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Efficacy of pusa hydrogel and chitosan on wheat (*Triticum aestivum* L.) growth and yield under water deficit condition

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Abstract
Rainfall and irrigation are the two main sources of water in agriculture. Although shifting in climate, results in changes in global rainfall pattern leading to unpredicted drought condition. As per "SAPCC 2014" some part of UP, especially eastern UP will face rise in temperature (3 to 5° C up to 2050) and water scarcity condition. 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). Pusa hydrogel and Chitosan were taken under different concentration to evaluate the effect of pusa hydrogel and chitosan on growth and yield of wheat under water deficit condition as pusa hydrogel can retain large quantity of water and chitosan can reduce transpirational loss of water. Pusa 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% PH 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 supply and quality will continue to be major global issues as shifts occur in urbanization, sanitation, declining availability of groundwater, and increased environmental regulations. Many of these issues relate directly to agricultural water use and urban competition with crop and animal agriculture. Water is most importantly used for irrigation in agriculture which is key component to produce food. Irrigation accounts for more than 70% of total water withdrawals on a global basis (FAO, 2012a) [5]. Much of the current irrigation water comes from surface supplies, but 40% of the irrigated area uses groundwater sources (Siebert *et al.*, 2010) [31].

Further climate change report states, rise in minimum temperature is appreciably higher than that maximum temperature and normal rainfall was recorded in only in one year (2008-09) in past decades (947mm), and average annual rainfall decreased from 947mm to 737 mm. Further, of the total 10 years, 6 years received even below the decadal average *i.e*., 737mm. Such increasing in temperature and low rainfall causes drought prone condition in coming years in utter Pradesh especially eastern UP will face rise in temperature (2 - 4.5) and water scarcity condition, which is directly, effects on agriculture production (SAPCC, 2014).The reduced precipitation and changed rainfall patterns are causing the frequent onset of droughts around the world (Lobell *et al*., 2011) [24]. It is reported by NIDM UP, 2012 [26] in Uttar Pradesh of India in past few years drought is experienced once in every third year in western part and once in five years in eastern parts. Drought stress takes place when soil and atmospheric humidity is low and the ambient air temperature is high. This condition is the result of an imbalance between the evapotranspiration flux and water intake from the soil (Lipiec *et al.*, 2013) [23]

Drought stress seriously limiting crop production in the majority of agricultural fields of the world and recent global climate change has made this situation more adverse (Ghamdi, 2009) [9]. Drought affects morphological, physiological, biochemical and molecular processes in plants resulting in growth inhibition, and can be said as one the most devastating environmental stresses (Pour *et al*., 2011) [28]. A study published for duration 1980 to 2015 reports 21 and 40% yield reductions in wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.), respectively due to drought on a global scale (Daryanto *et al*., 2016) [4]. These stresses limit plant growth and productivity more than any other environmental factor. For instance, global wheat production was simulated to decline by 6% for each degree Celsius rise in temperature (Asseng *et al*., 2015) [2].

Wheat (*Triticum aestivum* L.) belongs to family Poaceae having chromosome number (2n=42), it is occupies 17% of crop acreage worldwide, feeding about 40% of the world population and providing 20% of total food calories and protein in human nutrition (Gupta *et al*., 2008) [11].

It is obvious that continuous plant growth and reduction of drought stress influenced the plant and consequently its yield is increased (Mohammad *et al*., 2012) [25]. Super absorbent polymers are compound that absorb water and swell into many times of their original size and weight (Pandey *et al.*, 2017) [27] and they can increase soil's water holding capacity with delaying water stress in plants and providing a buffer against product loss during the time between two irrigations. (Hanieh *et al*., 2013) [12].

Antitranspirants are the chemical compound which favours reduction in rate of transpiration from plant leaves by reducing the size and number of stomata and gradually hardening them to stress (Ahmed *et al*., 2014; Khawaga, 2013) [1, 18]. Booting is the most sensitive stage of wheat to drought, which coincides with meiosis of pollen mother cells. At this stage water stress substantially impacts yield. Hence, the antitranspirant application prior to this stage may conserve water and improve grain set which could balance the photosynthetic limitations (Kettlewell *et al*., 2010) [15]. The objective of this study was to find out the efficacy of pusa hydrogel and chitosan on wheat growth and yield under water deficit condition.

Materials and Methods

Present study was conducted in central agricultural field of SHUATS, located at 25.57^0 N latitude, 81.51^0 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 Pusa 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 analysed during the course of study. All the observation and analysis are conducted by standard procedure and statistical analysis are provided.

Treatment details: T_0 (100% IR without PH & CHT), T_1 (60% IR without PH & CHT), T_2 (60% IR with 100% PH), T_3 (60% IR with 75% PH), T_4 (60% IR with 50% PH), T_5 (60% IR with 25% PH), T_6 (60% IR with 100% CHT), T_7 (60% IR with 75% CHT), T_8 (60% IR with 50% CHT), T_9 (60% IR with 100% PH & 100% CHT), T_{10} (60% IR with 100% PH & 75% CHT), T_{11} (60% IR with 100% PH & 50% CHT), T_{12} (60% IR with 75% PH & 100% CHT), T_{13} (60% IR with 75% PH & 75% CHT), T_{14} (60% IR with 75% PH & 50% CHT), T_{15} (60% IR with 50% PH & 100% CHT), T_{16} (60% IR with 50% PH & 75% CHT), T_{17} (60% IR with 50% PH & 50% CHT), T_{18} (60% IR with 25% PH & 100% CHT), T_{19} (60% IR with 25% PH & 75% CHT), T_{20} (60% IR with 25% PH & 50% CHT). Where, PH is Pusa hydrogel, CHT is chitosan and IR is irrigation.

Results and Discussion

Vegetative growth period of all crops have 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 (PH), grains per spike, spikes per plant, 1000-grain weight (TGW) in wheat (Kilic and Yağbasanlar, 2010) [19]. But in this study observation suggests that all the treatments which were treated with Pusa hydrogel and chitosan were showing better result in comparison to water deficit condition (60% Irrigation without Pusa 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 pusa hydrogel and chitosan were showing better result in comparison to water deficit condition (60% IR without PH and CHT). However, when we are comparing our observation with normal irrigation we observed that treatment T_9 (94.09 cm) and T_{10} (93.35 cm) were showing better result while T_{11} (92.57 cm) was showing non-significant relationship with T_0 (92.43 cm) (Table 1). Pusa 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) [32]. Similar results have been reported by (Sivalapan, 2001) [33] 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 pusa hydrogel and Chitosan were found to be better compare to treatment which is not treated with pusa hydrogel and chitosan i.e. T_1 (9.07) (60% IR without PH and CHT), however T_9 (11.40) and T_{10} (11.20) were showing better result while T_{11} (10.93) 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 nonstressed condition. Similar to present findings (Kimurto *et al*., 2003) [20] and (Baque *et al*., 2006) [3] 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 pusa hydrogel and chitosan were found to be better compare to treatment which is not treated with pusa hydrogel and chitosan i.e. T_1 (12.65 FLL; 1.32 FLW) (60% IR without PH and CHT), however T_9 (16.25 FLL; 1.73 FLW) and T_{10} were showing better result while T_{11} was showing non-significant relationship with T_0 (15.05 FLL; 1.61 FLW) (Table 1). The decreasing graph in grain number was linked with reduced leaf area and lower photosynthesis as outcome of drought stress (Fischer *et al.* 1980) [6].

For days to 50% flowering and days to maturity, treatment under water deficit condition in which Pusa hydrogel and chitosan is not applied i.e. T_1 (79.67 DTF; 116.67 DTM) showed early flowering and maturity as compared to PH and CHT applied treatments. However, T_9 (86.67 DTF; 122.67 DTM) followed by T_{10} (86.00 DTF; 122.33 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) [30].

For spike length per spike and number of spikelet per spike all the treatments which were treated with pusa hydrogel and Chitosan were showing better result in comparison to water deficit condition (60% IR with no PH and CHT). Whereas T_9 (SL12.22 cm; NSL 23.13), T_{10} (SL11.65 cm; NSL 23.07) were showing better result, However, when we are comparing our observations with normal irrigation T_{11} (SL11.57 cm; NSL 22.87) is showing non-significant relationship with T_0 (SL11.49 cm; NSL 22.80) (Table 2). The decrease in stem height and ear length due to water stress has been reported earlier in wheat (Iqbal *et al*., 1999) [13].Water stress during vegetative and reproductive development had an equal suppressive effect on number of spikelet per spike in four wheat varieties (Qadir *et al*., 1999) [29]. The results of this conform to the findings of (Karim *et al*., 2000) [14] and (Baque *et al.*, 2006) [3] who reported that water stress reduced grain yield by reducing productive tillers, fertile spikelet, number of grains per plant and individual grain weight. (Khanzada *et al*., 2001a) [17] Found that pod length in guar genotypes decreased significantly with application of water stress when compared with control. (Qadir *et al*., 1999) [29] 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 pusa hydrogel and chitosan is applied were showing better results in comparison to water deficit condition T_1 (BY 85.83; GY 22.17; HI 25.80; TGW 35.15) (60% IR without PH and CHT). However, when we are comparing our observation with normal irrigation T_0 (BY 108.73; GY 37.00; HI 34.08; TGW 42.77) we observed that treatment T_9 (BY 113.43; GY 40.17; HI 35.39; TGW 43.52)and T_{10} (BY 110.23; GY 37.23; HI 34.35; TGW 42.97) were showing better result (Table 4.16 and 4.17).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) [21]. 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) [10], (Garcia *et al.*, 2003) [7], and (Zaharieva *et al.*, 2001) [34]. 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) [8]. 1000 grain weights of all the treatments which were treated with pusa hydrogel and chitosan were showing better result in comparison to water deficit condition (60% IR without PH and CHT). (Gooding *et al.*, 2003) [10] 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) [16] and (Qadir *et al*., 1999) [29] who observed that 1000-grain weight of wheat was reduced mainly due to increasing water stress.

Table 1: Effect of pusa 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	92.43^{ab}	10.77^{abc}	15.05^{abc}	1.61^{abc}	121.67^{abcd}
T_1	85.30^{h}	9.07^{k}	12.65^{f}	1.32^{h}	116.67^{l}
T_2	91.28^{abcd}	10.67^{abcd}	14.71^{bcd}	1.57^{abcd}	121.67^{abcd}
T_3	90.42^{abcde}	10.33^{cdefg}	14.15^{cde}	1.47^{cdefgh}	120.67^{defg}
T_4	88.53^{cdefgh}	$10.13^{cdefghij}$	13.71^{def}	1.41^{efgh}	120.00^{fgh}
T_5	86.79^{efgh}	9.53^{ghijk}	13.57^{def}	1.39^{gh}	118.33^{jk}
T_6	86.78^{efgh}	9.47^{hijk}	13.49^{def}	1.39^{gh}	118.33^{jk}
T_7	86.44^{fgh}	9.40^{ijk}	13.41^{ef}	1.38^{gh}	117.67^{kl}
T_8	86.28^{gh}	9.33^{jk}	13.25^{ef}	1.37^{gh}	117.67^{kl}
T_9	94.09^{a}	11.40^{a}	16.25^{a}	1.73^{a}	122.67^{a}
T_{10}	93.35^{ab}	11.20^{ab}	15.47^{ab}	1.66^{ab}	122.33^{ab}
T_{11}	92.57^{ab}	10.93^{abc}	15.07^{abc}	1.62^{abc}	122.00^{abc}
T_{12}	91.06^{abcd}	10.60^{abcd}	14.45^{bcde}	1.57^{bcde}	121.33^{bcde}
T_{13}	90.92^{abcd}	10.53^{bcde}	14.32^{bcde}	1.56^{bcdef}	121.00^{cdef}
T_{14}	90.84^{abcd}	10.40^{bcdef}	14.19^{cde}	1.50^{cdefg}	121.00^{cdef}
T_{15}	90.21^{bcdef}	10.30^{cdefg}	14.13^{cde}	1.44^{defgh}	120.67^{defg}
T_{16}	89.96^{bcdefg}	10.27^{cdefg}	13.77^{def}	1.43^{defgh}	120.33^{efgh}
T_{17}	88.61^{cdefgh}	$10.20^{cdefghi}$	13.75^{def}	1.42^{defgh}	120.33^{efgh}
T_{18}	88.23^{cdefgh}	$9.93^{defghij}$	13.67^{def}	1.41^{fgh}	119.67^{ghi}
T_{19}	87.57^{cdefgh}	$9.73^{efghijk}$	13.59^{def}	1.41^{fgh}	119.33^{hij}
T_{20}	87.31^{defgh}	9.67^{fghijk}	13.61^{def}	1.40^{gh}	118.67^{ijk}
Mean	89.48	10.18	14.11	1.48	120.09
SE. d	1.283	0.271	0.425	0.052	0.437
C.D (5%)	5.102	0.806	1.686	0.154	1.298
C.V	5.588	4.798	5.425	6.494	0.653
F Test	S	S	S	S	S

Table 2: Effect of Pusa 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	11.49^{abcd}	22.80^{abc}	85.33^{abc}	108.73^{abcd}	37.00^{abc}	34.03^{ab}	42.77^{abc}
T_1	10.07^{g}	19.67^{h}	79.67^{i}	85.83^{h}	22.17^{f}	25.83^{d}	35.15^{k}
T_2	11.39^{abcd}	22.80^{abc}	85.33^{abc}	106.93^{abcde}	35.60^{abcd}	33.29^{abc}	42.14^{abcd}
T_3	11.09^{bcde}	22.27^{abcdef}	84.67^{bcde}	$102.40^{abcdefgh}$	34.10^{abcd}	33.53^{abc}	41.41^{bcdef}
T_4	10.93^{bcdef}	21.73^{defg}	84.00^{cdefg}	$95.33^{bcdefgh}$	29.57^{cdef}	31.01^{abc}	40.32^{efgh}
T_5	10.41^{efg}	21.40^{fg}	82.67^{fgh}	90.17^{efgh}	25.67^{ef}	29.79^{bcd}	38.89^{hij}
T_6	10.31^{efg}	21.33^{fg}	82.67^{fgh}	88.30^{fgh}	25.37^{ef}	28.99^{cd}	38.61^{ij}
T_7	10.31^{efg}	21.27^{fg}	82.33^{gh}	87.63^{gh}	25.33^{ef}	28.91^{cd}	38.46^{ij}
T_8	10.22^{fg}	21.07^{g}	81.67^{h}	88.40^{fgh}	25.27^{ef}	28.58^{cd}	37.80^{j}
T_9	12.22^{a}	23.13^{a}	86.67^{a}	113.43^{a}	40.17^{a}	35.41^{a}	43.52^{a}
T_{10}	11.65^{ab}	23.07^{ab}	86.00^{ab}	110.23^{ab}	37.63^{ab}	34.14^{ab}	42.97^{ab}
T_{11}	11.57^{abc}	22.87^{abc}	85.67^{abc}	109.53^{abc}	37.23^{abc}	33.99^{ab}	42.81^{abc}
T_{12}	11.25^{bcd}	22.60^{abcd}	85.33^{abc}	105.67^{abcdef}	35.57^{abcd}	33.66^{abc}	42.07^{abcd}
T_{13}	11.13^{bcde}	22.47^{abcde}	85.00^{abcd}	105.77^{abcdef}	35.50^{abcd}	33.56^{abc}	42.04^{abcd}
T_{14}	11.11^{bcde}	22.27^{abcdef}	84.67^{bcde}	$105.03^{abcdefg}$	34.83^{abcd}	33.16^{abc}	41.46^{bcde}
T_{15}	11.07^{bcde}	22.13^{abcdef}	84.67^{bcde}	$102.20^{abcdefgh}$	33.17^{abcde}	32.45^{abc}	41.26^{cdef}
T_{16}	11.04^{bcdef}	22.07^{bcdefg}	84.33^{bcdef}	$96.73^{abcdefgh}$	31.83^{bcde}	32.90^{abc}	40.59^{defg}
T_{17}	11.00^{bcdef}	22.00^{cdefg}	84.33^{bcdef}	$95.83^{bcdefgh}$	30.83^{bcde}	32.17^{abc}	40.37^{efgh}
T_{18}	10.79^{cdefg}	21.53^{efg}	84.00^{cdefg}	92.50^{cdefgh}	32.33^{abcde}	31.17^{abc}	39.80^{fghi}
T_{19}	10.77^{cdefg}	21.47^{efg}	83.33^{defgh}	91.17^{defgh}	27.67^{def}	30.35^{bcd}	39.36^{ghij}
T_{20}	10.67^{defg}	21.40^{fg}	83.00^{efgh}	87.77^{gh}	25.80^{ef}	29.40^{bcd}	39.03^{ghij}
Mean	10.98	21.97	84.06	98.55	31.55	31.53	40.52
SE. d	0.279	0.352	0.647	59.234	26.834	1.674	0.559
C.D (5%)	0.829	1.044	1.921	175.926	79.696	4.971	1.660
C.V	4.535	2.891	1.381	10.819	15.307	9.459	2.489
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 (60% IR without pusa hydrogel and Chitosan) for growth and yield parameters. Although T_9 (60% IR with 100% pusa hydrogel and 100% Chitosan) was was showing best results for all growth, reproductive and yield parameters. In comparison to T_0 (100% IR without pusa 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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