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Efficacy of hydrogel on wheat (*Triticum aestivum* L.) physio-biochemical and economical yield under different levels of irrigation

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Abstract
Suitable Irrigation to the crop is an important attribute for potential yield of among various crops. Present scenario of weather fallouts at destructing besides allocating rainfall pattern leading to different water stress. In some part of U.P, especially eastern U.P will face in temperature (3 to 5ºc up to 2050) as per SAPCC, 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 Efficacy of Hydrogel on Wheat (*Triticum aestivum* L.) Physio-Biochemical and Yield under Different Levels of Irrigation and Chitosan. Absorbing the water and retaining water in the soil and by reducing the loss of water through stomata by forming a layer of waxy coating, is the aspect to be considered to deal with such arriving future. Superabsorbent polymer can absorb large quantities of water and retain in soil and Antitranspirant may reduce the loss of water via transpiration. Hydrogel (50%) and Chitosan (100%, 75% and 50%) with twenty-five treatments and three replications along with control were laid out in randomized block design Result on Physio-Biochemical and yield under water deficit condition was observed Treatment T_1 (100% HG and 100% CHT) showed best results, however T_2 was statistically at par with T_1, whereas comparing with control T_0 (100% IR 70 Lit +NO SAP +NO AT.

Keywords: hydrogel, chitosan, water scarcity, level of irrigation

Introduction

Water is necessary for plant growth and development as it is involved in various physiological functions and is essential for different metabolic activities. (Saeedipour, 2012) [30]. It has been said that water stress is considered to be most important among various environmental factors that drastically reduce plant production (European plant science organisation, 2005) [6].

Climate change and global warming has destructing the available natural resources and agriculture (Paul, S.T., 2000) [20]. The change in pattern of precipitation it would directly effects the water resources in the concerned region. If the frequency and quality of rainfall changes that it alters the stream flows pattern and demands especially in agriculture, soil moisture and ground water reserves (Dore, M.H., 2005) [5]. Such increasing in temperature and low rainfall UP will face rise in temperature (2-4.5) and water scarcity condition, which is directly, effects on agriculture production. In the areas of India effected with water stress were declining half of its potential yield comparing with irrigated areas (GoP, 2010) [13].

Wheat (*Triticum aestivum* L.) is an essential grain food component and is a very important commodity among cereal crops. (Montazeri *et al.,* 2005) [22]. Demand of the wheat is increasing gradually due to growing world population and millions of hectares of agriculture land are being lost every year in India due to stresses. (Ashraf *et al.,* (2004) [1].

Water requirement of wheat plant is estimated as 450-650mm /ha. Due to current water shortage issues, it is essential that the water use efficiency (WUE) of wheat be improved, while maintaining, or potentially increasing, grain yields. (Shin *et al.,* 2012) [23]. There are various management practices through which water soil relationship can be maintained to make plant withstand water stress condition.

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) [39], and reduce seepage of water, and fertilizer and heavy metal leaching down the soil profile (Qu and Varennes, 2009) [29]. It was designed specifically to perform in tropical and sub-tropical conditions of the country. Similar products of foreign origin introduced and tried in India.

Antitranspirants are chemical compounds applied to plants to reduce transpiration and maintain high plant water status Chitosan is an antitranspirant compound that has proved to be effective in many crops (Karimi *et al.*,2012) [16] and can help to preserve water resources use in agriculture (Bittelli, *et al.*, 2001) [2]. Under chitosan application plant reacts to water deficit with a rapid, abscisic acid (ABA)-mediated closure of stomata bringing down rate of transpiration. The objective of this study was to understand the relationship of hydrogel for better growth and biochemical parameters of wheat under different level of irrigation and chitosan.

Materials and Methods

Present study was conducted central agricultural field of SHUATS as per the purpose of study experiment was conducted based on surface irrigation to create water deficit condition for Wheat variety (HD-2967), and experiment has undertaken with different irrigation levels & chitosan. Over all 25 treatments has been undertaken with soil application hydrogel (7kg/ha). Different biochemical parameters have been recorded & statistically analysed during the course of study.

Table 1: Treatment Details

Treatments	Treatment combination
T_0	100% IR 70 Lit +NO SAP +NO AT
T_1	80%IR (56 Lit) +100%AT (250ppm) +50%SAP (0.2 gm)
T_2	80%IR (56 Lit) +100%AT (250ppm) +NO SAP
T_3	80%IR (56 Lit) +75%AT (187ppm) +50%SAP (0.2 gm)
T_4	80%IR 56 Lit +75%AT (187ppm) + NO SAP
T_5	80%IR (56 Lit) +50%AT (125ppm) + 50%SAP (0.2 gm)
T_6	80%IR (56 Lit) +50%AT (125ppm) + NO SAP
T_7	80%IR (56 Lit) +NOAT +50%SAP (0.2 gm)
T_8	80%IR (56 Lit) + NOAT +NO SAP
T_9	60%IR (42 Lit) +100%AT (250ppm) +50%SAP (0.2 gm)
T_{10}	60%IR (42 Lit) +100%AT (250ppm) + NO SAP
T_{11}	60%IR (42 Lit) +75%AT (187ppm) +50%SAP (0.2 gm)
T_{12}	60%IR (42 Lit) +75%AT (187ppm) + NO SAP
T_{13}	60%IR (42 Lit) +50%AT (125ppm) +50%SAP (0.2 gm)
T_{14}	60%IR (42 Lit) +50%AT (125ppm) +NO SAP
T_{15}	60%IR (42 Lit) + NOAT+50%SAP (0.2 gm)
T_{16}	60%IR (42 Lit) + NOAT+NO SAP
T_{17}	40%IR (28 Lit) +100%AT (250ppm) +50% SAP (0.2 gm)
T_{18}	40%IR (28 Lit) + 100%AT 250ppm + NOSAP
T_{19}	40%IR (28 Lit) +75%AT (187ppm) +50%SAP (0.2 gm)
T_{20}	40%IR (28 Lit) +75%AT (187ppm) +NO SAP
T_{21}	40%IR (28 Lit) +50%AT (125ppm) +50%SAP (0.2 gm)
T_{22}	40%IR (28 Lit) +50%AT (125ppm) +NO SAP
T_{23}	40%IR (28 Lit) +NOAT +50% SAP (0.2 gm)
T_{24}	40%IR (28 Lit) +NOAT+ NOSAP

Results and Discussion

For Chlorophyll the treatments which were treated with Hydrogel and Chitosan were showing better result in comparison to water deficit condition Control (100% IR 70 Lit +NO PH +NO AT) (1.43) Dough: Maximum Chlorophyll 'a' was observed in T1 (1.74 mg/g fw) followed by T2 (1.67 mg/g fw), T3 (1.65 mg/g fw), T4 (1.59 mg/g fw), T5 (1.55 mg/g fw), T6 (1.52 mg/g fw), T7 (1.45 mg/g fw) whereas, Minimum Chlorophyll 'a' was observed in T24 (0.57 mg/g fw) Table No:2. 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) [24]. 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) [8]. For relative water content all the treatment in which Hydrogel and chitosan is applied showing better results in comparison to water deficit condition. Control (100% IR 70 Lit +NO PH +NO AT) (54.93) Maximum Relative water content was observed in T1 (59.34 %) followed by T2 (58.76 %), T3 (58.17%), T4 (57.83 %), T5 (57.35 %), T6 (56.31 %), T7 (55.47 %) whereas, Minimum Relative Water Content was observed in T24 (31.27 %).Relative water content (RWC) of leaves has been reported as direct indicator of plant water contents under water deficit conditions (Lugojan and Ciulca 2011) [20]. 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. Antioxidant - 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) [19]. 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 15th day of (IR) Maximum Proline was observed in T_{24} (0.22 mg/g fw) followed by T_{23} (0.21 mg/g fw), T_{22} (0.21 mg/g fw), T_{21} (0.18 mg/g fw), T_{20} (0.18 mg/g fw), T_{19} (0.17 mg/g fw), T_{18} (0.17 mg/g fw), T_{17} (0.16 mg/g fw), T_{16} (0.15 mg/g fw), T_{15} (0.15 mg/g fw), whereas, Minimum Proline was observed in T_1 (0.06 mg/g fw) Table No:3. 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) [37]. 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 H2O2 and O2. 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) [14]. Plants under water deficit stress showed a significant increase in SOD, CAT and GPX activities of canola leaves compared with control plants. 15th day of (IR) Maximum Superoxide dismutase was observed in T_{24} (1.85) followed by T_{23} (1.76), T_{22} (1.73), T_{21} (1.69), T_{20} (1.68), T_{19} (1.68), T_{18} (1.66) whereas, Minimum plant height was observed in T_1 (1.24) Table No:3. For yield parameters grain yield, 1000 grain weight all the treatments in which Hydrogel and chitosan is applied were showing better results in comparison to water deficit condition Maximum Grain yield was observed in T1 (32.65 q/ha^{-1}) followed by T2 (24.49 q/ha^{-1}), T3 (22.47 q/ha^{-1}), T4 (21.42 q/ha^{-1}), T5 (20.83 q/ha^{-1}), T6 (20.42 q/ha^{-1}), T7 (19.56 q/ha^{-1}) whereas, Minimum Grain Yield was observed in T24 (8.67 q/ha^{-1}) Table 4.6 Maximum Test Weight was observed in T1 (42.81 gm) followed by T2 (32.35 gm), T3 (31.45 gm), T4 (29.16

gm), T5 (28.56 gm), T6 (28.36), T7 (28.00 gm) whereas, Minimum Test Weight was observed in T24 (17.34 gm) Table No:3. The results of many researches show that drought stress at different stages of the growth wheat under different levels Irrigations and Chitosan. lead to a reduction in the yield of biomass, grain yield, harvest index and grain yield components wheat under different levels Irrigations and Chitosan. (Gooding *et al.*, 2003) [12], (Garcia *et al.*, 2003) [10], and (Zaharieva *et al.*, 2001) [40]. 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 Economical yield (Gebeyehu, 2006) [11]. 1000 grain weights of all the treatments which were treated with Hydrogel and Chitosan were showing better result in comparison to water deficit condition 80%IR (56 Lit) +100%AT (250ppm) +50%SAP (0.2 gm). (Gooding *et al.*, 2003) [12] 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) [17] and (Qadir *et al*., 1999) [28] who observed that 1000-grain weight wheat under different levels Irrigations and Chitosan was reduced mainly due to increasing water stress.

Table 2: Efficacy of hydrogel and Chitosan on Chlorophyll ‘a’(mg/g fw), Chlorophyll ‘b’(mg/g fw), Carotenoids (mg/g fw), Relative Water Content (%) of wheat under different levels of irrigation and chitosan

Treatments	Chlorophyll ‘a’(mg/g fw)	Chlorophyll ‘b’(mg/g fw)	Carotenoids (mg/g fw)	Relative Water Content (%)
T_0	1.43	1.36	2.51	54.93
T_1	1.74	1.67	2.83	59.34
T_2	1.67	1.65	2.74	58.76
T_3	1.65	1.57	2.71	58.17
T_4	1.59	1.51	2.68	57.83
T_5	1.55	1.44	2.57	57.35
T_6	1.52	1.41	2.59	56.31
T_7	1.45	1.37	2.54	55.47
T_8	1.42	1.34	2.41	54.69
T_9	1.38	1.32	2.43	54.31
T_{10}	1.36	1.30	2.42	53.74
T_{11}	1.34	1.27	2.37	53.57
T_{12}	1.32	1.28	2.39	53.41
T_{13}	1.30	1.23	2.31	53.38
T_{14}	1.25	1.17	2.19	52.63
T_{15}	1.23	1.15	2.17	52.27
T_{16}	1.21	1.13	2.11	51.73
T_{17}	1.23	1.15	2.17	51.46
T_{18}	1.20	1.12	2.09	51.19
T_{19}	1.16	1.08	2.02	49.91
T_{20}	1.14	1.06	1.96	49.56
T_{21}	1.08	1.03	1.87	48.92
T_{22}	1.06	1.01	1.91	48.46
T_{23}	1.03	0.84	1.84	48.34
T_{24}	0.57	0.53	1.26	31.27
Mean	1.3836	1.30	2.41	52.68
C.D.	0.116	0.006	0.117	3.846
SE(m)	0.041	0.002	0.041	1.351
F-test	Significant	Significant	Significant	Significant

Table 3: Efficacy of hydrogel Proline (mg/g fw), Superoxide dismutase (mg/g fw), Economical yield (q/ha^{-1}), Test Weight (gm) on of wheat under different levels of irrigation

Treatments	Proline (mg/g fw)	Superoxide dismutase (mg/g fw)	Economical yield(q/ha^{-1})	Test Weight (gm)
T_0	0.10	0.55	20.19	27.62
T_1	0.06	1.24	32.65	42.81
T_2	0.06	1.43	24.49	32.35
T_3	0.08	1.47	22.47	31.45
T_4	0.08	1.48	21.42	29.16
T_5	0.09	1.49	20.83	28.56
T_6	0.10	1.51	20.42	28.36
T_7	0.10	1.52	19.56	28.00
T_8	0.10	1.52	18.83	27.46
T_9	0.11	1.57	18.74	27.29
T_{10}	0.11	1.61	18.17	26.65
T_{11}	0.13	1.61	17.67	26.39
T_{12}	0.13	1.61	17.33	26.25
T_{13}	0.15	1.63	17.24	26.01
T_{14}	0.15	1.64	17.02	25.96
T_{15}	0.15	1.65	16.83	25.81
T_{16}	0.15	1.65	16.17	24.69
T_{17}	0.16	1.66	16.12	24.61

T_{18}	0.17	1.68	15.17	24.42
T_{19}	0.17	1.68	14.93	24.31
T_{20}	0.18	1.68	14.54	23.71
T_{21}	0.18	1.69	14.39	23.65
T_{22}	0.21	1.73	14.33	23.12
T_{23}	0.21	1.76	14.24	22.90
T_{24}	0.22	1.85	8.67	17.34
Mean	0.1684	1.5004	18.10	28.2
C.D.	0.024	-	44.555	139.354
SE(m)	0.008	0.081	15.648	48.941
F-test	Significant	Non-Significant	Significant	Significant

Conclusion

Under Agro climatic condition of Allahabad This study may conclude that T_1 is performing best for all the absorbed parameters with Chlorophyll'a', Chlorophyll'b', Carotenoids, Relative Water Content, Yield and Test Weight maximum yield **(**89.1 q/ha^{-1}) Minimum performance was showed by T_{24} yield **(**21.12q/ha^{-1}). Whereas in Proline, Superoxide dismutase under stress condition treatments are showing better in T_{24} than T_1. Recommendation: T_1, T_2, T_3, T_4, T_5, T_6, T_7 from all treatments are performing well, according to requirement and retention capacity of the soil any of these treatments can be adopted by the farmer. On the basis of cost benefit analysis following treatments are performing better comparison to T_0, thus on the basis of soil condition and availability of water any of these can be adopted by the farmer.

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