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Alleviation of Salt Stress Effects using Growth Regulators and Mineral Nutrients on Yield Attributes in Wheat (*Triticumaestivum* L.)

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ABSTRACT: India is second in the production of wheat in world and nearly 7 million hectare area in India is under salinity. Although wheat is moderately salt tolerant still this abiotic stress has lots of negative impact not only in germination but also on overall growth of the plant, which ultimately badly affect its yield. Being a staple food of more than 36% population of world, the improvement in yield is very important for the development of any country. In the present study, the experiments were conducted to alleviate the effect of chloride salinity by pre-soaking seeds of salt sensitive (HD 2329) and salt resistant (WH-542) varieties of wheat with the growth regulators (GA₃+ CK) and minerals (K⁺ and Ca²⁺). In the various combinations of Growth regulators and minerals, seed soaking in 'K⁺+ GA₃+ CK' was found most effective in improving the yield of wheat crops under chloride dominated soil.

KEYWORDS: Wheat, Salt stress, Chloride salinity, Phytohormones, Minerals.

I. INTRODUCTION

In world's grain production, wheat occupies the second position. Wheat is the major staple food crop in North Africa and West and Central Asia, where wheat alone provides almost half of total calories by human beings. Globally wheat is cultivated in an area of about 220 million hectares. Maximum area under wheat cultivation is in India (14%), then followed by Russia (12.43%), China (11.14%) and the USA (6.90%). In production, China is the major producer with about 136 million tonnes, followed by India (98.51 mt), Russia (85 mt) and the USA (47.35 mt)⁽¹⁾. To meet 2050 demands its production must increase at a rate of 2% annually⁽²⁾.

Various types of abiotic stress conditions often adversely affect the productivity of wheat. Among abiotic stresses, salinity is one of the major stress. Salt stress is on rise worldwide due to one or the other effects and it is estimated that 50% of all arable land worldwide will be affected by salt stress by 2050⁽³⁾. Salt stress may cause a loss of more than US\$12 billion annually due to reduction in crop production⁽⁴⁾. Salt stress is having several negative impacts on morphological, biochemical and physiological attributes of the plant including its germination, water uptake, nutrient uptake, photosynthesis, enzymatic activities, growth and yield components.

In India salt stress is a major threat to crop productivity as about 4.5 million hectares area is under wheat cultivation which is salt affected⁽¹⁾. Solutions to the problem of salinity like soil amendments and proper drainage are not substantial. As a result there is a significant reduction in the wheat yield occur. Under salt stress, growth and development of plants are affected adversely. Salinity severely limits plant metabolism by causing oxidative stress, water deficit, ion toxicity, and the nutritional deficiencies⁽⁵⁾.

Due to salt stress, the plant has to spend extra energy on ion transport, tissue reparation mechanism and osmotic adjustment and all this responsible for low productivity^(6,7). Recently, investigations have focused more on the mechanisms of salt tolerance in plants^(8, 9). Many researchers have suggested the role of plant growth regulators in alleviating salt stress effects^(10, 11,12, 13, 14). Positive effects of using plant growth regulators in alleviating salinity effect in various crops have been studied by many workers^(15,16,17,18).



Wheat is a moderately sensitive crop towards salinity. Various studies in wheat crop have shown the positive effect of growth regulators and minerals in mitigating effect of salt stress. The Auxins were reported to increase the germination percentage, shoots DW and maintained ion homeostasis under salt stress by Iqbal and Ashraf⁽¹⁹⁾. Shaddad et al⁽²⁰⁾ showed alleviation of salinity effect through seed priming with GA₃. Foliar application of GA₃ was found to confer salt stress tolerance by Tabatabaei⁽²¹⁾. Along with growth regulators, plant nutrients also reported to play positive roles in alleviating effects of salt stresses. Exogenous application of K⁺ enhanced salt stress tolerance in wheat seedlings was observed by El-Lethy et al⁽²²⁾ and Kausar and Gull⁽²³⁾. Foliar application of phosphorus (P) in alleviating salt-induced damage was reported by Khan et al⁽¹⁶⁾. Use of CaSO₄ was found to increase plant growth, water status and K and Ca uptake under salt stress condition by Zaman et al⁽²⁴⁾. Tian et al⁽²⁵⁾ reported positive effect of Ca(NO₃)₂ in reducing the effect of salinity in wheat seedlings. Salt stress alleviation was also noticed using calcium and sulphur by Singh⁽²⁶⁾. However, potassium did not show any salinity lessening effect. The pre-sowing seed soaking in plant growth regulators (GA₃) has been shown to be beneficial in the mitigation of salt stress effects⁽²⁷⁾.

II. METHODOLOGY

Seeds of cultivar WH-542 were obtained from Nuclear Seed Production unit, Department of Plant Breeding, CCS HAU, Hisar. Chloride dominated salinity of desired level (9dSm⁻¹ and 12dS m⁻¹) was prepared by dissolving mixtures of salts like NaCl, MgCl₂, CaCl₂ and MgSO₄ in distilled water, where Na: Ca+Mg ratio was 1:1 and Ca:Mg ratio was 1:3 and Cl:SO₄ ratio was 7:3 on milliequivalent basis. Before sowing sterilized seeds were given seed priming treatments (Seed soaking for 18hrs) of desired plant growth regulators and nutrients. Seed priming treatment was done with Kinetin (0.4 mM), GA₃ (0.4mM), KCl (20mM) and CaCl₂ (10mM) and their all possible combinations. On the basis of germination and early seedling growth, four most effective treatments were selected (K⁺, 'K⁺+ GA₃', 'Ca²⁺+GA₃', 'K⁺+ GA₃+ CK'). The fully mature seeds were harvested from the plants which were grown treated with these best treatments under various levels of salinity i.e. S₀-Control, S₁-9dSm⁻¹ and S₂-12dSm⁻¹. Various yields attributes studied were length of earhead, dry weight of earhead, grain yield, straw/ grain ratio, number of grains/plant and 100 grains weight.

III. EXPERIMENTAL RESULTS

The objective of this study was to find out the effect of chloride dominated salinity on yield and related attributes on salt sensitive and salt resistant varieties of wheat crop and how it could be alleviated with the use of growth regulators and minerals. Yield of plants was influenced by various physiological and biochemical processes under various salinity levels and seed priming treatments.

Length of Earhead:

It was observed that salinity adversely affected the length of earhead when compared with control i.e. S₀ treatment and this reduction was more in salt sensitive variety HD-2329 than salt tolerant WH-542. Reduction in ear length was estimated as 6.1% and 9.9% in HD2329 and 4.5% and 9% in WH 542 at S₁ and S₂ levels respectively. These negative impacts of salinity were observed to be minimised under some treatments. Among them the presoaking in 'K⁺+ GA₃+ CK' was found most effective in this respect (Fig. 1).

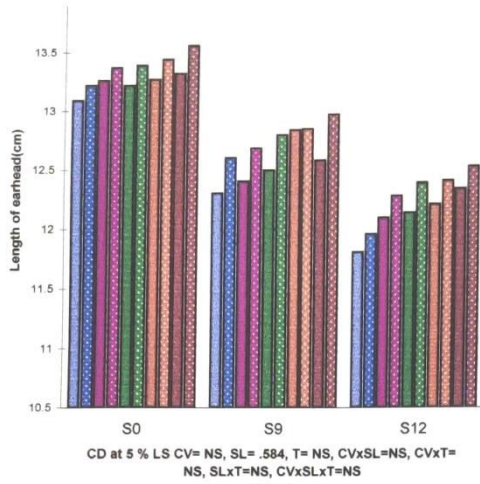


Fig.1

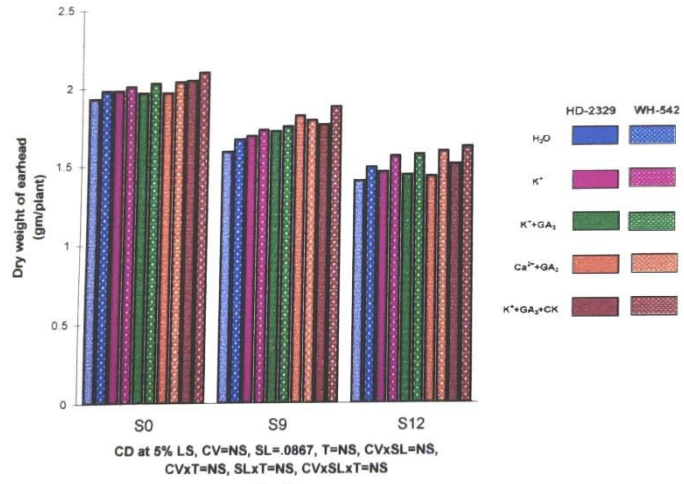


Fig. 2

Fig. 1 and 2: Effect of seed priming treatments on ear length and dry weight of ear head in two cultivars of wheat grown under various levels of salinity

Dry Weight of Earhead:

Salinity was also found to affect dry weight of earhead. At higher salinity dry weight of earheads per plant was reduced significantly in both cultivars. This reduction was 27.4% in HD-2329 and 24.7% in WH-542 at S₂ level of salinity. Cultivar WH-542 was found better under both control and saline conditions as compared to HD-2329. Although all the four treatments were effective but ‘K⁺+ GA₃’ and ‘K⁺+ GA₃+ CK’ were found better than other two treatments (Fig.2)

Grain Weight per Plant:

Depletion in grain weight per plant was observed under saline conditions as compared to non-saline conditions in both the cultivars and this reduction was more at S₂ than S₁ level of salinity. Grain weight per plant was reduced as much as 62% and 52% in HD-2329 and WH-542 respectively at S₂ level of salinity. Pre-sowing treatments considerably increased the grain weight per plant under S₀, S₁ and S₂ levels of salinity. However, amongst all the given treatments in all salinity levels ‘K⁺+ GA₃+ CK’ was found the best treatment. (Fig.3). The improvement in grain weight by this treatment was 33% in HD-2329 and 23.4% in WH-542 at S₂ level of salinity.

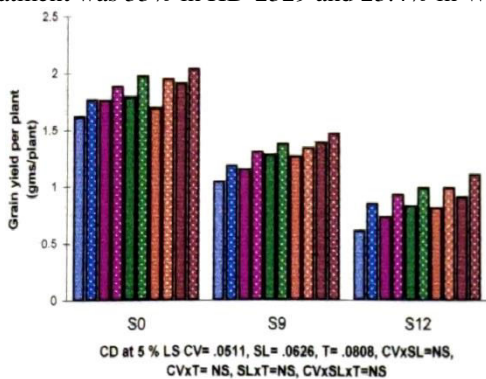


Fig.3

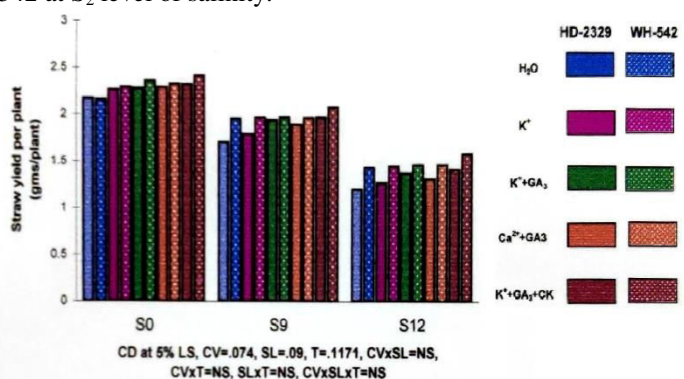


Fig. 4

Fig. 3 and 4: Effect of seed priming treatments on grain weight (gms/plant) per plant and straw yield (gms/plant) per plant in two cultivars of wheat grown under various levels of salinity.

Straw Yield per Plant:

WH-542 had better straw yield than HD2329 under all salinity levels, although in both the cultivars considerable reduction in straw yield per plant was observed. The reduction in straw yield per plant was estimated as 44% in HD-2329 and 33% in WH-542. Improvement in straw yield under non saline and saline conditions was observed with all the given treatments and ‘K⁺+ GA₃+ CK’ was found most effective (Fig. 4). The improvement was 17.3% and 10.4% at S₂ level of salinity in HD -2329 and WH-542, respectively in comparison to their respective controls.



Grain/ Straw Ratio:

A significant decrease in Grain/Straw ratio was observed under saline conditions in both the cultivars. At S₀ and S₂ WH 542 have high grain/ straw ratio but at S₁ both the cultivars were found at equal level. All the seed priming treatments were effective but potassium in combination with Gibberellins and Cytokinin ('K⁺+ GA₃+ CK') was found best treatment (Fig.5)

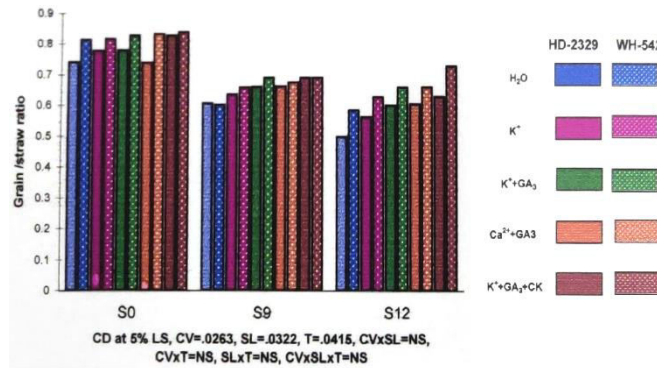


Fig. 5: Effect of seed priming treatments on grain straw ratio in two cultivars of wheat grown under various levels of salinity

Grain Number per Plant

It was found that number of grains per plant was drastically reduced with increase in salinity in both salt tolerant and salt sensitive varieties, although salt sensitive HD-2329 was more badly affected. This reduction in grain number per plant at S₂ level of salinity was 39% in HD-2329 and 32.4% in WH-542. Seed priming with 'K⁺+ GA₃+ CK' efficiently ameliorated the salinity induced reduction in grain number (Fig.6).

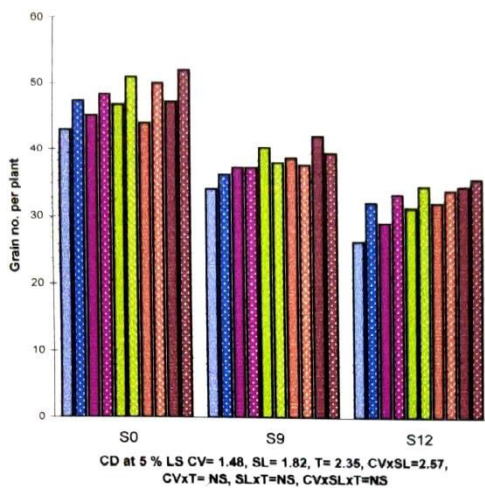


Fig. 6

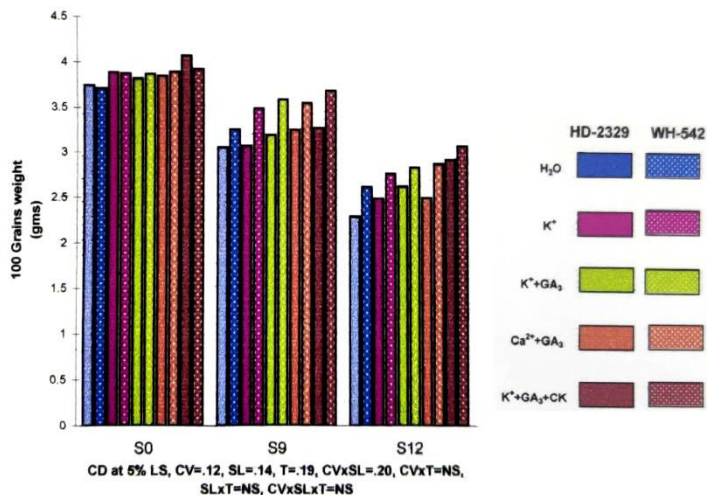


Fig. 7

Fig. 6 and 7: Effect of seed priming treatments on grain no. per plant and 100 grains weight (in gms) in two cultivars of wheat grown under various levels of salinity.

Grain Weight (100 seeds):

Significant reduction in 100 grain weight was observed due to salinity. This reduction was 18% and 38.5% in HD-2329, while, 12% and 29% reduction in WH-542 at S₀ and S₁ levels of salinity respectively. Results clearly show that with every increase in the salinity level, grain weight reduces considerably in both the cultivars and this reduction was found more in HD-2329. Although at S₀ i.e. under non saline conditions, HD-2329 cultivar had higher 100 grain weight than WH-542 (Fig. 7). Various seed priming treatments significantly enhanced the 100 grain weight under all salinity levels but 'K⁺+ GA₃+ CK' was found most beneficial.



IV. RESULTS AND DISCUSSION

Wheat is one of the major crop all over the world, particularly in the Asian region. In India lots of food items are made from wheat flour. After the green revolution its production in India increased tremendously. Change in the climate and the injudicious use of underground water will cost its impact on the production of wheat in future. Along with this salinity is also posing a threat to wheat production. Although wheat is a moderately saline tolerant crop and many salt resistant varieties are also being produced, still amelioration of salt stress in wheat crop is a good tool to enhance its production in salinity affected areas. Salt stress is having enormous negative effects on morphological, physiological, and biochemical attributes of plant including germination, growth, water uptake, photosynthesis, nutrient uptake, enzymatic activities and yield^(28,29). Salinity affects 20% of worldwide cultivable land and is increasing continuously due to the change in climate and many anthropogenic activities⁽³⁰⁾. So it has become necessary to tackle this problem through all possible ways.

At lower level of salinity the seed germination is mainly reduced due to ionic toxicity while at higher salinity, it is reduced by osmotic along with ionic toxicity⁽²⁷⁾. Many studies have been undertaken by researchers to study the mitigation of the above salinity induced attributes. In the present investigation, impacts at the harvesting stage have been observed. Effect of salinity at 2 levels and alleviation of stress using plant growth regulators and/or with minerals have been studied using many parameters. For many parameters Kinetin along with Gibberellins and minerals have been found to reduce the effect of salinity. For most of the parameters it was found in our studies that plant growth regulators alone and along with minerals were effective in alleviating the effect of salt stress. For most of the parameters GA₃ along with CK and K⁺ have shown most promising effects in reducing stress effect for most of the parameters observed in this study. It was also observed that WH-542 a salt tolerant line has shown better results of most of the ameliorative treatments. Reports from other workers have also reported the ameliorative effects of GA₃, Cytokinins and minerals. Shaddadet *et al.*⁽²⁰⁾ showed alleviation of salinity effect through seed priming with GA₃ and observed increase in grain weight and grain quality. Foliar application of GA₃ was found to confer salt stress tolerance by Tabatabaei⁽²¹⁾. The positive role of Cytokinins in restoring the chlorophyll content was observed by Iqbal *et al.*⁽³¹⁾ and Jain⁽³²⁾. Kumar⁽³³⁾ reported that Gibberellins and Cytokinin in combination were helpful in increasing water status in wheat under salt stress. Kumar⁽³³⁾ also suggested that GA₃ and CK antagonized the salinity induced ethylene production. Many other researchers have also suggested the role of plant growth regulators in alleviating negative effects of salinity^(10, 11, 12, 15, 17, 18). Mitigation of salt stress by using Potassium was reported by El-Lethy *et al.*⁽²²⁾ and Kausar and Gull⁽²³⁾, by using Phosphorus reported by Khan *et al.*⁽¹⁶⁾ and by using Calcium was reported by Zaman *et al.*⁽²⁴⁾ and Tian *et al.*⁽²⁵⁾. Salt stress alleviation was also noticed using calcium and sulphur by Singh⁽²⁶⁾.

As it has been speculated that problem of salinity will increase during the course of time⁽³⁰⁾, it has become necessary to work on all aspects to minimise the effect of this stress. Our previous studies⁽³⁴⁾ suggest that minerals in combination with plant growth promoters can prove instrumental in this direction. Studies by many other researchers also support our findings.

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