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# MITIGATION OF SALT STRESS IN WHEAT THROUGH THE APPLICATION OF INDOLE ACETIC ACID

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## ABSTRACT

Wheat a staple food of almost one third population of world is threatened by many biotic and abiotic stresses. Saline soils reduce the production significantly. Different strategies are being used to overcome salinity. In present study a pot culture experiment was conducted with loamy soil to investigate the effect of indole acetic acid (IAA), on growth, yield and some biochemical alteration in wheat grown under saline condition. The experiment was arranged completely randomized design (CRD) with two wheat varieties and two salinity levels (0, 10 dS m-1) each treatment had three replications. Plant growth hormone was applied @ 100 mg $L^{-1}$ IAA, along with control (without PGRs), at vegetative stage of wheat. Results showed that salinity significantly reduced the shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, Number of tillers plant-$^{1}$, grain yield per plant, spike length, number of spikelets/spike, thousands grain weight, while the foliar application of IAA significantly improved all the above parameters under normal as well as saline condition in both the wheat verities. Wheat variety "Akbar-19" performed better than that of "FSD-2008" for all above parameters. Therefore, it had higher growth and yield and yield components under saline as well as normal conditions.

**Keywords:** IAA; Indole Acetic Acid; Salt stress; Wheat

## INTRODUCTION

The grain yield of wheat in Pakistan is low as it is severely affected by various biotic and abiotic stresses (Asif *et al*., 2020). Among the abiotic stress, salinity stress is one of the main reasons for low wheat productivity in Pakistan (Faran *et al*., 2019). The basic reason for salinity is low water quality or alternate cause of use of underground brackish water or use of industrial effluents for irrigation (industry and factory) purpose (Majid *et al*., 2013). High salinity fixation leads to an irregularity of cell particles. High salinity causes ion toxicity and diffusion (Mandhania *et al*., 2006) of sodium (Na) and chloride (Cl). Sodium and chloride ions are the most dangerous for plant growth and development (Forghani *et al*., 2018) because they cause nutrients imbalance in plants. In Pakistan, 6.78 million hectares of land is salt-affected which is increasing day by day due to anthropogenic activities (Ashraf *et al*., 2020). Many plant species show various reactions in their sensitivity to salinity stress that causes reduction in water potential (Abd El-Samad *et al*., 2013). It is necessary to find out the proper solution to combat the salinity required to reduce heavy crop yield losses. Literature suggested different strategies to tackle this agricultural problem, e.g., the introduction of salt-tolerant crop varieties (Naeem *et al*., 2004; Hussain *et al*., 2018; Nawaz *et al*., 2020), crop nutrient or hormonal crop management (Ashraf *et al*., 2008; Hussain *et al*., 2018). The development of salt-tolerant crop varieties is a time consuming and long-term strategy; however, some shotgun approaches are being used to enhance crop yield necessary to fulfill the food demands of ever-growing population of Pakistan (Ashraf *et al*., 2020). Crop nutrient and hormonal management are being used all over the world but the work on the combination of different hormones to ameliorate the adverse effect of salinity is scanty. The use of plant growth regulators to enhance crop yield in saline soil is a good option to reduce the adverse effects of salinity on plant growth and yield (Small and Degenhardt, 2018). Reports indicate that foliar application of indole acetic acid (IAA) is effective in enhancing plant growth and productivity because it regulates the physiological and biochemical processes which promote plant growth and productivity in saline conditions (Majid *et al*., 2013; Fahad *et al*., 2015; Husen *et al*., 2017).

Application of IAA improves the rate of photosynthesis and stomatal conductance of plants development in soils containing excessive salts (Shiraz *et al*., 2021). Earlier reports also indicate that the application of IAA also regulates the physio-chemical characteristics which enhance the plant growth and yield when grown in salt-affected soils (Babar *et al*., 2021). The IAA plays a significant role in managing plant growth, development and yield.

The application of IAA under salinity showed similarity with abscisic acid in stress conditions in plants (Liu *et al*., 2019). The IAA has been connected with reduced adverse effect of salinity (Khan *et al*., 2019). Subsequently, the decrease in plant growth and development under saline conditions could be the consequence of changed hormonal balance (Iqbal and Ashraf, 2010). Consequently, their exogenous application gives an attractive way to deal with the counter-stress condition. The exogenous IAA created more impact on the shoot and root growth of wheat seedlings in salinity (Agami *et al*., 2013). Different scientists illustrated that wheat seed germination reduced with the increasing level of salinity. The antagonistic impact of salinity was reduced in seed priming with IAA (Javid *et al*., 2011). Therefore, keeping above findings regarding role PGRs in saline conditions and the importance of wheat grain yield for an ever-growing population of Pakistan, the present investigation was initiated.

## MATERIALS AND METHODS

The present study was conducted at the (IMBB), The University of Lahore, Lahore (Pakistan). To investigate the effect of IAA on wheat seedlings were raised in plastic pots containings loamy soil.

**Wheat Seed:** Seed of two wheat varieties, Akbar-19 and FSD-2008, having different genetic makeup and origin were collected from Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan. Sixteen plastic pots (11 cm in diameter and 15 cm in Depth) containing 4 kg loamy soil were arranged in completely randomized design (CRD) in wire-house of IMBB, under natural condition. Pots were labeled as per wheat verity and respective salinity and PGR treatments. The pots are filled with 4 kg soil consisted of 1/3 washed river sand and loamy soil 2/3. To remove the surface contaminants seeds had saturated after being cleansed with tap water for two hours in distilled water for imbibition necessary to accelerate seed germination. Then five soaked seed were sown in each pot having soil at field condition and were covered with thin layer of sand.

**Treatments:** Salinity was imposed 10 days after germination. Salinity level 0, 10 dS m-1 were maintained during whole wheat growth season. While PGR i.e., indole acetic acid along with control were applied when plants were of 60 days of old. The pots were irrigated with tap water as and when plant required. At physiological maturity data for shoot length, numbers of tillers per plant were recorded.

Before harvesting pots were flooded with water required to pull out plants with roots. Roots and shoots of harvested plants were washed with tap water and distilled water to remove dust and other contaminants. The roots and shoots were separated and dried with filter paper and their fresh weights were measured by digital electric scientific balance and placed in an oven (forced air) running at 70+SoC. Shoot and root dry weights were determined by measuring them on digital electrical balance.

## RESULTS

### Growth Parameters

**Shoot Length (cm):** Salinity significantly (P<0.05) affected the shoot length of wheat varieties. Plant grown under control had significantly higher shoot length (17.8 cm) than those plants which were grown under saline condition. Foliar application of IAA did not influence the shoot length. The maximum shoot length was noted in plant treated with IAA was 16.1 cm. The lowest plant height was recorded for control was 15.97 cm. The wheat varieties also responded similarly, in case of shoot length. However, wheat variety "Akbar-19" maintained slightly higher shoot length (16.46 cm) than that "FSD-2008" (16.1 cm) (Figure 1).

**Root Length (cm):** Salinity significantly (P<0.05) affected the root length of all the wheat varieties under study. However, plants grown under control condition had significantly higher root length (16.34 cm) than that of plants growing under saline condition (14.53 cm).

Foliar application of IAA significantly (P<0.05) influenced the root length. The maximum root length was recorded in plant treated with IAA was 15.71 cm. The lowest root length recorded for control was 14.7 cm (Figure 2).

The wheat varieties also responded differently in case of root length. The wheat variety "Akbar-19" maintained the higher root length (16 cm) than that of "FSD-2008" (14.8 cm).

**Shoot Fresh Weight:** Salinity significantly (p<0.05) influenced fresh weight of shoot of all wheat varieties. It was higher in plants grown under normal condition (18.3 g) than that of plants exposed to salinity (14.3 g). Plant growth regulators treatment significantly (p<0.05) affected the shoot fresh weight (SFW), it was the maximum in those plant which were foliarly sprayed with IAA (17.10 g). The minimum shoot fresh weight was observed in plants which were non-treated with IAA (15 g) (Figure 3).

The wheat varieties responded differently for shoot fresh weight, however, wheat "Akbar-19" maintained higher shoot fresh weight (17.07 g) than that of "FSD-2008" (15.6 g).

**Root Fresh Weight:** Salinity significantly influenced the root fresh weight, in both the wheat varieties. Plants grown under normal condition possessed higher root fresh weight (3.64 g) than that of plants exposed to salinity (2.61 g).

Plant growth regulators (PGRs) significantly (P < 0.05) influenced the root fresh weight; it was the Maximum in those plants which were foliarly sprayed with IAA (3.44 g) and lowest root fresh weight was recorded in those plants which were non-treated with IAA (2.6 g). The variety also responded differently to for this parameter. Wheat variety "Akbar-19" (3.31 g) maintained higher root fresh weight than that of "FSD-2008" (2.94 g) (Figure 4).

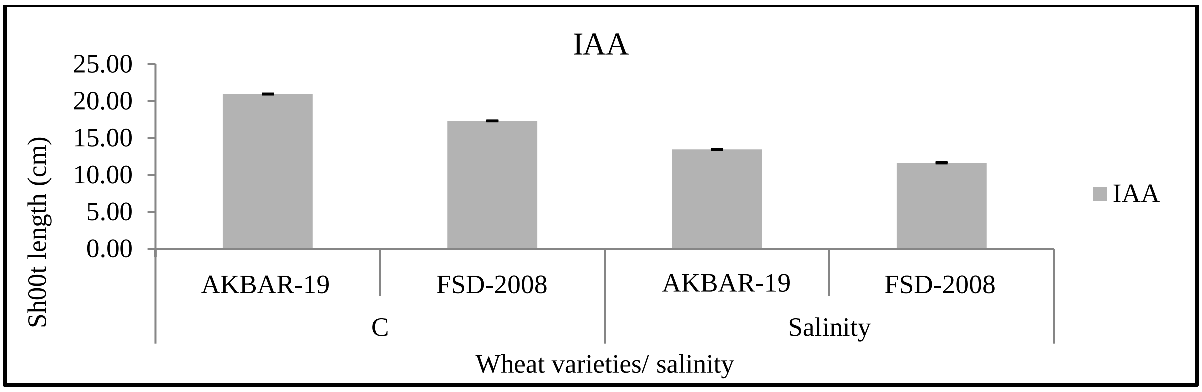


**Figure 1**. Influence of IAA, on shoot length (cm) of two wheat varieties grown under normal and salinve conditions.

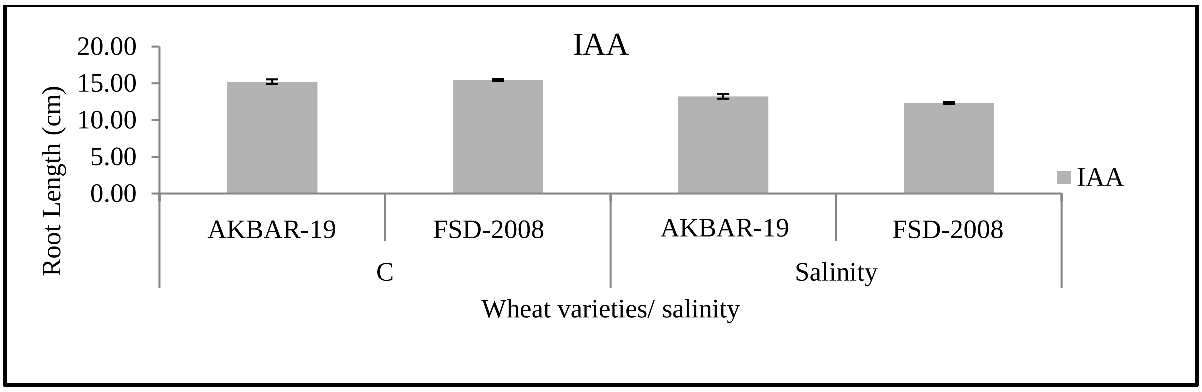


**Figure 2**. Effect of IAA, on root length (cm) of two wheat varieties grown under normal and saline conditions.

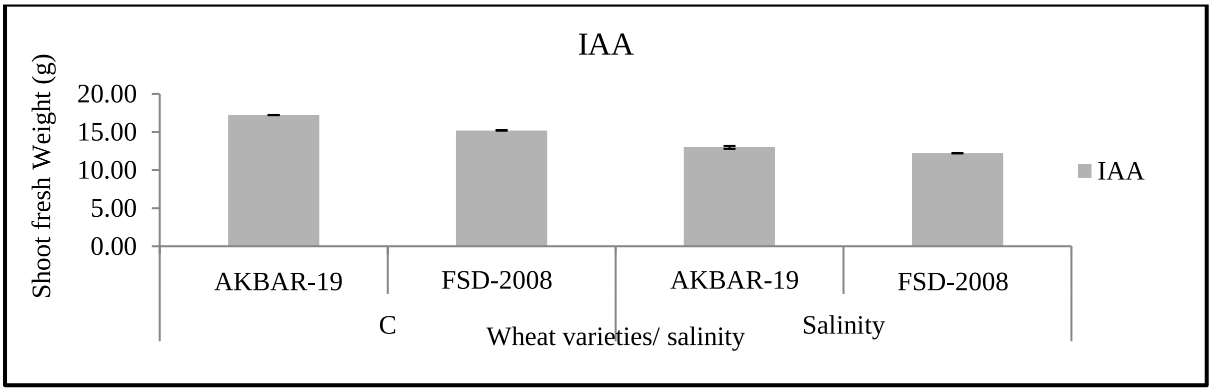


**Figure 3**. Effect of IAA, on shoot fresh weight (g) of two wheat varieties grown under normal and saline conditions.

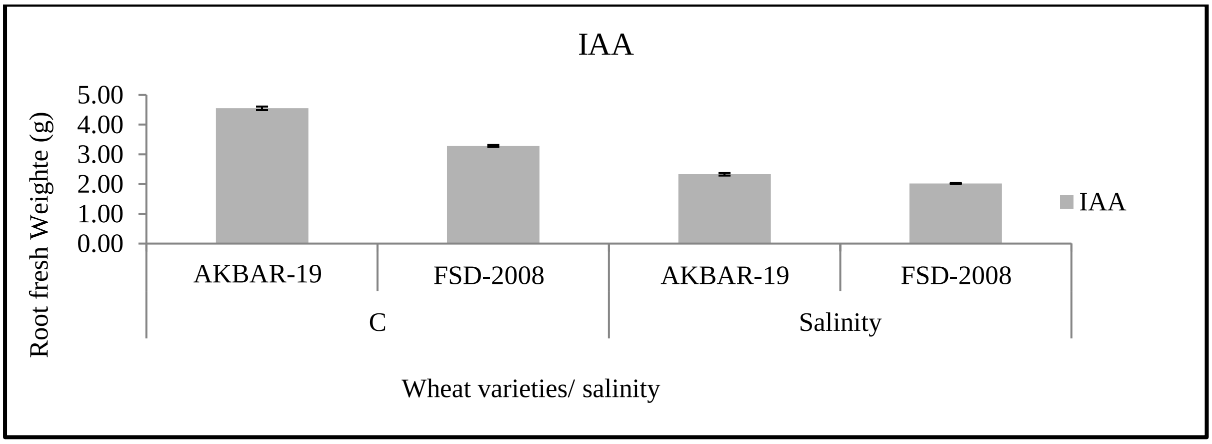


**Figure 4.** Effect of IAA, on root fresh weight (g) of two wheat varieties grown under normal and saline conditions.

**Shoot Dry Weight (g):** Salinity significantly ($p<0.05$) influenced the shoot dry weight in all tested wheat varieties. It was higher in plants grown under normal condition (1.5 g) than that of plants exposed to salinity (1.38 g).

Plant treated with plant growth regulators significantly affected the shoot dry weight, it was the highest in those plants which were foliarly spray with GA3 (1.5 g) closely followed by plant sprayed with IAA+GA3 (1.49 g). The lowest shoot dry weight was observed in those plants which were non-treated with any PGRs (1.32 g) closely followed by the plants treated with IAA (1.45 g) (Figure 5).

The wheat varieties also responded differently for shoot dry weight per plant, wheat variety "Akbar-19" maintained higher shoot dry weight (1.49 g) than that of "FSD-2008" (1.39 g).

**Root Dry Weight:** The root dry weight was varied due to salinity. It root dry weight was higher in plants grown under normal condition (0.62 g) than that of plants exposed to salinity (0.56 g) [Figure 6].

Plant growth regulators (PGRs) significantly ($P<0.05$) affected the root dry weight, it was the highest in those plant which were foliarly sprayed for GA3 (0.67 g) closely followed by plants sprayed with IAA+GA3 (0.54 g), plants treated with IAA (0.56 g).

The wheat varieties also showed similar behaviour for this attribute, however, wheat variety "Akbar-19" maintained higher root dry weight (0.61 g) than that of "FSD-2008" (0.51 g) (Figure 6).

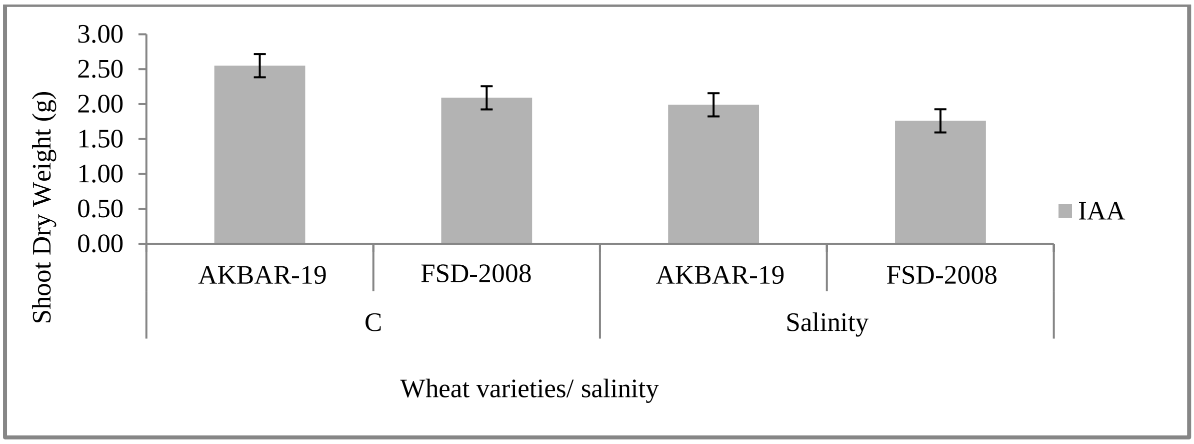


**Figure 5.** Effect of IAA, on shoot dry weight (g) of two wheat varieties grown under normal and saline conditions.

**Number of Tillers Plant$^{-1}$:** The ANOVA table clearly indicated that salinity did not affect the number of tillers plant-1. However, plant grown under saline condition had less number of tillers / plant (2.26) than that of control (2.94) (Figure 7).

The behaviour of varieties in case of number of tillers plant-1 was similar. However, variety "Akbar-19" maintained higher number of tillers plant-1 (2.6) than that of wheat variety "FSD-2008" (2.59). The treatments of PGRs also had similar response in case of number of tillers plant-1. The highest number of tillers plant-1 were recorded for GA3 (2.9) closely followed by GA3+IAA (2.75), IAA (2.5) and control (2.3).

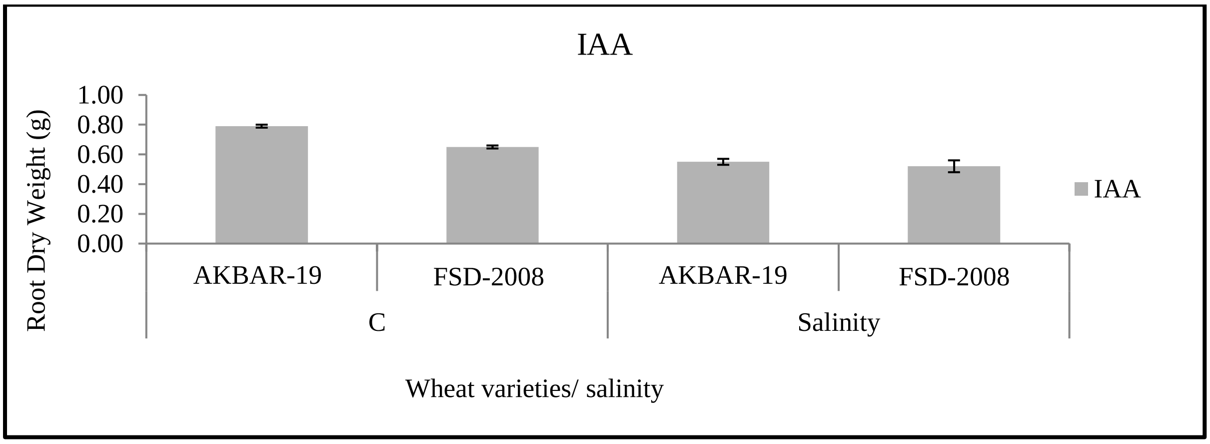


**Figure 6.** Effect of IAA, on root dry weight (g) of two wheat varieties grown under normal and saline conditions.

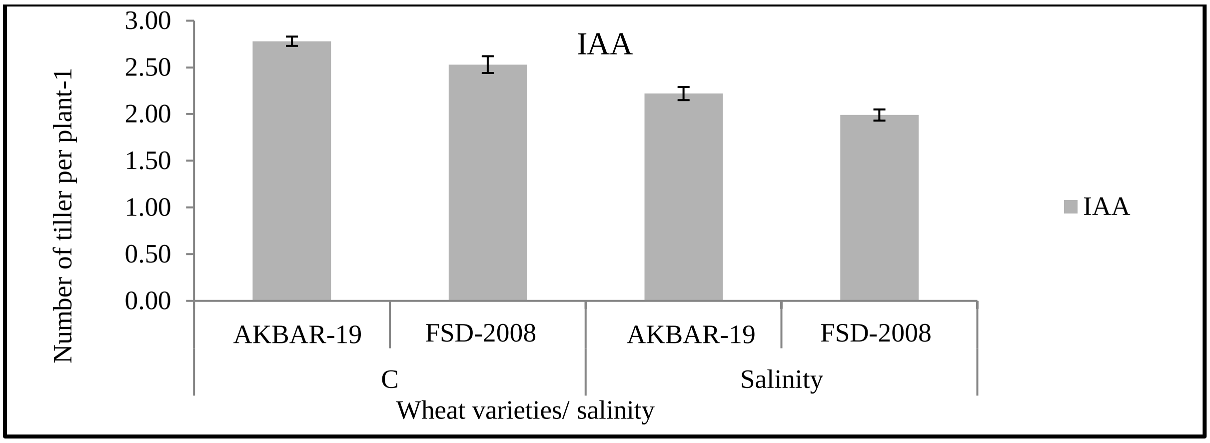


**Figure 7**. Effect of IAA, on number of tillers plant$^{-1}$ of two wheat varieties grown under normal and saline conditions.

**Spike Length (cm):** Salinity significantly affected (P<0.05) the number of spike length, in all wheat verities. It was higher in plants grown under normal condition (12.85 cm) than that of plants exposed to salinity (8.76 cm) [Figure 8]. Plant growth regulators significantly affected the spike length, it was the highest in those plant which were foliarly spray with GA3 (11.05 cm) closely followed by plant sprayed with IAA+GA3 (10.99 cm). The lowest length was observed in those plants which were non-treated with any PGRs (9.46 cm). The wheat varieties also varied significantly for spike length. The wheat variety "Akbar-19" maintained higher spike length (10.81 cm), than that of wheat variety "FSD-2008" (10.18 cm) (Figure 8).

**Number of spikelet /Spike:** Salinity significantly affected (P < 0.05) the number of spikelets per spike in all wheat varieties. It was higher in those plants which were grown under normal condition (17.85) than that of plants exposed to salinity (16) (Figure 9).

PGRs significantly affected the number of spikelets per spike, this parameter was the highest values in those plant which were foliarly spray for GA3 (17.7) and statistically similar to those plants which were treated with IAA+GA3 (17.48). The lowest numbers of spikelets per spike were observed in those plants which were non-treated with any PGRs (15.58).

The wheat varieties also responded differently for this parameter. The wheat variety "Akbar-19" maintained higher number of spikes (17.44) than that of "FSD-2008" (16.4) (Figure 9).

**Grain yield per plant:** Salinity significantly (P<0.05) reduced the grain yield plant$^{-1}$. The grain yield was higher in plants grown under normal condition (65.53 g) than those plants which were grown under saline condition (61.80 g) (Figure 10). PGRs treatments were significantly influenced the grain yield plant-1, it was the highest in those plant which were foliarly sprayed with GA3 (65.78 g) and statistically similar to those plants sprayed with IAA+GA3 (64.55 g). The lowest grain yield plant$^{-1}$ was observed in those plants which were not treated with any PGRs (61.24 g). The variety was varied non-significantly for this parameter. The wheat variety "Akbar-19" maintained higher grain yield plant-1 (64.14 g) than that of wheat variety "FSD-2008" (63.19 g) (Figure10).

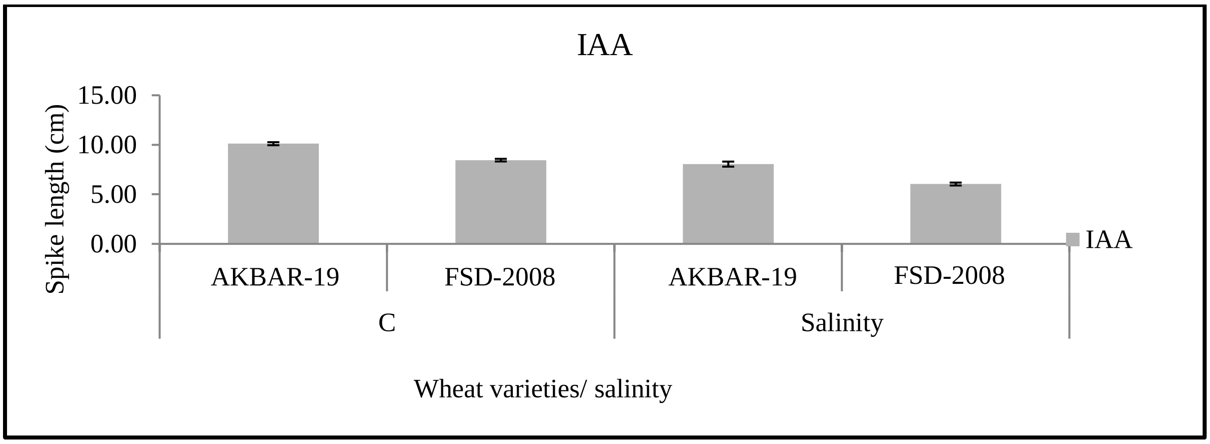


**Figure 8**. Effect of IAA, on spike length of two wheat varieties grown under normal and saline conditions.

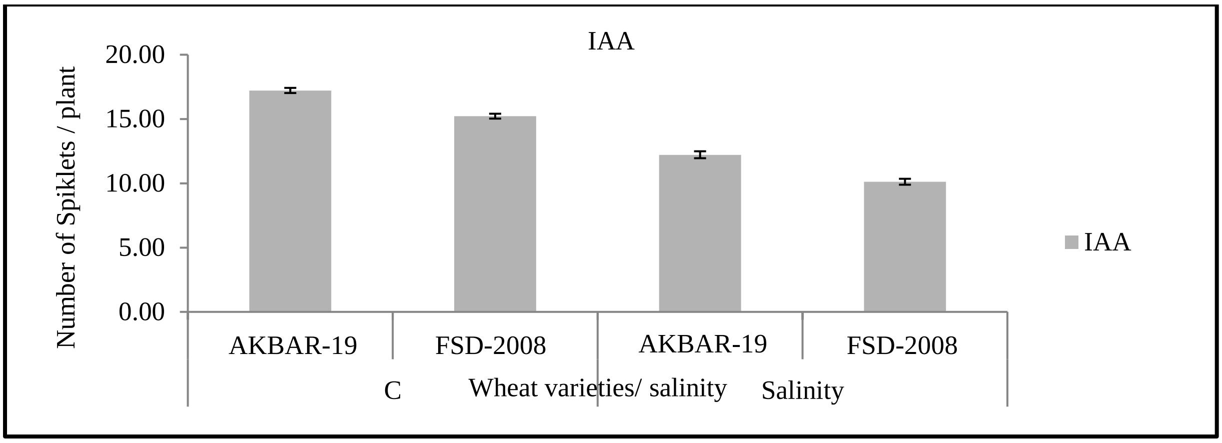


**Figure 9.** Effect of IAA, on number of spikelets of two wheat varieties grown under normal and saline conditions.

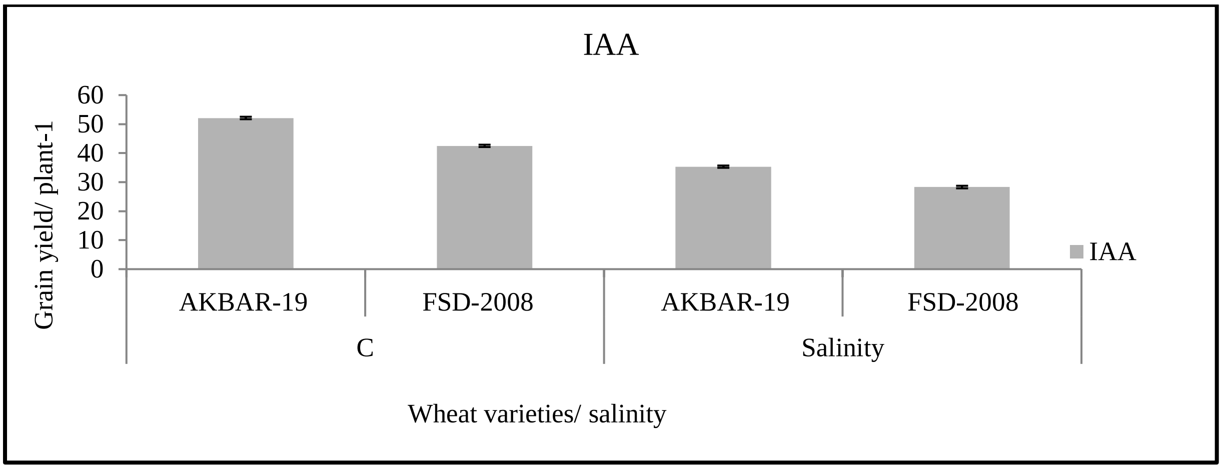


**Figure 10**. Effect of IAA, on grain yield plant-1 of two wheat varieties grown under normal and saline conditions.

**Thousand grain weight:** Salinity significantly reduced (P<0.05) thousand grain weight in all wheat varieties. It was higher in plants grown under normal condition (62.71 g) than that of plants exposed to salinity (58.55 g) [Figure 11].

PGRs application significantly affected the thousand grain weight. The highest 1000 grain weight was recorded for those plant which were foliarly spray with GA3 (63.10 g) closely followed by plant sprayed with IAA+GA3 (62.86 g). The lowest 1000 grain weight was observed in those plants which were non-treated with any PGRs (54.92 g) [Figure 11].

The varietal variations for 1000 grain weight was non-significant (Table 4.1.11). The highest thousand grain weight was maintained by wheat variety "Akbar-19" (60.93 g), when grown under normal condition and sprayed with GA3 than that of the plants of wheat variety "FSD-2008" (60. 30 g), when grown under saline condition and foliar spray with IAA.

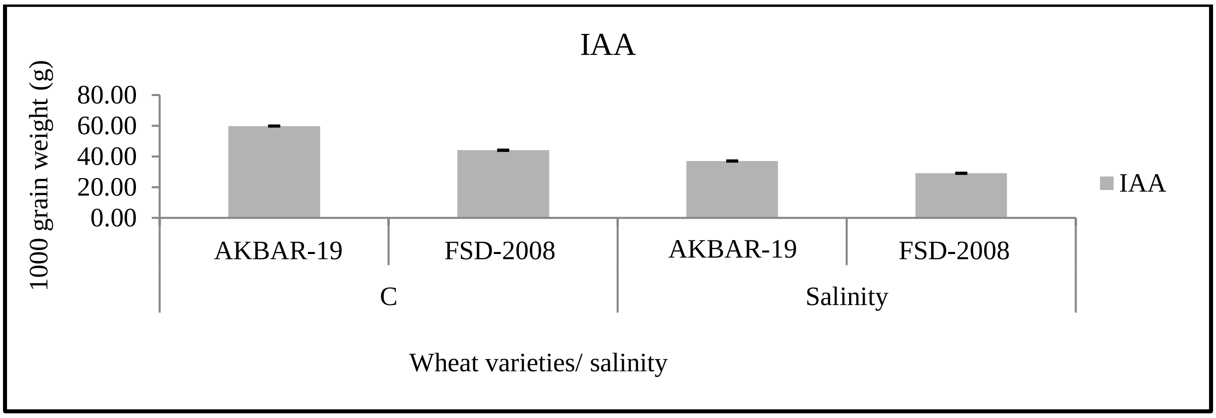


**Figure 11**. Effect of IAA, on thousand grain weight of two wheat varieties grown under normal and saline conditions.

## DISCUSSION

The presence study was focused on amelioration of adverse effects of salinity through the foliar application of IAA. The finding of this study showed that salinity significantly decreased the growth and growth related parameters in both the wheat varieties under study. However, wheat variety "Akbar-19" performed better than that of "FSD-2008" but both showed similar trend in reduction of their growth attributes like shoot length, root length, root fresh biomass, fresh biomass of shoot, dry biomass of shoot, and dry biomass of root. The earlier reports also indicated that presence of excessive salt in the growth media adversely affect the plant growth and biomass (Ali *et al*., 2014; Singh *et al*., 2015).

In this study, results revealed that the application of IAA was effective in reducing the deleterious effects of salinity on growth and biomass attributes. There are many reports in the literature which indicates that application of growth hormone is effective in improving stress tolerance and productivity of crop (Nadeem *et al*., 2014; Soliman, 2019). The most of the literature indicates that GA3 is more effective than that of IAA in promoting plant growth and productivity in saline conditions (Gulnaz *et al*., 1999; Iqbal and Ashraf, 2013).

Sarwar *et al*., (2004) found that application of IAA is beneficial in improving the stress tolerance of plant. While, Iqbal and Ashraf (2013) reported that GA3 is effective in promoting the plant growth and productivity under adverse environmental condition.

It is well documented that during stress condition plants break their heavy molecular weight compounds into smaller molecules, so that they become soluble and create osmotic protection for enzymes and others metabolites necessary to promote the growth and productivity of plants (Bartwal *et al*., 2013; Hasanuzzaman *et al*., 2013). Furthermore, they act as osmotica, essential to adjust the external environment condition created by stress (Iqbal *et al*., 2006; de Bang *et al*., 2021).

Due to the accumulation of above mention organic osmolites, water potential and osmotic potential of the plants decreased (Zhou and Yu, 2009) consequently water flow from its higher concentration (soil) to lower concentratio (plants) appeared (Naikoo *et al*., 2019; Marchiosi *et al*., 2020) which is necessary for the metabolic activities and the synthesis of essential compounds (enzyme) required to regulate the metabolic activities of the plants. In present study water relations of plant and soil were not studied. However, the accumulation of above mention solutes confirmed that the plants treated with IAA were successful in maintaining the water relation even under saline condition (Arora *et al*., 2012; Hasanuzzaman *et al*., 2013), thats why the plants treated with IAA maintained economic growth and productivity under normal as well as in saline condition.

The results of presents study indicated that yield (grain yield per plant) and yield component (number of tillers plant-1, spike length, number of spikelets/spike, thousands grain weight etc) were reduced due to salinity, but foliar application of IAA was effective in minimizing the adverse effect of salinity with respect to yield and yield components (Abdoli *et al*., 2013; Khan *et al*., 2019). The reports available in the literature indicate- that foliar application of PGRs promotes growth and yield under normal and stress conditions (Parveen *et al*., 2013: Aslam *et al*., 2016;). Varietal differences were present in the wheat varieties under study, i.e., wheat variety "Akbar-19" performed better than "FSD-2008" which may be due to the genetic potential of "Akbar" to tolerate the salinity up to that level (10 dS m-1) which was applied in present study. Many reports showed varietal difference regarding stress tolerance due to their genetic potential (Roychoudhury *et al*., 2013; Ruiz *et al*., 2016; Sharma *et al*., 2017). Furthermore, wheat variety "Akbar-19" showed better response to IAA application than "FSD-2008" that may be due to its better adaptation to IAA. The results of presents study showed that IAA application promoted the growth and yield even under saline condition (Afzal *et al*., 2005; Small *et al*., 2018).

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