for wheat variety HD-2967 we have taken different doses of Hydrogel (100%, 75%, 50%, and 25%) applied in soil initially before sowing and foliar spray of antitranspirant chitosan (100%, 75%, and 50%) at jointing and booting stage. Overall twenty-one treatments were laid under randomized block design with three replications.

Different vegetative growth (Plant height, No. of tillers/hill, flag leaf length, flag leaf width) and reproductive and yield parameter (Spike length/spike, No. of spikelet/spike, Days to 50% flowering, biological yield, grain yield, harvest index, and 1000 grain weight) are analyzed during the course of study. All the observation and analysis are conducted by standard procedure and statistical analysis are provided.

Treatment details: T0 (100% IR without HG & CHT), T1 (40% IR without HG & CHT), T2 (40% IR with 100% HG), T3 (40% IR with 75% HG), T4 (40% IR with 50% HG), T5 (40% IR with 25% HG), T6 (40% IR with 100% CHT), T7 (40% IR with 75% CHT), T8 (40% IR with 50% CHT), T9 (40% IR with 100% HG & 100% CHT), T10 (40% IR with 100% HG & 75% CHT), T11 (40% IR with 100% HG & 50% CHT), T12 (40% IR with 75% HG & 100% CHT), T13 (40% IR with 75% HG & 75% CHT), T14 (40% IR with 75% HG & 50% CHT), T15 (40% IR with 50% HG & 100% CHT), T16 (40% IR with 50% HG & 75% CHT), T17 (40% IR with 50% HG & 50% CHT), T18 (40% IR with 25% HG & 100% CHT), T19 (40% IR with 25% HG & 75% CHT), T20 (40% IR with 25% HG & 50% CHT). Where, HG is Hydrogel, CHT is chitosan and IR are irrigation.

Results and Discussion

Vegetative growth period of all crops has its importance as they form the base of plant health and resultant yield depends on it. During course of study growth parameter analysed were plant height, flag leaf length, flag leaf width along with days to maturity. Under drought condition decreasing pattern was experienced in morPHologically yield contributing characters like plant height (HG), grains per spike, spikes per plant, 1000-grain weight (TGW) in wheat (Kilic and Yagbasanlar, 2010) [19]. But in this study observation suggests that all the treatments which were treated with Hydrogel and chitosan were showing better result in comparison to water deficit condition (40% Irrigation without Hydrogel & Chitosan). However, when we are comparing our observation with normal irrigation we observed that treatment T_9 and T_{10} were showing better result while T_{11} was showing non-significant relationship with T_0.

For plant height all the treatments which were treated with hydrogel and chitosan were showing better result in comparison to water deficit condition (40% IR without HG and CHT). However, when we are comparing our observation with normal irrigation we observed that treatment T_9 (92.77 cm) and T_{10} (82.60 cm) were showing better result while T_{11} (80.00 cm) was showing non-significant relationship with T_0 (76.78 cm) (Table 1). Hydrogel have been reported to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased plant height (Singh, 2015). Similar results have been reported by (Sivalapan, 2001) in soybean and (Kumaran *et al.*, 2001) [22] in tomato.

For number of tillers per hill all the treatments under water deficit condition treated with hydrogel and Chitosan were found to be better compare to treatment which is not treated with hydrogel and chitosan i.e. T_1 (6.20) (40% IR without HG and CHT), however T_9 (10.96) and T_{10} (9.95) were showing better result while T_{11} (8.20) was showing non-significant relationship with T_0 (Table 1). Over the stress treatments, stress imposed at vegetative caused decline of 19.11% in tillers as compared to non-stressed condition. Similar to present findings (Kimurto *et al*., 2003) [20] and (Baque *et al*., 2006) [2] have reported that water stress at tillering or at booting significantly affected the formation of tillers in wheat.

For flag leaf length and flag leaf width all the treatments under water deficit condition treated with hydrogel and chitosan were found to be better compare to treatment which is not treated with hydrogel and chitosan i.e. T_1 (10.85 FLL; 0.99 FLW) (40% IR without HG and CHT), however T_9 (15.27 FLL; 2.25 FLW) and T_{10} were showing better result while T_{11} was showing non-significant relationship with T_0 (14.85 FLL; 1.75 FLW) (Table 1). The decreasing graHG in grain number was linked with reduced leaf area and lower PHotosynthesis as outcome of drought stress (Fischer *et al.* 1980) [5].

For days to 50% flowering and days to maturity, treatment under water deficit condition in which Hydrogel and chitosan is not applied i.e. T_1 (62.02 DTF; 106.94 DTM) showed early flowering and maturity as compared to HG and CHT applied treatments. However, T_9 (84.74 DTF; 123.97 DTM) followed by T_{10} (82.73 DTF; 123.46 DTM) (Table 2). The plants strive to complete their life cycle as early as possible to cope with drought stress conditions. Therefore, days required to initiate heading or flowering in wheat are generally decreased due to early start of reproductive stage (Riaz, 2003) [32].

For spike length per spike and number of spikelets per spike all the treatments which were treated with hydrogel and

Chitosan were showing better result in comparison to water deficit condition (40% IR with no HG and CHT). Whereas T_9 (SL10.58 cm; NSL 18.88), T_{10} (SL9.03 cm; NSL 18.18) were showing better result, However, when we are comparing our observations with normal irrigation T_{11} (SL8.19 cm; NSL 17.79) is showing non-significant relationship with T_0 (SL8.07 cm; NSL 16.85) (Table 2). The decrease in stem height and ear length due to water stress has been reported earlier in wheat (Iqbal *et al*., 1999). Water stress during vegetative and reproductive development had an equal suppressive effect on number of spikelets per spike in four wheat varieties (Qadir *et al*., 1999) [30]. The results of this conform to the findings of (Karim *et al*., 2000) and (Baque *et al.*, 2006) [2] who reported that water stress reduced grain yield by reducing productive tillers, fertile spikelet, number of grains per plant and individual grain weight. Found that pod length in guar genotypes decreased significantly with application of water stress when compared with control. (Qadir *et al*., 1999) [30]. Also found that water stress reduced the spikelet per spike in wheat.

For yield parameters biological yield, grain yield, harvest index and 1000 grain weight all the treatments in which hydrogel and chitosan is applied were showing better results in comparison to water deficit condition T_1 (BY 45.47; GY 37.86; HI 53.89; TGW 11.93) (40% IR without HG and CHT). However, when we are comparing our observation with normal irrigation T_0 (BY 80.90; GY 49.87; HI 65.97; TGW 35.49) we observed that treatment T_9 (BY 88.98; GY 55.24; HI 89.99; TGW 41.64) and T_{10}(BY 82.83; GY 54.55; HI 71.65; TGW 39.96) were showing better result (Table 2) Due to water shortage, the ability of absorbing nutrients, composing and transferring assimilate is decreased that leads to a reduction in biological yield (Kisman, 2003). The results of many researches show that drought stress at different stages of the growth of wheat lead to a reduction in the yield of biomass, grain yield, harvest index and grain yield components of wheat (Gooding *et al.*, 2003), (Garcia *et al.*,2003), and (Zaharieva *et al.*, 2001). The results of other researchers also show that harvest index will decrease in the treatments under drought stress due to the effect of drought stress on grain yield (Gebeyehu, 2006). 1000 grain weights of all the treatments which were treated with hydrogel and chitosan were showing better result in comparison to water deficit condition (40% IR without HG and CHT). (Gooding *et al.*, 2003) in their studies on intensity and duration of water stress on wheat reported that drought stress reduced grain yield and 1000-grain weight by shortening the grain formation period. (Khan *et al*., 2005) and (Qadir *et al*., 1999) [30]. who observed that 1000-grain weight of wheat was reduced mainly due to increasing water stress.

Table 1: Effect of Hydrogel and Chitosan on plant height (cm), number of tillers per hill, flag leaf length (cm) and flag leaf width (cm) and days to maturity of wheat under water deficit condition

Treatments	Plant height (cm)	No. of tillers per hill	Flag Leaf Length(cm)	Flag Leaf Width (cm)	Days to Maturity
T_0	76.78	8.10	14.85	1.75	122.63
T_1	59.93	6.20	10.85	0.99	106.94
T_2	76.05	8.09	14.70	1.62	121.73
T_3	72.06	7.60	13.68	1.44	120.64
T_4	68.24	7.24	12.76	1.26	115.76
T_5	67.93	7.16	12.39	1.17	114.85
T_6	66.17	6.80	11.79	1.16	113.74
T_7	66.16	6.70	11.48	1.14	113.67
T_8	61.95	6.58	11.41	1.02	107.88
T_9	92.77	10.96	15.27	2.25	123.97
T_{10}	82.60	9.95	15.19	1.90	123.46
T_{11}	80.00	8.20	15.06	1.89	123.10
T_{12}	75.87	7.98	14.25	1.55	121.59
T_{13}	70.98	7.51	14.14	1.45	120.87
T_{14}	72.68	7.77	13.20	1.42	118.39
T_{15}	68.92	7.34	13.48	1.42	120.12
T_{16}	68.75	7.32	13.14	1.41	117.71
T_{17}	68.48	7.31	13.13	1.39	117.59
T_{18}	68.05	7.22	13.09	1.36	116.44
T_{19}	66.98	7.13	12.58	1.22	114.97
T_{20}	66.24	6.91	12.05	1.16	114.61
Mean	71.31	7.62	13.26	1.43	117.65
SE. d	0.274	0.273	2.99	-	0.287
C.D (5%)	0.549	0.546	5.991	-	0.574
C.V	0.462	4.301	1.314	32.338	0.293
F Test	S	S	S	N/S	S

Table 2: Effect of Hydrogel and Chitosan on Spike length, no, of spikelet per spike, days to 50% flowering, biological yield, grain yield, harvest index and 1000 grain weight of wheat under water deficit condition

Treatments	Spike Length (cm)	No. of Spikelet/ spike	Days to 50% Flowering	Biological yield (q/ha)	Grain yield (q/ha)	Harvest Index (%)	1000 grain weight(g)
T_0	8.07	16.85	78.71	80.90	49.87	65.97	35.49
T_1	5.81	9.67	62.02	45.47	37.86	53.89	11.93
T_2	7.86	16.71	78.30	80.55	49.65	65.71	34.26
T_3	6.61	14.79	77.37	77.11	46.98	62.83	33.82
T_4	6.24	13.10	71.29	70.75	43.73	60.01	30.07
T_5	6.14	12.15	69.10	68.59	43.54	58.98	28.04

T_6	6.05	11.96	67.45	64.29	42.93	57.58	27.95
T_7	6.01	11.85	65.54	60.88	42.54	55.94	26.27
T_8	5.91	10.12	65.40	58.31	41.97	54.74	23.95
T_9	10.58	18.88	84.74	88.98	55.24	89.99	41.64
T_{10}	9.03	18.18	82.73	82.83	54.55	71.65	39.96
T_{11}	8.19	17.79	80.78	81.82	50.69	67.68	37.90
T_{12}	7.77	15.85	77.98	79.91	48.60	64.25	33.95
T_{13}	7.06	15.60	77.53	79.75	47.77	63.00	33.91
T_{14}	7.00	14.59	75.80	74.97	46.31	61.78	31.99
T_{15}	7.02	14.69	76.53	75.87	46.60	61.82	32.48
T_{16}	6.95	13.92	74.86	74.84	45.82	61.37	31.84
T_{17}	6.80	13.78	74.62	71.87	44.94	61.04	30.75
T_{18}	6.79	13.42	73.85	71.52	44.86	60.70	30.36
T_{19}	6.61	12.66	70.31	68.78	43.70	59.65	29.91
T_{20}	6.17	12.09	68.58	67.86	43.47	58.63	14.30
Mean	7.08	14.22	73.98	72.66	46.27	62.72	30.51
SE. d	0.171	0.323	0.381	7.35	0.207	0.533	0.580
C.D (5%)	0.343	0.646	0.763	14.701	0.414	1.067	1.161
C.V	2.921	2.756	0.625	12.264	0.541	1.035	2.310
F Test	S	S	S	S	S	S	S

Conclusion

This study may conclude that under water deficit condition all the treatments are showing better results in comparison to T_1 (40% IR without hydrogel and Chitosan) for growth and yield parameters. Although T_9 (40% IR with 100% hydrogel and 100% Chitosan) was showing best results for all growth, reproductive and yield parameters. In comparison to T_0 (100% IR without hydrogel and chitosan), T_9 and T_{10} were found better for all the parameters observed, analyzed during the study although T_{11} states non-significant with T_0.

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