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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
Water stress affects morphological, physiological, biochemical and molecular processes. 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 physiological and biochemical parameters 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 Physio-chemical parameters and antixidants 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 nonsignificant with T_0.

Keywords: pusa hydrogel, chitosan, water scarcity, physiological, biochemical

Introduction

Water stress is the most significant environmental stress in agriculture worldwide. Drought is a situation where by moisture become insufficient either due to low precipitation or low soil moisture storage for optimum plant growth. Drought affects the growth of many plants and hence leads to a very poor yield (Hayatu *et al.,* 2014) [9]. In Uttar Pradesh of India, almost once in every third year in western part and once in five years in eastern part, drought is experienced in past few years (NIDM UP, 2012) [16]. 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.

Drought tends to be the deficiency of precipitation causing a side impact on the society, economy and environment in a period of time (Zhao *et al*., 2012) [24]. Drought stress is a decrease of soil water potential so plants reduce their osmotic potential for water absorption by congestion of soluble carbohydrates and proline and in other words osmotic regulation is performed (Martin *et al.,* 1993) [13]. Leaf relative water content (RWC) is an important indicator of water status in plants; it reflects the balance between water supply to the leaf tissue and transpiration rate (Lugojan and Ciulca 2011) [12]. Decrease of relative water content close stomata and also after blocking of stomata will reduce photosynthesis rate (Cornic, 2000) [1].

Super absorbent polymers (SAP's) are a unique group of materials that can absorb over a hundred times their weight in liquids and do not easily release the absorbed fluids under pressure. The ability of SAPs to absorb large volumes of water and retain it within them has many practical applications in agriculture (Pandey *et al.*, 2017) [19].

Foliar application of antitranspirants is a promising tool for regulating transpiration to maintain a favourable plant water status (Goreta *et al*., 2007) [5]. It was used to protect plants against oxidative stress (Guan *et al*., 2009) [6] and to stimulate plant growth

(Farouk *et al.*, 2011) [3]. It is experimentally proved that chitosan increased the chlorophyll pigments under drought stress, its cleared that chitosan can induced the rate of photosynthesis and the accumulation of organic matter in wheat seedlings (Pandey *et al.*, 2017) [19]. The purpose of this research was to study the efficacy of pusa hydrogel and chitosan on some Physio-chemical processes and antioxidant level of wheat.

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 (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, 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 (60% 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 (1.36 mg/g fw) and T_{10} (1.30 mg/g fw) were showing better result while T_{11} (1.27 mg/g fw) was at par with T_0 (1.26 mg/g fw) (Table No. 1) while for chlorophyll b T_{11} (1.67 mg/g fw) was showing nonsignificant relationship with T_0 (1.66 mg/g fw) (Table no. 1). Water stress effects on biochemical component of plant like chlorophyll, carotenoid and total chlorophyll of plant. The decrease in chlorophyll content under drought is a commonly observed phenomenon (Nikolaeva *et al.,* 2010) [17]. The reduction in chlorophyll content under drought stress has been considered a typical indication of oxidative stress and may be the result of pigment photo-oxidation and chlorophyll degradation (Farooq *et al.,* 2009) [2]. A reason for decrease in chlorophyll content as affected by water deficit is that drought or heat stress by producing reactive oxygen species (ROS) such as O_2- and H_2O_2, can lead to lipid peroxidation and consequently, chlorophyll destruction (Mirnoff, 1993; Foyer *et al*., 1994) [15, 4].

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) [21, 23]. The minimum glutent content (7.93 %) was observed in T_9 over all the treatments whereas, maximum glutent content (10.77 %) was observed in T_1 (60% IR). However, T_{10} (8.07 %), T_{11} (8.13 %) and T_0 (8.17 %) was statistically at par in comparison to T_9. Whereas, T_{10} and T_{11} was non-significant with each other (Table No. 1). 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) [18], Similar findings have also been reported by (Gudeira *et al*., 2002) [7] and (Mary *et al*., 2001) [14].

For relative water content all the treatment in which Hydrogel and chitosan is applied showing better results in comparison to water deficit condition T_1 (77.92) (60% IR with no PH and CHT). However, when we are comparing our observations with normal irrigation we observed that treatment T_9(86.41) and T_{10}(85.79) were showing better result while T_{11}(85.56) was nonsignificant with T_0 (85.45) (Table No.1). Relative water content (RWC) of leaves has been reported as direct indicator of plant water contents under water deficit conditions (Lugojan and Ciulca 2011) [12]. Increasing water stress caused a drastic decrease in leaf relative water content (%). Drought stress leads to reduction of water status during crop growth, soil water potential and plant osmotic potential for water and nutrient uptake which ultimately reduce leaf turgor pressure which results in upset of plant metabolic activities.

Naturally there is a balance between antioxidant enzymes and reactive oxygen species (ROS) in a system. Any stress can disturb the balance which leads to an increase in the ROS amount, causing oxidative stress. Antioxidant enzyme levels increase to overcome ROS damage and bring cellular homeostasis back (Lee *et al.,* 2007) [11].

For antioxidant Proline and Superoxide dismutase (SOD) treatments under water stress are showing higher level Proline and superoxide dismutase level the highest level was found in T_1(60% IR without PH and CHT). However, when we are comparing our observation with normal irrigation we observed that treatment T_9 (Proline1.05; SOD 2.81) and T_{10} (Proline 1.16; SOD 2.97) are showing better result while T_{11} (Proline 1.23; SOD 2.99) is showing nonsignificant relationship with T_0 (Proline 1.27; SOD 3.02) (Table No. 1). There was an inverse relationship between drought severity and proline content, which create a defence mechanism in stressed in order to control osmotic pressure (Wang, 2003) [22]. Proline is well known to occur extensively in higher crop plants and accumulates in higher concentration in response to different abiotic environmental stresses specially drought stress.

Superoxide dismutase (SODs) are ubiquitous metalloenzymes that catalyze the dismutation of superoxide radical to H_2O_2 and O_2. The superoxide radical is a potential precursor of the highly oxidizing hydroxyl radical and, therefore, SODs are a critical defense of plants, other aerobic organisms, and some anaerobes against oxidative stress (Halliwell and Gutteridge 1999) [8]. Plants under water deficit stress showed a significant increase in SOD, CAT and GPX activities of canola leaves compared with control plants (Tohidi *et al.,* 2009) [20].

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)
T_0	2.12^{cd}	1.83^{bc}	3.96^{c}	3.36^{c}	8.17^{ijk}	85.45^{abc}	3.02^{efg}	1.18^{efg}
T_1	1.75^{n}	1.15^{l}	2.90^{n}	2.64^{n}	10.77^{a}	77.92^{g}	3.93^{a}	1.42^{a}
T_2	2.09^{cd}	1.82^{c}	3.91^{d}	3.19^{d}	8.23^{ijk}	84.75^{abcd}	3.09^{defg}	1.20^{defg}
T_3	2.07^{fgh}	1.68^{ef}	3.74^{fg}	3.13^{ef}	8.87^{efgh}	83.97^{abcdef}	3.24^{bcdefg}	1.22^{cdefg}
T_4	2.03^{hij}	1.63^{gh}	3.66^{ij}	2.94^{ghi}	9.37^{def}	82.97^{cdef}	3.49^{abcdef}	1.24^{cdef}
T_5	2.00^{jkl}	1.57^{i}	3.57^{k}	2.81^{kl}	9.77^{bcd}	82.38^{def}	3.63^{abcd}	1.27^{bcd}
T_6	1.99^{kl}	1.53^{j}	3.52^{l}	2.76^{lm}	10.17^{abc}	82.13^{def}	3.64^{abcd}	1.28^{bcd}
T_7	1.98^{l}	1.50^{j}	3.49^{l}	2.74^{m}	10.20^{abc}	81.97^{ef}	3.67^{abc}	1.30^{bc}
T_8	1.94^{m}	1.45^{k}	3.40^{m}	2.71^{m}	10.33^{ab}	81.45^{f}	3.75^{ab}	1.33^{b}
T_9	2.21^{a}	1.93^{a}	4.14^{a}	3.74^{a}	7.93^{k}	86.41^{a}	2.81^{g}	1.15^{g}
T_{10}	2.17^{b}	1.85^{b}	4.02^{b}	3.51^{b}	8.07^{jk}	85.79^{ab}	2.97^{fg}	1.17^{fg}
T_{11}	2.14^{c}	1.84^{bc}	3.98^{bc}	3.39^{c}	8.13^{jk}	85.56^{abc}	2.99^{efg}	1.18^{fg}
T_{12}	2.08^{ef}	1.78^{d}	3.86^{e}	3.18^{de}	8.53^{hijk}	84.49^{abcde}	3.10^{defg}	1.21^{defg}
T_{13}	2.07^{efg}	1.76^{d}	3.83^{e}	3.15^{def}	8.57^{ghij}	84.46^{abcde}	3.13^{cdefg}	1.21^{cdefg}
T_{14}	2.07^{efg}	1.70^{e}	3.77^{f}	3.14^{def}	8.77^{fghi}	84.06^{abcdef}	3.20^{bcdefg}	1.22^{cdefg}
T_{15}	2.05^{fgh}	1.68^{ef}	3.73^{gh}	3.11^{f}	8.97^{efgh}	83.69^{bcdef}	3.30^{bcdefg}	1.23^{cdefg}
T_{16}	2.05^{gh}	1.67^{f}	3.72^{gh}	2.98^{g}	9.17^{defg}	83.65^{bcdef}	3.37^{bcdefg}	1.23^{cdefg}
T_{17}	2.04^{ghi}	1.65^{fg}	3.69^{hi}	2.95^{gh}	9.23^{def}	83.22^{bcdef}	3.41^{abcdef}	1.24^{cdef}
T_{18}	2.02^{hijk}	1.62^{h}	3.64^{j}	2.92^{hi}	9.47^{de}	82.74^{def}	3.53^{abcdef}	1.24^{cdef}
T_{19}	2.01^{ijkl}	1.62^{h}	3.63^{j}	2.89^{ij}	9.67^{cd}	82.50^{def}	3.54^{abcde}	1.25^{bcdef}
T_{20}	2.01^{jkl}	1.57^{i}	3.58^{k}	2.86^{jk}	9.73^{bcd}	82.45^{def}	3.55^{abcde}	1.26^{bcde}
Mean	2.04	1.66	3.70	3.05	9.15	83.43	3.35	1.24
SE. d	0.011	0.009	0.013	0.019	0.205	0.903	0.190	0.029
C.D (5%)	0.032	0.028	0.039	0.058	0.609	2.683	0.563	0.085
C.V	0.929	0.986	0.585	1.103	4.022	1.946	10.260	3.942
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 (60% IR without PH and CHT) for physiological and biochemical parameters. Although T_9 was showing best result for chl.’a’ (1.36 mg/g fw), chl ‘b’ (1.76 mg/g fw), Total chl. (3.12 mg/g fw), carotenoid (3.39 mg/g fw), RWC (86.41%), proline (2.81 µg/g fw), superoxide dismutase (µg/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 nonsignificant with T_0

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