Pak. J. Bot., 54(5): 1619-1628, 2022. DOI: http://dx.doi.org/10.30848/PJB2022-5(24)

EVALUATING THE EFFECTIVENESS OF BORON ON THE GROWTH OF COTTON (*GOSSYPIUM HIRSUTUM* L.) UNDER SALINE CONDITIONS

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Abstract

The present experiment was designed to monitor growth and yield responses of a cotton genotype after applying salinity and boron stresses either alone or in combination and subsequent estimation of sodium-boron interaction in the cotton genotype. Treatments were set under complete randomized design (CRD) with 3 replications. Results revealed that 37.00 number of flowers/plant were found in control which was decreased by 25.24 and 34.24% by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively compared to control. Number of flowers/plant was improved by 46.92% by the addition of 75 mM NaCl + 12 mM B (Boron) compared with control. Number of leaves/plant of 75.66% was found in control treatment which was decreased by 16.29 and 29.07% by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively compared with control. Number of leaves/plants was improved by 25.08% by the application of 75 mM NaCl + 12 mM B compared with control. Similarly, plant height, lint weight, fresh root weight, dry root weight, root length and shoot length were improved after boron applications. Concentration of Na^+ (Sodium) ion in soil analyzed for control was 4.1 meq. L^{-1} that increased to the level of 4.40 and 4.89 meq. L^{-1} by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively. Under boron applications, the lowest Na^+ in soil were recorded 3.91 meq. L^{-1} for 12 mM B and 4.26 meq. L^{-1} for 6 mM B respectively. Similarly, the lowest Cl^- (Chloride) ion in soil was recorded under boron application, while boron contents in soil was reduced under both salinity stresses.

Key words: Salinity stress, Boron, Growth parameters and soil.

Introduction

Cotton is grown in more than 100 countries. Throughout the world, 150 countries are involved in cotton exchange and making it one of the most dynamically substituted horticultural items. In cotton production, almost 350 million men were involved including 100 million families involved directly in generation (Plastina *et al*., 2007).

Boron (B) is a basic element required by cotton (*Gossypium hirsutum* L.) for ideal development and advancement. Different genotypes of cotton respond in a different way to B application. Optimum levels of B required for one type of cotton may be deficient or toxic for other genotype of cotton (Zancanaro *et al*., 2006). B is a fundamental supplement for typical development of flora with high accessibility within soil & water system. B inadequacies cause distinctive impacts in flora e.g., root prolongation, corrosive oxidase glucose movement, gel translocation, starch digestion, corrosive amalgamation, and dust tube development. B assumes a critical part in starch digestion and transportation. However, B prompted lethality as reported by Kato *et al*., (2009). B is likewise answered to control diverse responses in sugar digestion, e.g., glucose, ß-amylase and decrease of UDPG-amalgamation. B is mainly lacking fundamental nutrient within cotton areas. Fiber has a generally elevated necessity for B (Zhao *et al*., 2002), and require a normal of 330 g ha^{-1} B (Rochester *et al*., 2007).

Nutritional issues caused by B inadequacy in fiber are very regular in soils. B accessibility is altogether diminished in soils (Nable *et al*., 1997). Consequently, boron inadequacy or lethality has been found in cotton developing areas around the world (Agarwala *et al*., 1996; Goldbach *et al*., 2001). B lethality applies diverse impacts on vascular plants and lessened root cell division. A lessened development of shoot and root is common to plant presented to elevated boron level (Nable *et al*., 1990).

Distinctive plant type reacts diversely to various level of boron. Boron inadequacy decreased productivity (El-Shintinawy *et al*., 1999). Impacts of foliar utilizations of boron built-in expanded capitulate and bigger seed estimate (Gascho *et al*., 1997). Soil saltiness is a noteworthy imperative restricting agrarian efficiency on almost 20% of the developed range and half of the flooded zone around the world (Lobell *et al*., 2007; Haque *et al*., 2006).

Salinization of soils is formed because of 2 sources; essential and optional salinization. Essential salinization happens because of regular procedures like release of minerals from weathering of saline parent rocks though auxiliary salinization comes about because of agrarian administration works as well as poor water administration, substantial water system and past introduction to ocean water (Goldberg *et al*., 2003). Secondary soil salinity affects almost one third of the productive land of agriculture (Anon., 2018). This abundance increases in salinity levels which adversely affect the needs of increasing world's population that is predictable to rise up to 9.0 billion in 2050 (Anon., 2019).

Saltiness is a typical abiotic concern among the cotton growing season. Saltiness pushes cause a progression of harmful impacts on fiber development, yield, and thread class. Though cotton is measured as sensitive to salts level of 7.7 dS m^{-1}, it capitulates and seed are inclined through various saltiness level. In this manner, recognizable proof of salt-resilience in cotton germplasm assets is a critical angle for advance change in cotton generation. Studies have demonstrated that saltiness effects the development of the flora to different degree at all phases of vegetation's series at various saltiness level (Ashraf, 2002). The stone and seedling stage are remarkably delicate to saltiness. Saltiness antagonistically effects the development of essential root, folio region, shoot duration, shoot origin new mass and root development, though there are information that demonstrate an expansion in root development at direct saltiness level. Saltiness in light of the fact that these species indicate long-remove dispersal through float in sea streams.

Therefore, this research experimentation was done to monitor growing response of cotton to sodium and boron applied either alone or in combination and to estimate sodium-boron interaction on cotton and its role on growth after analyzing sodium and boron concentration.

Materials and Methods

Site selection: Trial was led in pots to appraise the interaction of salinity and boron stress on cotton at College of Agriculture, Sargodha, Pakistan located at 72.67° East longitude & 32.08° North latitude and its height above water level is 192 meters. Sargodha falls in the dry climatic zone having normal yearly precipitation of around 400 mm.

Experimental layout: Without lint, seed of *Bacillus thuringiensis* (Bt) cotton variety CIM-599 was used in experiment. Experiment comprised of 9 treatments and all these treatments were arranged under factorial completely randomized design (CRD) through 03 repetitions. The treatments were: T_1 = Control; T_2 = 75 mM NaCl; T_3 = 150 mM NaCl; T_4 = 6 mM B; T_5 = 12 mM B; T_6 = 75 mM NaCl + 6 mM B; T_7 = 75 mM NaCl + 12 mM B; T_8 = 150 mM NaCl + 6 mM B; T_9 = 150 mM NaCl + 12 mM B. Seed delinting was performed with strong H_2SO_4 and then delinted seeds were reacted with a pesticide Actara ST 70. Before sowing, seeds were dipped in water for 9-15 hours. Five seeds per pot were sown and 3 plants per pot were kept 15 days after sprouting.

Soil analysis: Soil samples from various pots were collected. The collected soil samples were dried and ground through 2mm sieve size. Test procedures of Hand book 60 (Anon., 1969) Method # 2, 27a, 21a, 82,13, 7 and 10a were followed. for paste preparation, saturation percentage, pH, ECe, carbonates and bicarbonates, chlorides, calcium + magnesium, potassium and sodium determination (Table 1).

Water analysis: For water examination, value of RSC was also calculated (Table 2).

Table 1. Analysis of original soil used for experiment.

Properties	Unit	Values
Saturation percentage	%	37.5
pHs	-	7.86
ECe	dS m^{-1}	0.70
Carbonates	m molc L^{-1}	3.6
Bicarbonates	m molc L^{-1}	6.3
Cl-	m molc L^{-1}	4.1
Sulphates	m molc L^{-1}	3.8
Ca^{+2} + Mg^{+2}	m molc L^{-1}	83
Na	m molc L^{-1}	4.18
Sodium adsorption ratio (SAR)	$(m\ molcL)^{1/2}$	3.54
Sand	%	<43%
Silt	%	<50%
Clay	%	<7%
Textural Class	-	Sandy loam soil

Table 2. Analysis of water used in experiment for irrigation.

Properties	Unit	Values
EC	dS m^{-1}	0.88
Total soluble salts (TSS)	m molc L^{-1}	8.8
Carbonates	m molc L^{-1}	Nil
Bicarbonates	m molc L^{-1}	6.2
Chlorides (Cl-)	m molc L^{-1-1}	1.4
Sulphates	m molc L-1	1.2
Calcium+ Magnesium	m molc $L\text{-}1^{-1}$	2.41
Sodium (Na+)	m molc L^{-1}	6.39
Sodium adsorption ratio (SAR)	(m molc L-1) $^{-1}$	5.82
Residual sodium carbonate	m molc L^{-1}	3.7

Residual sodium bicarbonate (RSC): RSC of irrigation water was determined using Eaton *et al*., (1950) method

RSC = (Carbonate + bicarbonate) – (calcium + magnesium)

Plant analysis: The analysis was made according to the methods written in Hand Book 60 of U.S Laboratory Staff (1969).

Total nitrogen: Digestion mixture was used to digest 1.0 g plant sample using procedures described by Hu and Barker (1999) and Jackson (1962) for the determination of total nitrogen from plant samples.

Determination of Na, K, Ca, Mg and P contents: Plant samples of 0.5 g were transferred into digestion vessel. 10 ml of diacid mixture (HNO_3: $HClO_4$= 2:1) was added into vessel and kept for one day. In this way, digestion of plant samples was completed (Method 54 a) Hand book 60 (Anon., 1969).

Sodium, potassium, calcium, magnesium and phosphorous determination: Na (Sodium) and K (Potassium) from plant samples were measured by flame photometer (Method 57 & 58 a) Hand book 60 (Anon., 1969). Ca (Calcium) and Mg (Magnesium) were analyzed by atomic absorption spectrophotometry (Method 55a and 56) Hand book 60 (Anon., 1969). Total P (phosphorus) was measured by means of the extracts of wet digestion and spectrophotometer (Method 61) Hand book 60 (Anon., 1969).

Soil boron: Chemical analysis was also done to measure the boron content in soil samples following methods given by Sah & Brown (1997).

Statistical analysis: All data were evaluated statistically by statistix 8.1 ANOVA technique by comparing the significance of treatments through Tukey's (HSD) test at 5% probability level (Steel *et al*., 1997).

Results

Number of flowers/plant: In cotton, number of flowers is of the most significance. Flowers per plants directly enhance bolls/plant as a result of which cotton seed yield is increased. Results of variance and mean correlation for number of flowers/ plant are presented in (Fig. 1). Number of flowers/ plant remained significantly influenced by boron addition and salt stress. Number of flowers/plant was found 37 in control which was decreased by 27.66 and 24.33 by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively when compared with control. However, additional B application alleviated the deleterious belongings of saltiness on floral nourishment and improved flowers/ plant. Under boron applications flowers/plant were improved by 42.66, 49.33, 53.66, 58.66, 62.33 and 67.00 by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12mM B, respectively.

Leaves/plant: In cotton, leaves/plant is also most important as more the number of leaves/plant, more will be the net photosynthetic rate and more accumulation of photosynthates which ultimately results in more seed yield. Observations of difference for No. of leaves per plant are shown in (Fig. 2). Number of leaves/plant remained inclined? by various salt levels and boron addition. Number of leaves/plant i.e., 75.66 was found in control treatment which was decreased by 63.33 and 53.66 by salinity-1 (75 mMNaCl) and salinity-2 (150mMNaCl), respectively when compared to control. Under boron applications the number of leaves/plant were improved by 83.66, 87.00, 93.33, 97.66, 101.00 and 94.66 by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B,150 mM NaCl + 12 mM B, 75 mM NaCl + 12 mM B and150 mM NaCl + 6 mM B, respectively.

Height of plants (cm): Height of plant is one of the vital yields determining attributes in cotton. Taller plant has more monopodial and sympodial branches which results in higher seed cotton yield. Examination of difference and average judgment for plant tallness is presented in (Fig. 3.) Plant height remained significantly affected by boron addition. Maximum height of 90.00 cm was found in control treatment which was decreased by 82.66 and 73.66 by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively in comparison to control. However, boron application reduces the detrimental effect of salts on the growth of plants. Under boron applications, plant height was improved by 94.33, 100.00, 107.33, 110.00, 112.67 and 123.00 by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B, respectively with significant statistical differences.

Lint weight (g): In cotton the most important part is the lint as it is directly used for processing of fiber. Difference and average judgment for lint mass is presented in (Fig. 4). Lint mass had considerably ($p \leq 0.05$) manipulated through salinity level and boron application. Lint mass of 36.93 g was found in control treatment was decreased by 32.03 and 25.90 g by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl) respectively when compared to control. However, boron application increased lint weight of cotton. Under boron applications the weight was improved by 39.96, 42.76, 45.66, 46.77, 42.96 and 49.26 g by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B, respectively and all these differences proved significant.

Fresh weight of roots (g): Root weight is the most important selection criteria under salinity stress as more root weight suggests the more accumulation of solutes in roots. Thus, it results in more uptake of water from soil and plant shows better growth under salinity stress. Examination of difference and average contrast intended for fresh root weight is presented in (Fig. 5). Fresh root mass was considerably ($p \leq 0.05$) manipulated via salinity level and boron application. Minimum root mass of 30.28 g was noted in control treatment which was increased by 32.48 and 33.55 g by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively in comparison to control. However, boron application had a positive effect on root weight of cotton. Under boron applications, fresh root weight was improved by 37.48, 42.64, 39.46, 45.71, 47.72 and 49.55 g by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B, respectively indicating significant differences among various treatments.

Dry root weight (g): Weight of root is an important parameter under saltiness conditions. More weight of roots promotes more solutes accumulation. Thus, it is responsible for high availability of water up taken by roots from soil and plants shows successful growth under saltiness conditions. Examination of difference and average comparison for dry root mass is presented in (Fig. 6). Dry root mass can be ($p \leq 0.05$) inclined considerably through salinity levels and boron application. The least dry root mass of 12.50 g remained for control treatment that raised to the levels of 13.39 and 13.72 g by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively when compared with control. Under boron applications the dry root weight was improved by 15.61, 19.44, 16.51, 20.40, 24.69 and 26.64 g by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B, respectively and all these treatments indicated significant differences.

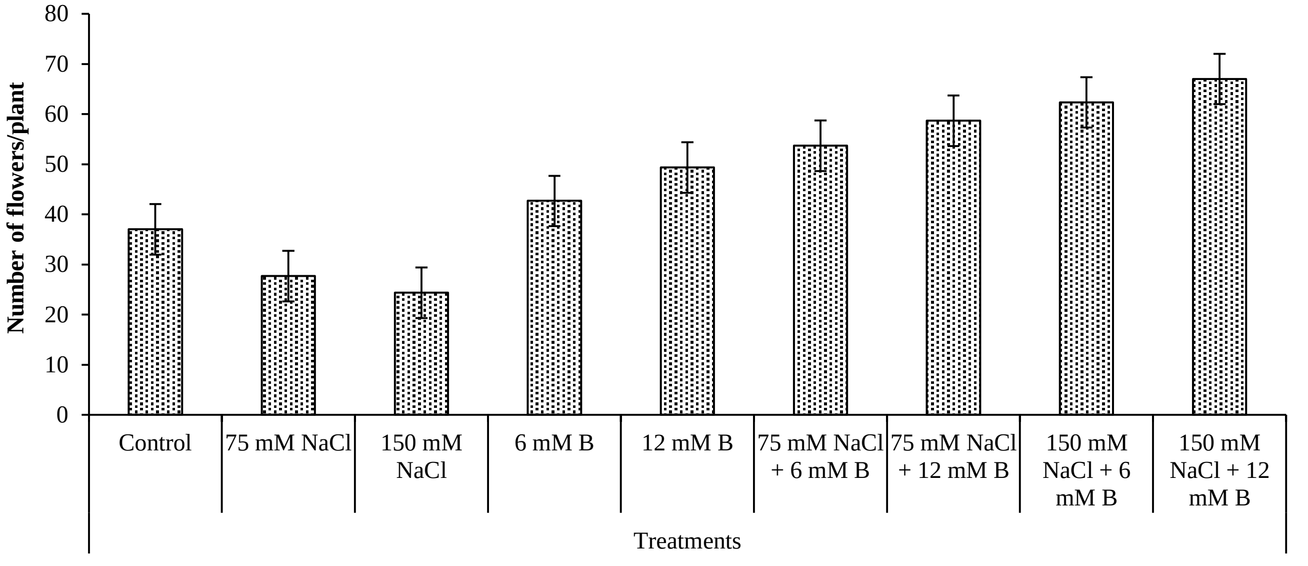

Fig. 1. Effect of different salinity treatments and boron applications on the number of flowers/plant in cotton.

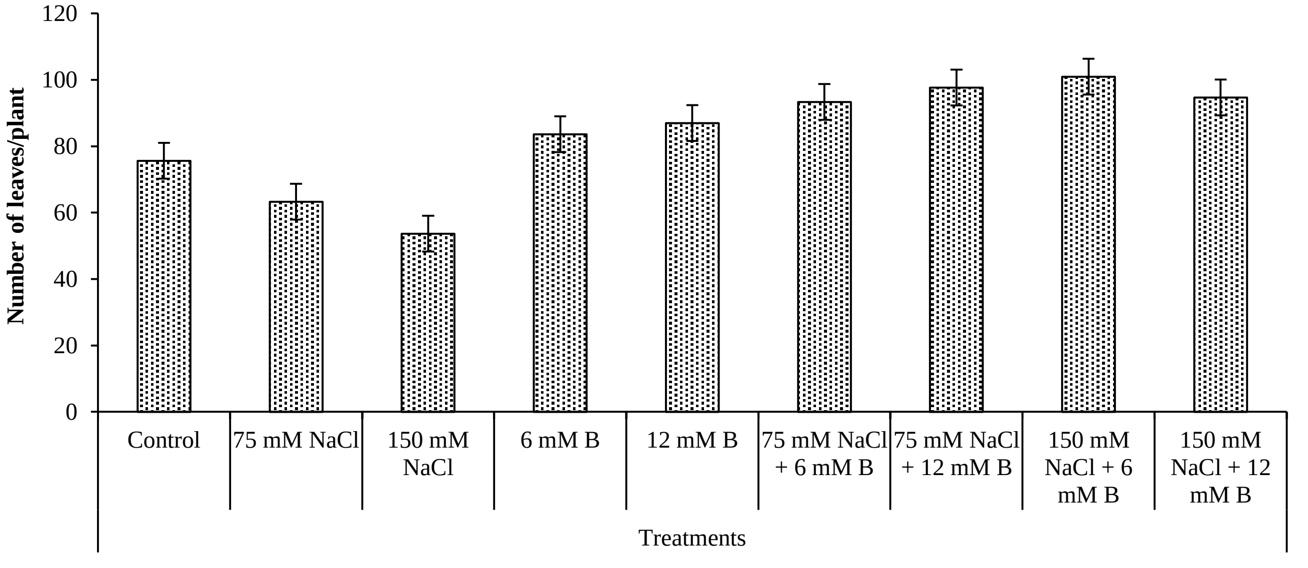

Fig. 2. Effect of different salinity treatments and boron applications on the number of leaves/plant in cotton.

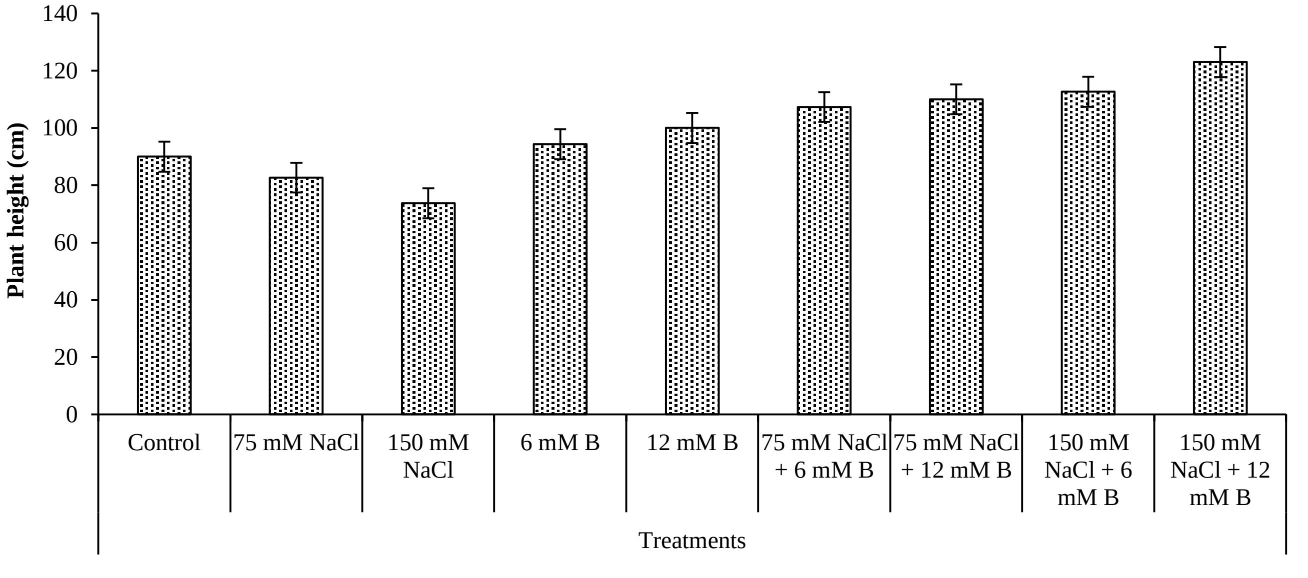

Fig. 3. Effect of different salinity treatments and boron applications on plant height (cm) in cotton.

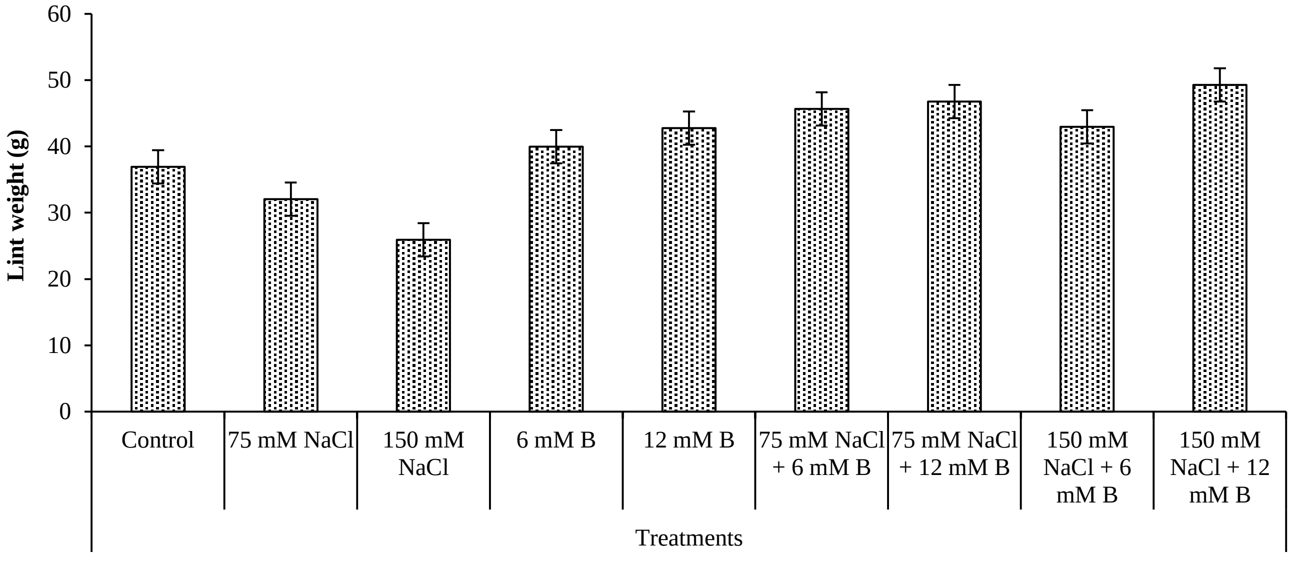

Fig. 4. Effect of different salinity treatments and boron applications on lint weight (g) in cotton.

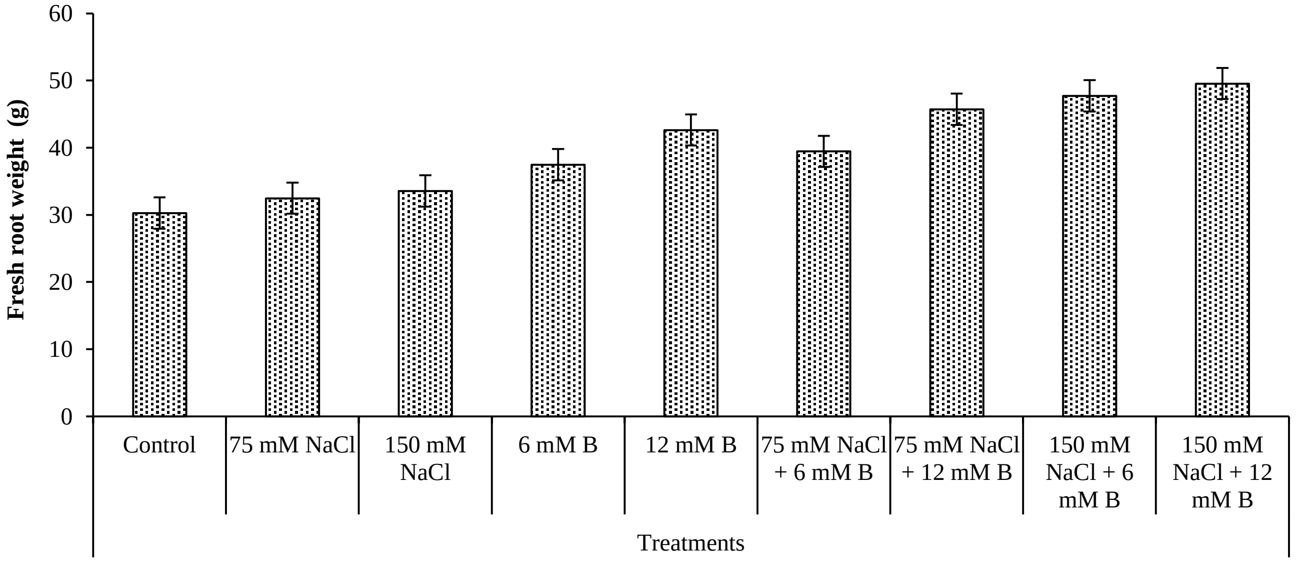

Fig. 5. Effect of different salinity treatments and boron applications on fresh root weight (g) in cotton.

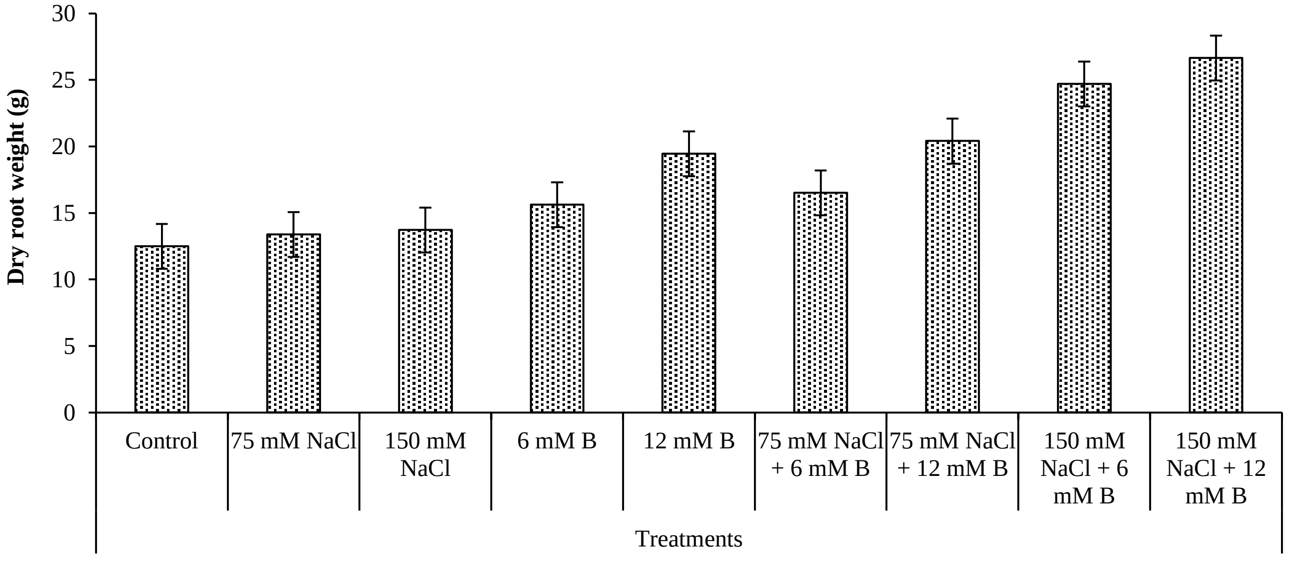

Fig. 6. Effect of different salinity treatments and boron applications on dry root weight (g) in cotton.

Root length (cm): Deep roots are of vital importance for uptake of more water from deep soil surface as compared to shallow roots. Examination of difference and average contrast for root length is presented in (Fig. 7) that remained significantly influenced through salinity and boron addition. Least root length of 13.46 cm was found in control which was increased to the levels of 14.79 and 15.26 cm for the treatments having salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl) respectively. Root's length was also increased significantly by boron application. Under treatments of boron applications, the root length was improved to the values of 15.75, 15.44, 16.24, 16.88, 15.83 and 17.05 cm for the treatments 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B respectively.

Shoot length (cm): Shoot length is the most important selection criteria under salinity stress as more shoot length suggests the better growth under salinity stress. Examination of difference and average comparison for shoot length indicated that shoot length was significantly affected through salinity level and boron application (Fig. 8). The shoot length of 32.44 cm was found in control treatment which was decreased to the values of 30.27 and 28.76 cm for treatments having salt addition salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl) respectively. Under treatments of boron applications alone and in combination with salt addition, the shoot length was improved to the levels of 35.67, 39.44, 36.54, 40.23, 43.55 and 46.79 cm respectively for treatments having 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12mM B.

Na^+ in soil (mg kg^{-1}): Examination of variation and average contrast for concentration of Na^+ in soil is indicated in (Fig. 9). According to data of Fig. 9, concentration of Na^+ in soil was considerably influenced by boron application and salt stress (addition of NaCl salt) and variances amongst treatments remained significant statistically. The content of Na^+ in soil analyzed for control treatment was 4.10 mg kg^{-1} which was increased to the values of 4.40 and 4.89 mg kg^{-1} for salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl) treatments respectively. Addition of boron in the soil helped to reduce the Na^+ concentration and thus, maintained soil ionic balance. Under treatments of boron applications, concentration of Na^+ in soil was noted to the levels of 4.26, 3.91, 4.52, 4.37 4.60 and 4.42 mg kg^{-1} respectively for treatments having 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B.

Cl^- in soil (mg kg^{-1}): Examination of difference and average comparison for Cl^- in soil is presented in (Fig. 10). The chlorides 4.15 mg kg^{-1} was found in control which was increased by 13.72 and 18.46% by salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl), respectively compared to control. Addition of B in the soil helps to reduce the Cl^- concentration in soils and maintains the soil ionic balance. Under boron applications the Cl^- in soil were improved by 14.96, 17.04, 6.66, 8.10, 4.36 and 10.18% compared to salinity-1 (75 mM NaCl) and 19.64, 21.61, 11.98, 17.09, 9.62 and 15.12 % compared to salinity-2 (150 mM NaCl) by the application of 6 mM B, 12 mM B, 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B, respectively.

Boron in soil (mg kg^{-1}): Data showed that addition of NaCl and boron alone and in combination showed significant differences amongst treatments when adjudged statistically (Fig. 11). Concentration of boron in soil for control treatment was noted as 0.493 mg kg^{-1} which was reduced to the levels of 0.443 and 0.386 mg kg^{-1} in treatments having addition of NaCl, i.e., salinity-1 (75 mM NaCl) and salinity-2 (150 mM NaCl) respectively. Likewise, concentration of boron was increased in treatments where it was applied at both levels. The respective values of boron concentration in soil remained 0.690 and 1.19 mg kg^{-1} for 6 mM B, 12 mM B treatments. In the same way values of boron concentration in soil for treatments having combination of NaCl and boron were noted as 0.506, 0.606, 0.476 and 0.546 mg kg^{-1} for 75 mM NaCl + 6 mM B, 75 mM NaCl + 12 mM B, 150 mM NaCl + 6 mM B and 150 mM NaCl + 12 mM B, respectively.

Discussion

Cotton is one of the most important cash crops of Pakistan that mainly contributes to the economy of country. Pakistan is the 4th major cotton producing country next to China, USA and India (Ahmad *et al*., 2009). Along with the major fiber contribution, an important vegetable oil is also produced from its seed. It is cultivated on 3.1-million-hectare area, out of which 12.4 million bouquets are of Pakistan (Anon., *et al*., 2007). The mean comparison for number of flowers/plant showed non-significant differences under different salinity and boron applications except for control, 75 mM NaCl and 150 mM NaCl which showed significant differences. Boron insufficiency is also the main reason in reduction of plant height, plant total dry matter, number of reproductive parts during fruiting stage and leaf photosynthetic rate. When B is supplanted in the supplement arrangement after a transitory inadequacy, full development recuperation does not happen and, thusly, a brief B lack makes continuous injury to the plants (Rosolem & Costa, 2000). The mean correlation for plant height demonstrated critical contrasts under various saltiness and boron applications with the exception of 75 mM NaCl + 12 mM B and 150 mM NaCl + 6 mM B which indicated non-significant differences in terms of statistics. Generally little measures of B remain essential to help development of cotton components in boll (Silva *et al*., 1979). The mean comparison for lint weight showed significant differences under different salinity and boron applications except for 75 mM NaCl + 6 mM B and 75 mM NaCl + 12 mM B which showed non-significant differences.

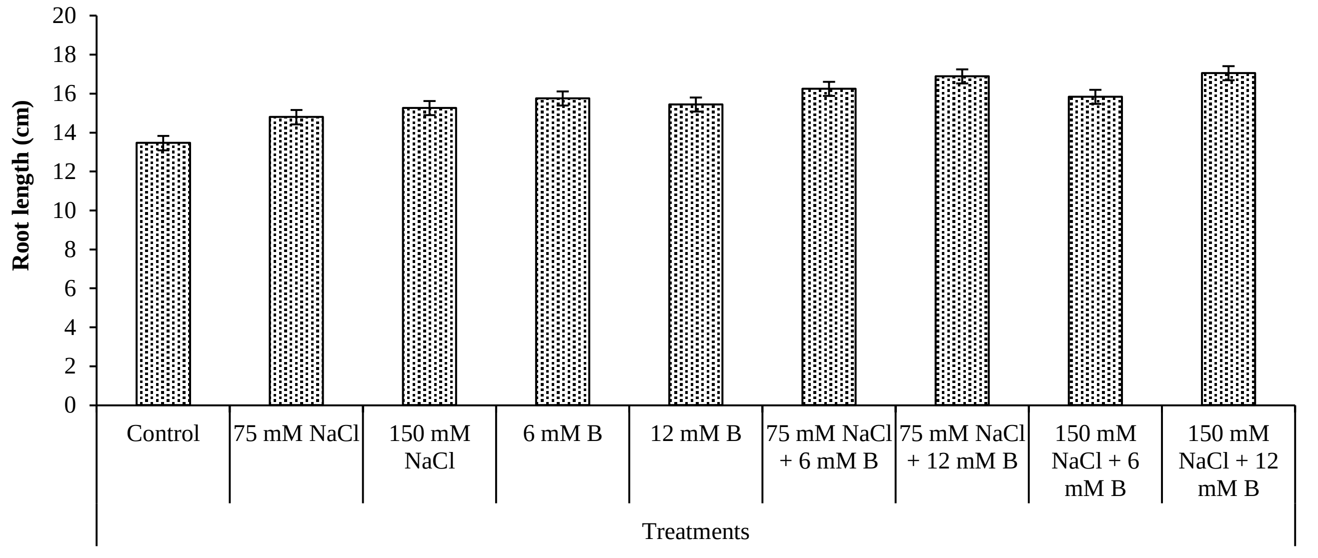

Fig. 7. Effect of different salinity treatments and boron applications on root length (cm) in cotton.

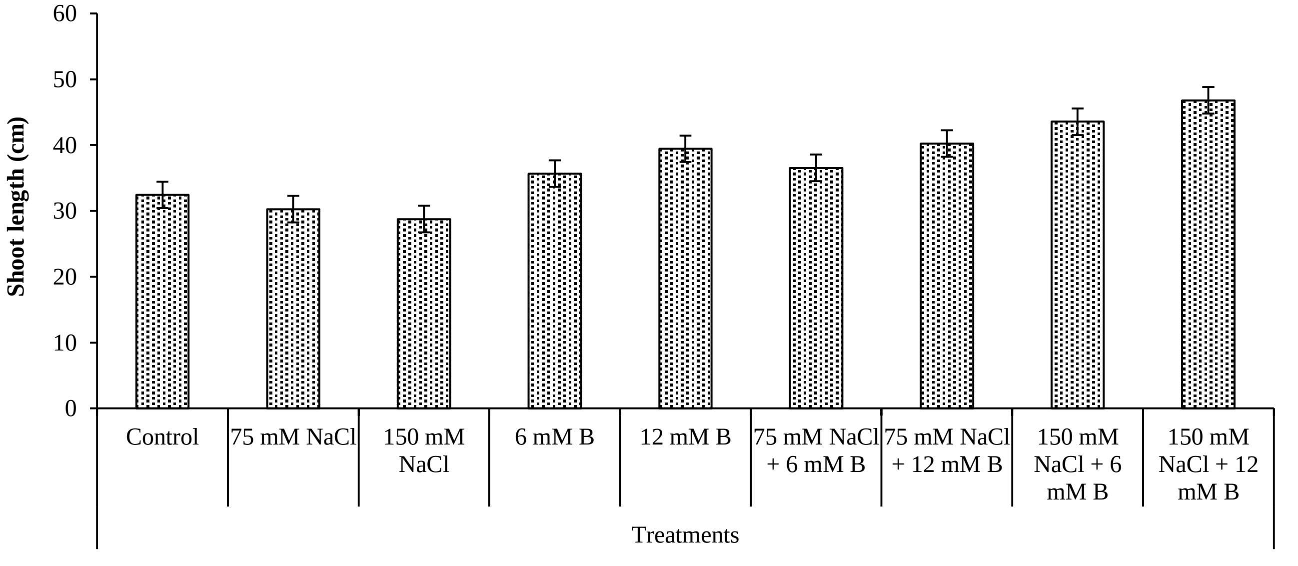

Fig. 8. Effect of different salinity treatments and boron applications on shoot length (cm) in cotton.

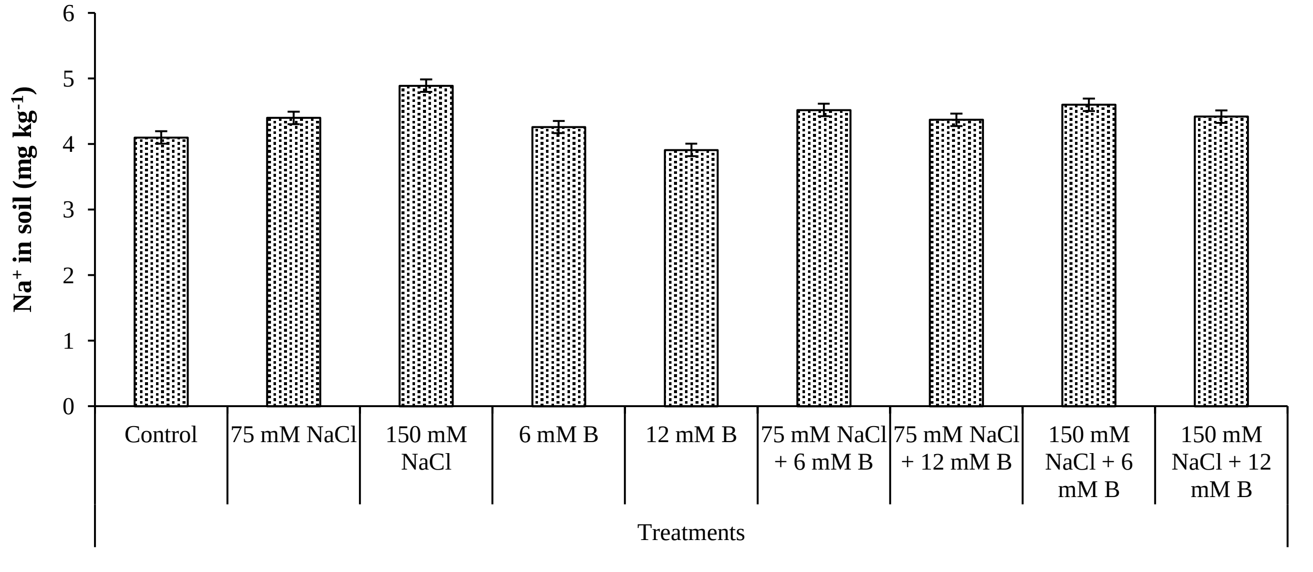

Fig. 9. Effect of different salinity treatments and boron applications on Na^+ in soil (mg kg^{-1}) in cotton.

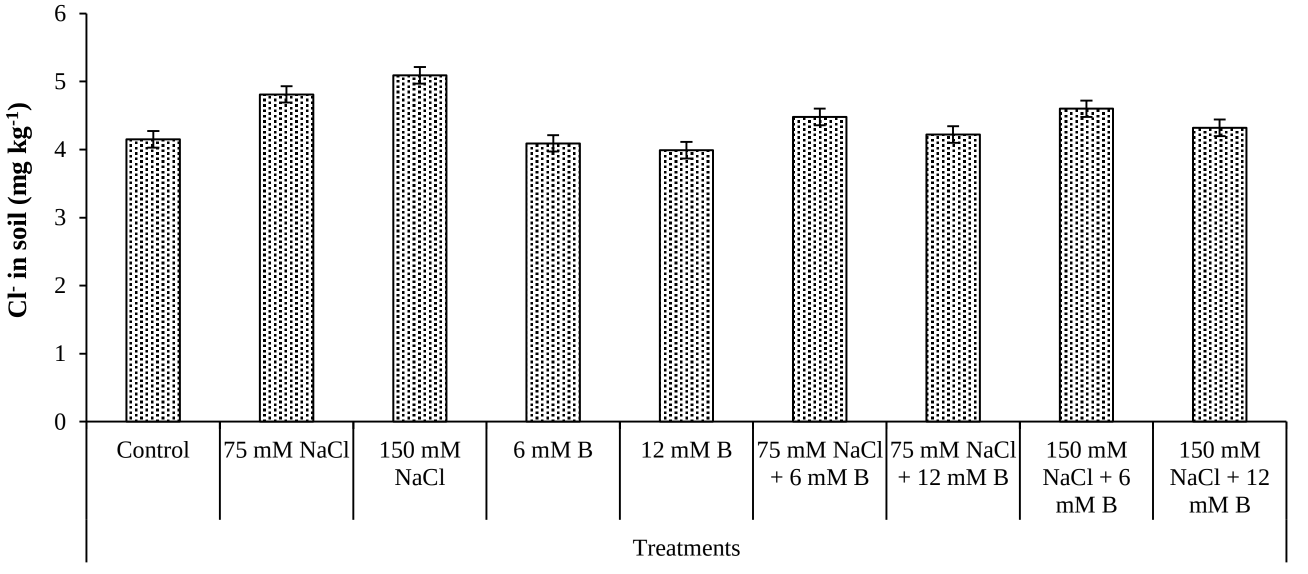

Fig. 10. Effect of different salinity treatments and boron applications on Cl^- in soil (mg kg^{-1}) in cotton.

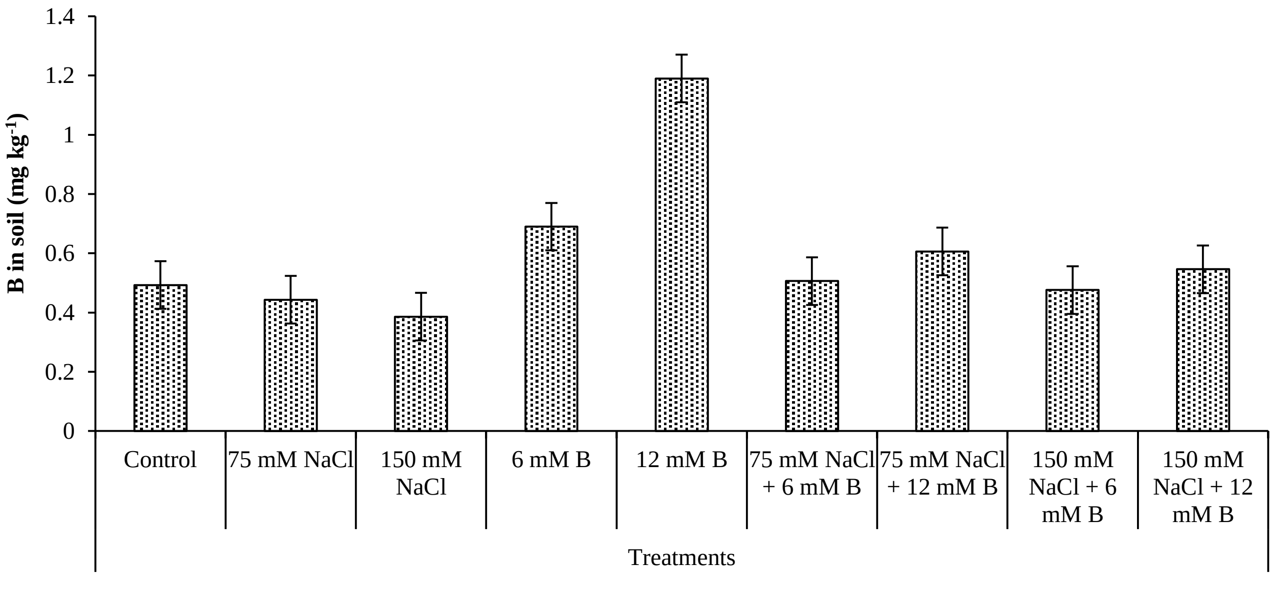

Fig. 11. Effect of different salinity treatments and boron applications on B in soil (mg kg^{-1}) in cotton.

In salty soil environment, more salt in the soil surroundings lesser the potential of soil resolution so that fiber can't take up sufficient water. It was observed that addition of boron under salinity stress improved water uptake by enhancing root length (Khan *et al*., 2004). Root length showed significant differences with various salinity and boron applications. Wang *et al.*, (2006) reported that boron improved buds and roots. The mean comparison for shoot length showed significant differences under different salinity and boron applications. The mean comparison for Na^+ in soil showed significant differences under different salinity and boron applications (Greenway & Munns, 1980). Soil salinity stress lessens plant development and cotton yield mostly through three pathways-osmotically incited water push, particular particle lethality because of high centralization of sodium and chloride and supplement particle lopsidedness because of abnormal state of Na^+ and Cl^- that diminishes take-up of K^+, NO_3^-, PO_4^{3-}, and so forth. (Satya *et al.*, 2009). The mean comparison for Cl^- in soil showed significant differences under different salinity and boron applications. Boron connected to new leaves extended fixation, having little impacts regardless of B deficiency restraining meristematic development. There might be a helpful reaction to boron use to develop leaves (Rosolem & Costa, 2000). Moreover, poor seepage of saline soils might be in charge of unreasonable amassing of boron in the dirt arrangement (Grieve & Poss, 2000). The mean correlation for B in soil demonstrated critical contrasts under various saltiness and boron applications.

Wang *et al*., (2006) predicted that boron deficiency suppresses the tip development of plants. Mao *et al.*, (2014) reported that more boron application increased chlorophyll and carotenoid content in the soil. Similarly, Das *et al.*, (2019) studied the boron availability under varying inorganic and integrated nutrient management practices. They observed a 15% increase in boron availability by applying NPK+ FYM and 20% increase in boron in plant tissues. Likewise, Aydin *et al.*, (2019) studied the adaptation strategy of tomatoes under excessive boron and scarcity of water. They observed that activation of stress related genes under such condition helped to protect plants under excessive boron. The use of genetically modified crops like Bt. cotton has gained much attention due to their many benefits and resistant against diseases and stresses. Yang *et al*., (2019) explored outcome of addition of manures. Adding of nutrients is practiced all over the world to sustain the productivity of crops. Addition of manures along with mineral fertilizers increased the soil organic carbon along with nutrients in soil. Saleem *et al*., (2020) demonstrated that the thermo sensitivity of cotton as high temperature during reproductive stage was one of the main factors affecting cotton yield. They found that foliar application of selenium mitigated drastic effects of heat on cotton yield. In the same way, Zhu *et al.*, (2019) observed that excessive boron could cause toxicity in many plant species. They also observed that enhancing boron level lowered the accumulation of phosphorus and manganese in plants. Wang *et al.*, (2020) suggested that understanding the distribution of salinity was important for better soil management. It is also necessary to understand the salinity distribution as well as its composition for better management of soil.

Ansari *et al.*, (2019) found that injurious impacts of salinity could be alleviated by the use of microbial inoculants. The elevated levels of NaCl restricted many growth parameters of wheat. However, those plants that were inoculated with bacterial strain showed improvement in growth parameters and tolerated salinity. Likewise, Zhao *et al.*, (2019) found that jasmonic acid application enables plants to tolerate elevated level of boron at different germination periods. Tsiantas *et al.*, (2019) found excessive boron caused a significant decrease in loquat development and stem diameter along with alteration in nutrient pattern in various plant organs. Boron is a micronutrient required by crop plants. However, excess of boron restricts plant development. Yousefi *et al.*, (2020) studied role of boron in alleviating salt stress in roses. They found that the application of boron mitigated the stress of salts by improving leaf area, relative water and soluble carbohydrate content which are necessary for tolerating salinity. Boron application also enhanced the membrane permeability. Shaaban *et al*., (2004) recognized that B foliar use with 25 ppm B or 25 ppm B + 50 ppm Zinc within splash arrangement has essentially expanded equally new and dry mass of fiber plant developed beneath elevated $CaCO_3$ stage in the dirt. Similarly, Reid *et al.*, (2004) demonstrated that zinc and boron treatment essentially expanded plant organic yield and concentration of boron and zinc in callus tissues. Atmosphere, especially elevated light intensity, lower temperature reason should be measured in connection to boron deficiency (Shorrocks, 1997). Fontes *et al*., (1976) found that lettuce plant (*Lactuca sativa* L.) developed in a boron deficient environment created tip burn. Leaves showed no general prolonged auxin action contrasted, those manage plant awaiting, when boron insufficient plants demonstrated a relative increment in the action of one auxin. An extensive variety within connection to boron utilize proficiency have established in various fiber varieties (Bogiani *et al*., 2012).

Conclusion

Boron is a critical element required for optimal development of cotton. It was also observed that boron helped to cope the cotton under drought stress. So, keeping in view, this study was designed to evaluate the performance of cotton under salinity stress by the application of boron. Results showed that all the treatments differed significantly among all the studied traits. It was noted from the results that various plant parameters like number of flowers/plant, number of leaves/plant, plant height, lint weight, fresh and dry root weight, root and shoot length were decreased under salt stress and application of boron proved fruitful to overcome this stress. Similarly, concentration of Na and Cl ions also enhanced under salt stress treatments that was again addressed in a positive way by the addition of boron. Hence, it can be safely concluded that application of boron in salt stress environment proved beneficial to promote growth and composition of cotton plants.

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(Received for publication 20 January 2021)