Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 1589-1591
Received: 25-07-2018
Accepted: 27-08-2018

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Efficacy of pusa hydrogel and chitosan on wheat (*Triticum aestivum* L.) physiological and biochemical parameters under water deficit condition

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Abstract
Drought often causes serious problems in wheat production areas, it is 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. 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.

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

Introduction
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) [2]. Drought is a highly recurrent and common feature in India (Singh *et al.*, 2008) [14] 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) [6].
On the basis of study of the Intergovernmental Panel on Climate Change (IPCC, 2007) [3], 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) [4] 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.

Wheat (*T. aestivum* L) is one of the significant food crop 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) [3] 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) [10] There is different type of anti-transpirant: film forming which stops almost all transpiration; stomatic, which only effect the stomata; reflecting materials. (Narsui., 1993) [8]. 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) [13]. 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 physiological and biochemical parameters (Chlorophyll 'a', Chlorophyll 'b', total chlorophyll, carotenoid, gluten content, relative water content) and antioxidant (proline and Superoxide dismutse) 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 (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} (80% 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, IR is irrigation, 100% PH is 5 kg/ha and 100% CHT is 250 ppm.

Result and Discussion

For Chlorophyll 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). However, for chlorophyll 'a' 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 at par with T_0 (Table 4.9) while for chlorophyll b T_{11} was showing non-significant relationship with T_0 (Table, 4.10, 4.11 and 4.12). similar report suggest that the chlorophyll content was decreased with increases in draught severity, it should be partly responsible for photo-inhibition. Under draught stresses, recovery of material especially nitrogen will interrupt (pastore *et al.,* 1989) [11] and furthermore, chloroplast need to nitrogen to generate chlorophyll through proteins and under nitrogen and water limited condition, chlorophyll production rate becomes slower and as a results, leaves will become more susceptible to photo-inhibition. (Lauer and boyer, 1992) [7]. on the other hand, Rong-hua *et al.* (2006) [12] reported that the values of chlorophyll content in drought tolerance genotypes of barley were significantly higher than those in drought sensitive genotypes under drought stress.

The water stress has played a key role to reduce the moisture percentage and fat, while it increased protein, ash, gluten contents and zeleny sedimentation test (Noorka *et al.,* 2009) [9], Gluten content was found higher in water stressed condition in T_1(80% IR with no PH and CHT). However, when we are comparing our observation with normal irrigation we observed that treatment T_9 and T_{10} are showing lesser result while T_{11} is showing non-significant relationship with T_0. The rubbery mass that is left when wheat flour is washed with water to remove starch, non-starchy polysaccharides, and water-soluble constituents, is called gluten. Gluten is comprised of 80–85% protein and 5% lipids; most of the remainder is starch and non-starch carbohydrates (Wall, 1979; Wieser, 2007) [16,].

For relative water content all the treatment in which Pusa hydrogel and chitosan is applied showing better results in comparison to water deficit condition (80% IR with no PH and CHT). However, when we are comparing our observations with normal irrigation we observed that treatment T_9 and T_{10} were showing better result while T_{11} was non-significant with T_0 (Table 4.13). (Anjum *et al.,* 2011) [1] reported that the Relative water content (RWC) of leaves is regarded as a measure of plant water status, reflecting the metabolic activity of the plant organization. It is usually used as an index of dehydration in most plants.

For antioxidant Proline and Superoxide dismutase (SOD) treatments under water stress are showing higher level Proline and superoxide dismutase level was found higher (increased)in T_1(80% IR with no PH and CHT). However, when we are comparing our observation with normal irrigation we observed that treatment T_9 and T_{10} are showing better result while T_{11} is showing non-significant relationship with T_0 (Table 4.14 and 4.15) similarly the increased superoxide dismutase and proline in response to water stress (Kukreja *et al.* 2005) [5]. SOD is a main antioxidant enzyme defender against oxidative stress caused by ROS, which is a major scavenger of O2·- free radicals converting into H2O and O2 by catalase and a variety of peroxidases (Smirnoff, 1998) [15].

Table 1: Efficacy of pusa hydrogel and chitosan chlorophyll ‘a’, ‘b’, total chlorophyll, carotenoid, gluten, RWC, proline and SOD of wheat under water deficit condition

Treatments	Chlorophyll ‘a’ (mg/g fw)	Chlorophyll ‘b’ (mg/gfw)	Total Chlorophyll (mf/g fw)	Carotenoid (mg/g fw)	Gluten Content%	Relative Water Content (%)	Proline (µg/gfw)	Superoxide Dismutase (µg/gfw)
T0	1.29	1.69	7.6	3.31	8.13	85.38	2.5	1.10
T1	1.13	1.10	3.7	2.64	10.73	77.93	3.8	1.49
T2	1.27	1.68	7.6	3.19	8.13	84.74	2.5	1.10
T3	1.24	1.57	7.4	3.16	8.87	82.45	2.9	1.11
T4	1.21	1.51	7.2	2.94	9.37	82.96	3.2	1.14
T5	1.16	1.44	6.8	2.81	9.77	82.38	3.5	1.18
T6	1.16	1.41	6.6	2.76	10.17	82.14	3.6	1.19
T7	1.15	1.39	6.1	2.74	10.47	81.97	3.6	1.19
T8	1.12	1.32	5.3	2.71	10.67	81.44	3.6	1.23
T9	1.39	1.79	8.5	3.48	7.93	86.41	1.7	0.97
T10	1.33	1.75	8.0	3.43	8.07	85.78	2.0	1.07
T11	1.30	1.70	7.6	3.42	8.13	85.55	2.2	1.09
T12	1.25	1.64	7.6	3.19	8.47	84.47	2.5	1.10
T13	1.24	1.62	7.5	3.18	8.57	84.45	2.6	1.11
T14	1.24	1.60	7.5	3.17	8.77	84.06	2.9	1.10
T15	1.21	1.57	7.3	3.14	8.97	83.69	3.0	1.11
T16	1.21	1.52	7.3	3.11	9.17	83.66	3.0	1.12
T17	1.21	1.52	7.2	2.99	9.23	83.21	3.2	1.13
T18	1.20	1.51	7.2	2.92	9.47	82.75	3.3	1.16
T19	1.18	1.50	7.0	2.91	9.67	82.51	3.5	1.17
T20	1.17	1.46	6.9	2.88	9.73	82.45	3.5	1.17
Mean	1.22	1.54	7.0	3.05	9.16	83.35	3.0	1.14
SE. d	0.002	0	0.683	0.006	0.190	0.939	0.391	0.054
C.D (5%)	0.007	0.001	2.029	0.020	0.567	2.789	1.164	0.163
C.V	0.238	0.167	13.044	0.390	3.753	2.023	23.547	8.476
F Test	S	S	S	S	S	S	S	S

Conclusion

Under water deficit condition all the treatments are showing better results in comparison to T_1 (80% IR without PH and CHT) for physiological and biochemical parameters. Although T_9 was showing best result for chl.’a’ (1.39 mg/g fw), chl ‘b’ (1.79 mg/g fw), Total chl. (8.5 mg/g fw), carotenoid (3.48 mg/g fw), RWC (86.41%), proline (1.7 µg/g fw), superoxide dismutase (0.97µg/g fw).

In comparison to T_0 (100% IR) 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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