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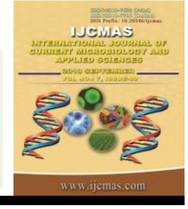

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Efficacy of Pusa Hydrogel and Chitosan on Wheat (*Triticum aestivum* L.) Growth and Yield under Water Deficit Condition

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A B S T R A C T

Drought, one of the environmental stresses, is the most significant factor restricting plant production in the majority of agricultural fields of the world. Wheat is generally grown on arid-agricultural fields. Drought often causes serious problems in wheat production areas. A field study was conducted on Central Agricultural field, Sam Higginbottom University of Agriculture, Technology & Sciences, U.P on wheat variety (HD-2967). Hydrogel and Chitosan were in use under different concentration to estimate 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. In a twenty-one treatments and three replications along with control were laid out in randomized block design where Hydrogel (100%, 75%, 50% and 25%) and Chitosan (100%, 75% and 50%) were used. Growth, yield, physiological and biochemical 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 $T_{0.}$

Introduction

On the basis of study of the Intergovernmental Panel on Climate Change (IPCC, 2007), future climate change is expected to affect agriculture, increase the risk of hunger and water scarcity, and lead to more fast melting of glaciers. The accessibility of freshwater in many river basins in India is likely to decrease due to climate change (Gosain *et al.*, 2006).

The implications of climate change on Indian water resources (Gosain *et al.*, 2006) have measured the influence of climate change on the water resources of Indian river systems (Kalra *et al.*, 2008) Under the situations of skewed water availability and its mismatch with demand, large storage reservoirs may be needed to adjust the natural flow of streams in accordance with the requirements of a specific region.

The main rainfall in Indian climate is dominated by the southwest monsoon. About 80% of the rainfall in India occurs during the four monsoon months (June–September) with large spatial and temporal variations over the country. Such a heavy concentration of rainfall results in a scarcity of water in many parts of the country during the non-monsoon period. Therefore, in India, where agriculture has a significant influence on both the economy and livelihood, the availability of adequate water for irrigation under changed climatic situations is very important and the yield of wheat, mustard, barley and chickpea indicate signs of stagnation or decrease following a rise in temperature in four northern states of India.

Drought is a type of extreme weather that has continued and adverse effects on agricultural production, groundwater storage, and the socioeconomics of a country (Beguer'ıa *et al.*, 2010). Drought is a highly recurrent and common feature in India (Singh *et al.*, 2011) While investigating the climatology of drought in India (due to deficient rainfall), we have found that, in the eastern and central part of India (West Bengal, Madhya Pradesh, Konkan, Bihar and Orissa), the frequency is one in five years; whereas, in the southern Karnataka, eastern Uttar Pradesh and Vidarbha region, it occurs once in every four years.

According to the India Meteorological Department (IMD), if the seasonal average rainfall deficiency is 6-26% and within 26% to 50% of its climatological value, a moderate and severe drought, respectively, is signified. Alternately, if the area affected by drought is within 20%–40% or more than 40%, it can also be classified as moderate and severe drought, respectively (Kumar*et al.*, 2005).

Wheat (*T. aestivum L*) is one of the significant food crops of the world farming and occupies significant position among the cultivated cereals. Cultivation of wheat has been symbiotic of green revolution that played major role in making the nation a food surplus nation. Wheat is member of poaceae family with chromosome number 42 and a Self-pollinated crop. The Wheat yields a western district of U.P are well comparable to adjoining Punjab and Haryana, but poor average yield of Eastern U.P. use to bring down the productivity of whole state this clearly indicate that in spite of considerable in improvement in genetic potential of the crop; productivity of Wheat is very poor in country as well as in the state in light of realized of yield level of 45-50 q/ha. Based on experimentation at New Delhi, India (IPCC, 2007) has reported that a 1C rise in temperature throughout the growing period will reduce wheat production by 5 million tonnes

We have opportunity to combat water scarcity with the help of anti-transpirant (AT) and hydrogels to increase leaf resistance to the diffusion of water vapour. Anti-Transpirant is a chemical compound whose role is to train plants by gradually hardening them to stress as a method of reducing the impact of drought. It is a substance involved in increasing drought stress resistances (Pandey *et al.*, 2017) There is different type of anti-transpirant: film forming which stops almost all transpiration; stomatic, which only effect the stomata; reflecting materials (Narsui, 1993*)*. Also in the field of agriculture, mostly in arid region we face a problem of low productivity due to less available of water and also from less water use efficiency of food crop. In field of agriculture, mostly hydrogels are used to increase water holding capacity reduce water run-off. (Sharma, 2004). Hydrophilic gels, or "Hydrogels", which are commonly known as super absorbents, are cross linked polymers that can absorbed 400-1500 times their dry weight in water, due to network space created by its cross linked structure.

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 (80% IR without PH & CHT), T_2 (80% IR with 100% PH), T_3 (80% IR with 75% PH), T_4 (80% IR with 50% PH), T_5 (80% IR with 25% PH), T_6 (80% IR with 100% CHT), T_7 (80% IR with 75% CHT), T_8 (80% IR with 50% CHT), T_9 (80% IR with 100% PH & 100% CHT), T_{10} (80% IR with 100% PH & 75% CHT), T_{11} (80% IR with 100% PH & 50% CHT), T_{12} (80% IR with 75% PH & 100% CHT), T_{13} (60% IR with 75% PH & 75% CHT), T_{14} (80% IR with 75% PH & 50% CHT), T_{15} (80% IR with 50% PH & 100% CHT), T_{16} (80% IR with 50% PH & 75% CHT), T_{17} (80% IR with 50% PH & 50% CHT), T_{18} (80% IR with 25% PH & 100% CHT), T_{19} (80% IR with 25% PH & 75% CHT), T_{20} (80% IR with 25% PH & 50% CHT). Where, PH is Pusa hydrogel, CHT is chitosan and IR is irrigation.

Results and Discussion

Under drought condition decreasing pattern was experienced in morphologically yield contributing characters like plant height (PH), grains per spike, spikes per plant, 1000grain weight (TGW) in wheat (Kilic and Yagbasanlar 2010). Drought stress lead to reduction in number of fertile tillers per plant, grains per spike and 1000-grain weight (TGW) which ultimately cause noticeably low grain productivity. The decreasing graph in grain number was linked with reduced leaf area and lower photosynthesis as outcome of drought stress (Fischer *et al.*, 1980).

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. It is a substance involved in increasing drought stress resistance (Pandey *et al.*, 2017).

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 80% flowering and maturity.

All the treatments which were treated with Pusa hydrogel and Chitosan were showing better result in comparison to water deficit condition (80% IR). 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 through Pusa hydrogel and Chitosan were presenting better result in comparison to water deficit condition (80% IR with no PH and CHT).

Table.1 Effect of Hydrogel and Chitosan on number of tillers per hill, spike length (cm), number of spikelet per spike, flag leaf length (cm) and flag leaf width (cm) 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	91.15	10	17.11	1.63	121.67
T_1	80.49	**9**	**11.90**	**1.33**	**116.67**
T_2	91.13	10	16.76	1.60	121.67
T_3	89.94	10	15.77	1.56	120.67
T_4	89.33	10	14.72	1.49	120.00
T_5	88.87	9	13.65	1.42	118.33
T_6	88.16	9	13.47	1.41	118.33
T_7	83.29	9	12.83	1.40	117.67
T_8	82.52	9	12.35	1.37	117.67
T_9	**93.76**	**11**	**19.01**	**1.72**	**122.67**
T_{10}	93.35	10	17.81	1.69	122.33
T_{11}	91.79	10	17.64	1.65	122.00
T_{12}	91.04	10	16.53	1.60	121.33
T_{13}	90.09	10	16.47	1.60	121.00
T_{14}	89.99	10	16.31	1.57	121.00
T_{15}	89.83	10	15.39	1.55	120.67
T_{16}	89.51	10	15.19	1.53	120.33
T_{17}	89.48	10	15.00	1.49	120.33
T_{18}	89.33	9	14.64	1.46	119.67
T_{19}	89.21	9	14.40	1.45	119.33
T_{20}	89.08	9	13.99	1.45	118.67
Mean	**89.11**	**10**	**15.28**	**1.52**	**120.09**
SE. d	**1.46**	**0.202**	**1.07**	**0.072**	**0.437**
C.D (5%)	**4.535**	**0.601**	**3.204**	**0.215**	**1.298**
C.V	**2.827**	**3.838**	**12.716**	**8.459**	**0.653**
F Test	**S**	**S**	**S**	**S**	**S**

Table.2 Effect of Hydrogel and Chitosan on biological yield, grain yield, harvest index and 1000 grain weight of wheat Effect of Hydrogel and Chitosan on days to maturity of wheat under water deficit condition

Treatments	Spike Length (cm)	No. of Spikelet/spike	Grain yield (q/ha)
T_0	9.9	21	29.10
T_1	**8.1**	**19**	**16.50**
T_2	9.8	20	28.10
T_3	9.6	20	26.00
T_4	9.5	20	24.30
T_5	9.2	19	20.05
T_6	9.2	19	20.40
T_7	9.1	19	17.80
T_8	9.0	18	17.46
T_9	**11.2**	**22**	**31.30**
T_{10}	10.8	21	30.73
T_{11}	10.3	21	30.63
T_{12}	9.7	20	27.43
T_{13}	9.7	20	27.13
T_{14}	9.6	20	26.20
T_{15}	9.6	20	25.56
T_{16}	9.6	20	24.86
T_{17}	9.6	20	24.80
T_{18}	9.3	19	23.53
T_{19}	9.3	19	22.20
T_{20}	9.2	20	21.80
Mean	9.6	20	24.578
SE. d	**0.508**	**0.431**	**21.71**
C.D (5%)	**1.511**	**1.282**	**64.487**
C.V	**7.165**	**3.928**	**15.949**
F Test	**S**	**S**	**S**

However, when we are comparing our observation with normal irrigation we observed that treatment T_9 (93.76 cm) and T_{10} (93.35 cm) were showing better result while T_{11} (91.79 cm) was showing non-significant relationship with T_0 (91.15 cm) (Table 1). Plant height in wheat varieties reduced significantly under water stress when it was compared with irrigated (Inamullah *et al.*, 1999).

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) (80% IR with No PH No CHT), however T_9 (11) and T_{10} (10) were showing better result while T_{12} (10), T_{13} (10) and T_{14} (10) was showing non-significant relationship with T_0 (Table 2). Some morphological characters such as root length, tillering, spike number per m-2, grain number per spike and number of fertile tillers per plant affect wheat tolerance to the moisture shortage in the soil (Passioura, 1977)

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 (80% IR with No PH No CHT), however T_9 and T_{10} were showing better result while T_{11} was showing non-significant relationship with T_0 (Table 2) Flag leaf traits are controlled by multiple genes and strongly influenced by environmental factors (Kobayashi *et al.*, 2003). Drought accelerates the rate of leaf senescence (Evans, 1993).

For days to maturity, treatment under water deficit condition in which pusa hydrogel (PH) and Chitosan(CHT) is not applied i.e. T_1 116.67 Days to maturity(DTM) showed early flowering and maturity as compared to PH and CHT applied treatments. However, T_9 122.67 DTM followed by T_{10} (122.33 DTM) (Table 2). Drought stress reduced the number of days to maturity, days to 50% flowering, plant height, no. of tillers, number of spike per m2, spike length, number of grains per spike, 1000 grain weight of genotypes while it increased the chlorophyll content, grain protein content. (Kımurto *et al.*, 2003)

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 (80% IR with no PH and CHT). Whereas T_9, $T_{10,}$ were showing better result, However, when we are comparing our observations with normal irrigation T_{11} is showing non-significant relationship with T_0 (Table 2). The spike length and number of spike per m2, 1000 grain weight and grain yield of durum wheat is reduced in the drought and terminal heat stress conditions. (Kılıç *et al.*, 1999)

For yield parameters grain yield all the treatments in which pusa hydrogel and chitosan is applied were showing better results in comparison to water deficit condition T_1 (GY 16.50) (80% IR without PH and CHT). However, when we are comparing our observation with normal irrigation T_0 (GY 29.10) we observed that treatment T_9 (GY 31.30) and T_{10} (GY 30.73); were showing better result (Table 2) (Giuanta *et al.*, 1993) that the severe water stress from the seedling stage to maturity reportedly reduced all grain yield components, particularly the number of fertile ears per unit area by 60%, grain number per head by 48%, dry matter and harvest index.

This study may conclude that under water deficit condition all the treatments are showing better results in comparison to T_1 (80% IR without pusa hydrogel and Chitosan) for growth and yield parameters. Although T_9 (80% IR with 100% pusa hydrogel and 100% Chitosan) 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, analysed during the study although T_{11} states non-significant with T_0.

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