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Influence of Brassinosteroid (Brs) In Roots and Foliar Spray Against Salinity on Physiological Parameters and Micro Nutrients Upon Tomato (Lycopersicon Esculentum Mill)

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Abstract : *The different physiological parameters viz. chlorophyll, carotenoids, carbohydratrates, proteins and micro nutrients concentrations of Lycopersicon esculentum were observed under different salt concentrations from control (non-saline), 60mM NaCl and 100mM NaCl solutions. The rates of different physiological parameters and micro nutrients' concentrations exhibited decreases in saline media in comparison with their respective controls while brassinosteroids were used exogenously as a foliar spray and in roots at the concentration of 0.25 ppm and 0.50 ppm, and showed a promotion in the non-saline control when compared to salt concentrations' media. In physiological parameters analysis i.e. Chlorophyll a, Chlorophyll b, Chlorophyll a/b ratio, total chlorophyll, carotenoids, total carbohydrates and total proteins were studied and treated against different NaCl concentrations i.e. 60 and 100mM. Salt concentrations showed an increase in NaCl media compared to their controls, while plants treated with brassinosteroids at 0.25 ppm and 0.50 ppm, which were applied as a foliar spray and in roots, showed an increase in all physiological parameters analysis in control and at 60mM NaCl concentration. Amongst the micro nutrients, the ionic composition i.e. Na, K and Na/K ratio showed that plants treated with different NaCl concentrations at 60mM NaCl and 100mM salt concentrations showed an increase in Na and K ions, and brassinosteroids applied exogenously as a foliar spray and in roots showed a decrease in Na and K ions.*

Keywords: *Brassinosteroid, Lycopersicon Esculentum, Salt Concentration*

INTRODUCTION

Salinity means the presence of different kinds of salts in soil which slows down the growth and development of crops (Khan et al., 2001). A total of 397 million hectares' area in the world are saline in which 229 million hectares are irrigated lands, while 168 million hectares are dry lands, and 77 million hectares of soil are saline affected by humans in both irrigated and dry lands (FAO, 2003). Total geographical area of Pakistan is 80.0 million hectares having the best irrigation system of about 62,400 km in which 6.29 million hectares of land are salinity affected (Cao, et al., 2010).

Tomato (Lycopersicon esculentum) is an important crop used worldwide belonging to the family of Solanaceae. Its total yield worldwide in 2001 was 105 million tons from 3.90 million hectares. It is grown on area of about 4528519 hectares having yield of 124748282 million tons at the world level. In Pakistan, it is grown over an area of 46.2 thousand hectares having a total yield of 468.1 thousand tones which is quite less in comparison with other countries i.e. Indonesia, Japan, and Srilanka. Tomato having a large amount of vitamin A and C, is used in making food dishes. It is a mostly cultivated crop in the world, and is a cash crop for farmers (Borguini and Torres, 2009). In order to meet the challenges of providing food to the ever increasing population of Pakistan, there is an urgent need to boost crop yield especially on the saline land.

Brassinosteroids are the endogenous plants' hormones which show their activities against biotic and biotic stress in plants. They usually cause the removal of pathogens and cell elongation, tolerate the high and low temperatures, elongation of root, shoot length, and enhance the soluble proteins, prolines, chlorophyll, carotenoids, xanthophylls, minerals and peroxidases contents of the cell (Aslam ,2006). They also enhance source- sink relation, proton pump and membrane polarity, and stress responses i.e. salt, water and temperature tolerating capacities and promotion of vascular tissues (Xio jian et al., 2009). They are important for the proper maintaining of biochemical, morphological and physiological processes necessary for plant growth (Adams, 1999 & Irfan et al, 2017). Its foliar application causes expansion, elongation of cells, normal cell division and cell wall thickening. They are also important for the pollen elongation, pollen tube formation (Knight et al., 1992).

Objectives of the study:

To observe the effects of different applications (roots and foliar) on growth and chemical contents of Lycopersicon esculentum (Mill).

To improve Tomato plants' conditions under the salt stress by using brassinosteroids

Material and Methods

The research work was performed in the green house of Abdulwali khan university, Mardan, Khyber Pakhyunkhwa, Pakistan. The seeds of Lycopersicon esculentum (Mill) were obtained from Bafa research centre located at district Mansehra (KPK), Pakistan. The seeds were sterilized then cultivated after germination, then the 20 day old seedlings were transplanted to earthen pots of uniform size having 4 kilograms of soil and containing a basal hole for the leaching purpose; three seedlings per pot, totally 60 pots, were grown. After 10 days of transplantation, the pots were irrigated with Hoagland (Nutritive) solution. The responses were studied on different salinity levels in triplicates. The experiment was terminated after four months i.e. plants were harvested, different physiological parameters and micronutrients were studied and the treatments at which tomato seeds showed better results were selected for further studies. In this experiment, the plants were divided into five trials having twelve pots per trial.

Trial: I; Without brassinosteroid (Control)

Trial: II; 0.25 ppm brassinosteroid applied in roots

Trial: III; 0.50 ppm brassinosteroid applied in roots

Trial: IV; 0.25 ppm brassinosteroid applied as a foliar spray

Trial: V; 0.50 ppm brassinsteroid applied as a foliar spray

Each trial has four pots per treatment. Each pot was irrigated with 1liter of tap water per salt solution twice a week.

Chlorophyll estimation:

Chlorophyll was estimated in the leaf samples which was collected from control, 60mM salt concentration and 100mM salt concentration and brassinosteroid treated plants by the method of Maclachlan, and Zalik (1963).

Carbohydrate estimation:

The estimation of carbohydrates in the leaf samples was collected from control, 60mM salt concentration and 100Mm salt concentration and brassinosteroid treated plants as by Yemm and Willis(1954).

Proteins estimation:

The estimation of protein in the leaf samples was collected from control, 60mM salt concentration and 100mM salt concentration and brassimsteroids treated plants by the method of Bradford (1976).

Micro nutrients estimation:

Samples of root, stem and leaf were analyzed for different micro nutrients I.e. Na^+, K^+. Samples were dried in the incubator and 1.0 g of each sample was analyzed for ash weight. Then ash solution was prepared in 50ml of de-ionized water by the method of Wolf (1982). Concentration of micro nutrients in the samples was analyzed using PFP 1 Flame Photometer.

Experimental design and statistical analysis:

The experimental design was a completely randomized Design (CRD) with three salt levels and three replicates. Analysis of all the data trials was conducted by using Costat 6.33 (Cohort Software, California, USA). The mean values and percent promotion (+) and reduction (-) were found out based on the new Duncan's Multiple Range test ($P < 0.05$).

Results and Discussion

Chlorophyll:

Tomato grown in Trial-I, II, and -V resulted in a non-significant decrease in chlorophyll a, b, total chlorophyll and chlorophyll a/b ratio in both salinity levels as compared to their control. While trial III resulted in a significant decrease ($P<0.05$) in chlorophyll a, b and non-significant decrease in total chlorophyll and chlorophyll a/b ratio as compared to their control trial. Trial-IV showed a non-significant decrease in chlorophyll a, b, total chlorophyll and chlorophyll a/b ratio in 60Mm salt concentration and 100Mm salt concentration over their respective control trial (Table 01). This shows similar results with earlier research works of (Günes et al.,1996; Kaya et al.,2007; Lycoskoufis et al., 2005).

Comparison of trial II and I showed that plants of trial-II resulted in lower chlorophyll, chlorophyll a/b ratio in total, and an increase in chlorophyll a, chlorophyll b in control, while a decrease in chlorophyll and an increase in chlorophyll b, total chlorophyll and chlorophyll a/b ratio in 60mM salt concentration and a decrease in chlorophyll a, chlorophyll a/b ratio and an increase in chlorophyll b, total chlorophyll in 100mM salt concentration. Comparison of trial III and I resulted that plants of trial-III showed a decrease in chlorophyll a, chlorophyll a/b ratio, an increase in chlorophyll b, total chlorophyll in control and 100mM salt concentration while an increase in chlorophyll b, total chlorophyll and an increase in chlorophyll a, total chlorophyll in 60mM salt concentration. The same work was agreed with the earlier works of (Ormaetxe et al.,1998; Anuradha and Rao, 2003; Nunez et al., 2003, and Arora et al.,2008).

Comparison of the trials IV and I resulted that plants of trial-IV lowered in chlorophyll a, chlorophyll b, total chlorophyll and increased chlorophyll a/b ratio in control while showed an increase in chlorophyll a, chlorophyll b, total chlorophyll and chlorophyll a/b ratio in 60mM and 100mM salt concentrations except chlorophyll a which was lowered. Comparison of trial V and I resulted that plants of Trial-V showed an increase in chlorophyll a and a decrease in chlorophyll b, total chlorophyll and chlorophyll a/b ratio in control and 100mM salt concentration while lowered chlorophyll a, and increased chlorophyll b, total chlorophyll and chlorophyll a/b in 60mM salt concentration.

Carotenoids:

Plants grown in trial I-V resulted in a non-significant decrease in carotenoids under different salt stress concentrations except trial-III that resulted in significant ($P<0.05$) decrease in both 60mM and 100mM salt concentrations (Table 01).

Comparing the trial II with III, it was indicated that the plants of trial II lowered the control and salt concentrations. Comparison of trial IV and V showed that plants of trial IV lowered the control, and increased the salt concentrations. Comparison of trial-II and V with trial -I resulted that plants of both trials made a decrease, while trial-III when compared with Trial-I trial III showed an increase in control and salt concentrations; while trial-IV when compared with trial I then trial IV showed a decrease in control and an increase in salt concentrations. The same research work agrees with the earlier work of (Agastian et al., 2000 and Meloni et al.,2004).

Carbohydrate estimation:

Plants grown in different trials (I-V) resulted in a non-significant increase in control as compared to 60mM NaCl and 100mM NaCl concentration (Table 01). Comparison of plants of trial-II and III showed that trial-II showed an increase in control and a decrease in salt concentrations. Comparison of trial-IV and V showed that trial -IV showed an increase in control and salt concentrations. Comparison of trial-II with I resulted that plants of trial -II showed an increase in control and a decrease in salt concentrations while comparison of trial III-V with -I resulted that all the three trials showed a decrease in control and an increase in salt concentrations. The same work agrees with the earlier work of (Ashraf and Tufail,1995; Parida et al., 2002).

Total Proteins:

Plants grown in trials (I-V) resulted in a significant ($P<0.05$) decrease except in trial III that showed a significant ($P<0.05$) increase in control as compared to 60mM NaCl and 100mM NaCl concentration. While trial II and IV showed a significant ($P<0.05$) decrease in proteins in both NaCl levels as compared to control, while trial V showed a non-significant increase in control as compared to salt concentrations (Table 01).

Comparison of plants of trial II with III resulted that plants of trial II showed an increase in control and a decrease in salt concentrations. Comparison of plants of trial IV and V resulted that plants of trial IV showed a decrease in control and 60mM NaCl concentration while a decrease in 100mM NaCl concentration. Comparison of plants of trial II with I resulted that plants of trial II showed an increase in control and 100mM NaCl concentration while 60mM NaCl concentration showed an increase. Comparison of trial III and IV with trial I resulted that both sets showed a decrease in control and an increase in salt concentrations. Comparison of plants of trial V and I resulted that trial V showed an increase in control and salt concentrations. The same work agrees with the earlier work of (Hasegawa et al.,2000; Pareek-Singla and Grover,1997).

Table 1. The effect of brassinosteroid and different salt concentrations on chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, total sugars and proteins of Lycopersicon esculentum

Trial I= Without BRs

Treatment	Chlorophyll-a	Chlorophyll-b	Total Chlorophyll	Chlorophyll a/b Ratio	Carotenoids	Total Sugar	Total Protein
	(mg/g)	(mg/g)	(mg/g)		(mg/g)	(mg/g)	(mg/g)
Control, Mean, SE	0.0528a ±0.00447	0.0239a ±0.0034	0.0767a ±0.0079	2.254a ±0.1506	0.179a ±0.0116	2.112a ±0.0808	1.69a ±0.0769
mM NaCl, Mean, SE	0.0380a ±0.0055	0.0109a ±0.0086	0.0490a ±0.00602	1.3308a ±0.1288	0.1133a ±0.0027	0.2344a ±0.0135	0.268ab ±0.0072
% (+/-)	(-28.081)	(-54.078)	(-36.179)	(-40.960)	(-36.755)	(-88.90)	(-84.151)
100mM NaCl, Mean, SE	0.0321a ±0.0019	0.0182a ±0.0004	0.0339a ±0.0168	1.756a ±0.059	0.091a ±0.0072	0.202a ±0.006	0.126ab ±0.0103
% (+/-)	(-39.196)	(-23.625)	(-55.826)	(-22.06)	(-49.039)	(-90.40)	(-92.523)
LSD0.05	0.0483	0.01637	0.0411	1.892	0.0661	0.532	0.493

Table 01……(Contd)
Trial-II= 0.25 ppm BRs applied through roots

Treatment	Chlorophyll-a	Chlorophyll-b	Total Chlorophyll	Chlorophyll a/b Ratio	Carotenoids	Total Sugar	Total Protein
	(mg/g)	(mg/g)	(mg/g)		(mg/g)	(mg/g)	(mg/g)
Control, Mean, SE	0.053a ±0.0087	0.030a ±0.005	0.0740a ±0.0148	1.7907a ±0.0813	0.167a ±0.0075	2.424a ±0.0587	2.134a ±0.0370
60mM NaCl, Mean, SE	0.0317b ±0.0017	0.0185a ±0.0009	0.0502a ±0.0026	1.709a ±0.0195	0.0707a ±0.0254	0.0453b ±0.0033	0.0230b ±0.0024
% (+/-)	(-40.931)	(-38.243)	(-32.131)	(-4.558)	(-57.691)	(-98.13)	(-98.919)
100mM NaCl, Mean, SE	0.0235b ±0.0040	0.0265a ±0.0112	0.0501a ±0.0147	1.382a ±0.6377	0.0802a ±0.0051	0.0191b ±0.001	0.0244b ±0.0017
% (+/-)	(-56.092)	(-9.142)	(-31.321)	(-22.80)	(-52.049)	(-99.21)	(-98.853)
LSD0.05	0.0197	0.021	0.0407	0.892	0.1499	0.542	0.476

Table 01…… (Contd)
Trial III= 0.5 ppmBRs applied through roots

Treatment	Chlorophyll-a	Chlorophyll-b	Total Chlorophyll	Chlorophyll a/b Ratio	Carotenoids	Total Sugar	Total Protein
	(mg/g)	(mg/g)	(mg/g)		(mg/g)	(mg/g)	(mg/g)
Control, Mean, SE	0.0527a ±0.0077	0.0369a ±0.0065	0.089a ±0.0043	1.870a ±0.4651	0.198a ±0.0091	1.906a ±0.0841	0.985a ±0.0462
60mM NaCl, Mean, SE	0.0406b ±0.0013	0.0089ab ±0.0053	0.049a ±0.0040	1.849a ±0.0544	0.118ab ±0.0092	1.656a ±0.0352	0.674a ±0.0456
% (+/-)	(-22.909)	(-75.821)	(-44.708)	(-1.083)	(-40.059)	(-13.11)	(-45.223)
100mM NaCl, Mean, SE	0.0291b ±0.0080	0.023a ±0.01404	0.0529a ±0.01521	1.730a ±0.6752	0.105b ±0.0091	1.460a ±0.0341	1.288ab ±0.0815
% (+/-)	(-44.653)	(-35.750)	(-40.985)	(-7.479)	(-46.940)	(-23.39)	(+4.703)
$LSD_{0.05}$	0.029	0.0224	0.0374	0.8924	0.12	0.64	0.53

Table 01…….. (Contd)
Trial-IV= 0.25 ppm BRs applied as a foliar spray

Treatment	Chlorophyll-a	Chlorophyll-b	Total Chlorophyll	a/b Ratio	Carotenoids	Total Sugar	Total Protein
	(mg/g)	(mg/g)	(mg/g)		(mg/g)	(mg/g)	(mg/g)
Control, Mean, SE	0.05057a ±0.0114	0.01074a ±0.0040	0.0613a ±0.0079	7.226a ±3.412	0.159a ±0.0261	1.785a ±0.0929	1.655a ±0.0616
60mM NaCl, Mean, SE	0.0461a ±0.0102	0.0188a ±0.0086	0.065a ±0.0127	4.282a ±2.044	0.146a ±0.0253	1.016a ±0.0067	0.862b ±0.032
% (+/-)	(-8.785)	(+75.879)	(+6.051)	(-40.73)	(-8.460)	(-43.06)	(-47.925)
100mM NaCl, Mean, SE	0.0269ab ±0.0090	0.0206a ±0.0073	0.0475a ±0.0029	2.010a ±1.0093	0.131a ±0.0223	0.964a ±0.0355	0.729b ±0.0241

% (+/-)	(-46.665)	(+91.902)	(-22.383)	(-72.183)	(-17.796)	(-45.977)	(-55.940)
$LSD_{0.05}$	0.0358	0.0295	0.0308	4.564	0.149	0.71	0.61

Table 01…….. (Contd)

Trial V = 0.5 ppm BRs applied as a foliar spray

Treatment	Chlorophyll-a	Chlorophyll-b	Total Chlorophyll	a/b Ratio	Carotenoids	Total Sugar	Total Protein
	(mg/g)	(mg/g)	(mg/g)		(mg/g)	(mg/g)	(mg/g)
Control, Mean, SE	0.0583a ±0.0031	0.033a ±0.0073	0.091a ±0.0103	1.912a ±0.354	0.162a ±0.0191	2.056a ±0.0604	1.876a ±0.0390
60mM NaCl, Mean, SE	0.0313a ±0.0085	0.0202a ±0.0069	0.0515a ±0.0140	1.775a ±0.6440	0.0934a ±0.0467	1.809a ±0.0456	1.695a ±0.0362
% (+/-)	(-46.378)	(-39.006)	(-43.704)	(-7.163)	(-42.512)	(-12.04)	(-9.662)
100mM NaCl , Mean, SE	0.0330a ±0.009	0.0211a ±0.0055	0.0542a ±0.0127	1.619a ±0.49	0.080a ±0.0065	1.475a ±0.0292	1.472a ±0.0269
% (+/-)	(-43.318)	(-36.202)	(-40.737)	(-15.339)	(-50.552)	(-28.28)	(-21.56)
$LSD_{0.05}$	0.026	0.0232	0.044	1.778	0.102	0.62	0.59

Means followed by different letters in the same column differ significantly at 95% probability level according to new Duncan's Multiple Range Test. Figures in parentheses indicate % promotion (+) and reduction (-) of 60 mM NaCl and 100mM NaCl as compared to control.

Sodium (Na^+):

Plants grown in different trials I-V resulted in a non-significant increase in stem, roots and leaves at 100mM salt concentration as compared to non saline control except trial III in stem and trial II in leaves showed a non-significant decrease in 100mM salt concentration as compared to 60mM salt concentration (Table 02).

Comparing trial II with III showed that the plants of trial II resulted in a decrease in Na+ concentration at non-saline control and 60mM salt concentration in stem, while indicated an increase in 100mM salt concentration in stem along with all concentrations in roots and leaves. Comparison between trial IV and V resulted that plants of trial IV showed a decrease in non-saline control and an increase in 60 and 100mM salt concentration, while a decrease in control and 60mM salt concentration and an increase in 100mM salt concentration in Na^+ of roots and leaves.

Comparison of trial II, and V with trial -I resulted that plants of trial I showed an increase in stem while comparison of trial -III in stem and trial II and V in roots compared with trial I resulted that trial I showed a decrease in control and 60mM salt concentration while an increase in 100mM salt concentration. Comparison of trial -IV with I in stem resulted that plants of trial -I exhibited an increase in control set and a decrease in 60 and 100mM salt concentration which is in agreement with the earlier work of (Amtmann and Sanders,1999; and Amzallag, 2002).

Potassium (K^+):

Plants grown in trial I, II and III in stem and trial II in leaves resulted a non-significant increase in K^+ in 60mM salt concentration over the control and 100mM salt concentration. Plants grown in trial I, II, III and IV in roots and trial I in leaves resulted in a non-significant increase in K^+ in 100mM salt concentration in the control and 60mM salt concentration. Plants grown in trial IV, V in stem and trial III, IV and V in leaves resulted in a non-significant increase in K^+ in control over 60 and 100mM salt concentrations (Table 02).

Comparing of trial II with III, plants of trial II showed a decrease in all concentrations of stem while they showed an increase in all the concentrations of K^+ of roots and leaves. Comparison of plants of trial II, III, IV

and V with I resulted that trial I exhibited an increase in all the concentrations of stem and leaves while showed a decrease in all the concentrations of roots except 100mM salt concentration of trial V which showed an increase as previously observed by (Anuradha and Rao, 2001; Borguini and Torres,2009).

Na^+/K^+:

Plants grown in trial -I and V in stem, trial I, III, IV and V in roots and trial II, III and IV in leaves resulted in a non-significant decrease in salt concentrations as compared to their respective controls. While plants grown in trial -II, III, and IV in stem and trial I and V in leaves resulted in a non-significant increase in 60mM salt concentration as compared to their controls. Plants grown in trial -II in roots resulted in a non-significant increase in 100mM salt concentration as compared to the control and 60mM salt concentration (Table 02).

Comparing the plants of trial II with III, the plants of trial II exhibited an increase in control and 60mM salt concentration in stem and leaves, while showed an increase in 100mM salt concentration in stem and leaves. Comparing the trial IV and V indicated that plants of trial IV exhibited an increase in all the concentrations of root and leaves along with the control in stem, while a decrease in 60 and 100mM salt concentrations in stem. Comparison of trial II, III, IV and V with trial -I resulted that trial -I exhibited an increase in all the concentrations of stem, roots and leaves except 100mM salt concentration in trial III; control in trial IV in stem and control in trial II and 60mM salt concentration in trial II and V showed a decrease in roots which were also previously studied by (Gassmann et al.,1996 and Amtmann & Sanders,1999).

Table 2. Micro nutrients composition of Lycopersicon esculentum grown at different concentrations of Brassinosteroid (BRs) against salt concentrations

Trial I= Without BRs

Treatment		STEM			ROOT		LEAVES		
	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+
Control, Mean, SE	246.56a ±39.27	200.85a ±6.6	0.861a ±0.1468	294.78a ±43.61	143.26a ±30.07	0.48a ±0.04	153.26a ±23.3	307.32a ±36	2.088a ±0.387
60mM NaCl, Mean, SE	243.26a ±61.7	182.78a ±84.9	0.804a ±0.3	259.82a ±9.9	84.5a ±17.5	0.33a ±0.072	146.59a ±20.2	345.54a ±18.5	2.47a ±0.443
% (+/-)	(-1.337)	(-8.99)	(-6.62)	(-11.85)	(-41.01)	(-31.56)	(-4.35)	(+12.43)	(+18.31)
100mM NaCl , Mean, SE	371.91a ±36.6	111.28a ±11.6	0.31a ±0.057	710.47a ±74.09	163.93a ±48.1	0.242a ±0.086	329.74a ±43.2	378.82a ±88.9	1.167a ±0.264
% (+/-)	(+50.83)	(-44.5)	(-63.9)	(+141.01)	(+14.42)	(-49.6)	(+115.15)	(+23.26)	(-44.1)
$LSD_{0.05}$	163.5	171.7	0.984	198.82	233.8	0.34	212.76	38.034	0.7

Table 02…… (Contd)

Trial-II= 0.25 ppm BRs applied through roots

Treatment		STEM			ROOT		LEAVES		
	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+
Control, Mean, SE	223.18a ±14.5	116.22a ±30.7	0.54a ±0.174	499.87a ±70.04	171.73a ±13.06	0.365a ±0.075	199.87a ±23.1	134.55a ±10.30	0.697a ±0.118
60mM NaCl, Mean, SE	233.22a ±38.4	124.54a ±39.6	0.61a ±0.23	639.78a ±104.09	151.84a ±10.9	0.245a ±0.0237	303.22a ±44.8	116.22a ±1.56	0.398ab ±0.049
% (+/-)	(+4.5)	(+7.15)	(+12.4)	(+27.99)	(-11.58)	(-32.79)	(+51.7)	(-13.6)	(-42.8)
100mM NaCl , Mean, SE	293.25a ±26.6	66.17a ±8.32	0.225a ±0.0087	667.31a ±138.6	251.81a ±53.7	0.385a ±0.075	209.9a ±9.9	124.54a ±10.4	0.59b ±0.024
% (+/-)	(+31.39)	(-43.06)	(-58.69)	(+33.49)	(+46.63)	(+5.68)	(+5.02)	(-7.4)	(-15.12)

$LSD_{0.05}$	97.81	101.64	0.6	373.6	112.63	0.22	102.7	29.5	0.262

Table 02…….(Contd)

Trial III= 0.5 ppm BRs applied through roots

Treatment		STEM			ROOT		LEAVES		
	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+
Control, Mean, SE	253.23a ±18.5	126.1a ±24.15	0.513a ±0.125	226.55a ±11.96	217.62a ±21.8	0.9622a ±0.093	203.25a ±3.37	134.55a ±10.33	0.6612a ±0.0439
60mM NaCl, Mean, SE	266.5a ±16.7	141.18a ±18.33	0.542 ±0.0967	428.57a ±73.1	223.47a ±40.2	0.524b ±0.0349	309.81b ±20.01	118.69a ±20.42	0.3904b ±0.082
% (+/-)	(+5.23)	(+11.95)	(+5.78)	(+89.17)	(+2.68)	(-45.525)	(+52.43)	(-11.78)	(-40.9)
100mM NaCl , Mean, SE	219.88a ±35.08	86.19a ±9.2	0.417a ±0.0855	509.91b ±0.01	259.74a ±49.2	0.51b ±0.096	483.23c ±23.2	114.53a ±12.63	0.236b ±0.016
% (+/-)	(-13.1)	(-31.64)	(-18.6)	(+125.07)	(+19.35)	(-47.05)	(+137.75)	(-14.8)	(-60.48)
$LSD_{0.05}$	85.99	63.4	0.4	148.021	134.41	0.28	61.7	81.8	0.19

Table……. 02 (Contd)

Trial-IV= 0.25 ppm BRs applied as a foliar spray

Treatment		STEM			ROOT		LEAVES		
	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+
Control, Mean , SE	117.92a ±14.02	169.39a ±20.02	1.48a ±0.234	236.6a ±87.4	97.89a ±4.3	0.525a ±0.162	186.5a ±27.36	204.4a ±25.1	1.107a ±0.064
60mM NaCl, Mean, SE	269.18ab ±39.3	59.67ab ±2.25	0.231b ±0.031	384.79a ±58.2	118.69b ±10.13	0.33a ±0.0667	239.9a ±61.1	147.81a ±16.8	0.774a ±0.32
% (+/-)	(+128.28)	(-64.7)	(-84.3)	(+62.63)	(+21.24)	(-37.8)	(+28.65)	(-27.6)	(-30.1)
100mM NaCl, Mean, SE	415.84b ±112.1	67.6b ±8.2	0.1911b ±0.056	679.73a ±69.58	223.21b ±27.86	0.332a ±0.038	326.6a ±48.09	137.8a ±18.7	0.433a ±0.068
% (+/-)	(+252.66)	(-60.1)	(-87.07)	(+187.29)	(+128.02)	(-36.7)	(+75.16)	(-32.5)	(-60.8)
$LSD_{0.05}$	238.98	43.5	0.5	209.57	59.9	0.36	164.74	71.04	0.67

Table 02…….. (Contd)

Trial V = 0.5 ppm BRs applied as a foliar spray

Treatment		STEM			ROOT		LEAVES		
	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+	Na^+	K^+	K^+/Na^+
Control, Mean, SE	189.9a ±35.11	119.47a ±10.01	0.69a ±0.15	443.21a ±69.33	250.77a ±115.4	0.52a ±0.168	199.87a ±37.83	131.17a ±13.61	0.684a ±0.0838
60mM NaCl, Mean, SE	176.5a ±36.6	83.07a ±6.63	0.5ab ±0.081	536.6b ±29.073	122.85a ±12.06	0.23a ±0.018	266.57a ±99.03	127.8a ±10.8	0.701a ±0.334
% (+/-)	(-7.064)	(-30.4)	(-27.1)	(+21.06)	(-51.01)	(-55.9)	(-33.37)	(-2.57)	(-2.47)
100mM NaCl, Mean, SE	238.28a ±31.9	65.52a ±13.7	0.271b ±0.036	643.85b ±65.2	159.38a ±15.2	0.25a ±0.0073	309.9b ±10.04	124.54a ±7.66	0.4044a ±0.0389
% (+/-)	(+25.47)	(-45.157)	(-60.544)	(+45.26)	(-36.4)	(-52.2)	55.044	(-5.05)	(-40.8)
$LSD_{0.05}$	125.622	39.049	0.135	198.829	233.029	0.343	145.068	117.264	0.882

Means followed by different letters in the same column differ significantly at 95% probability level according to new Duncan's Multiple Range Test. Figures in parentheses indicate % promotion (+) and reduction (-) of 60 mM NaCl and 100 mM NaCl concentrations as compared to control.

Conclusion

The tomato plants grown under different salt stress i.e. 60mM and 100mM salt concentrations resulted in a decrease in different biochemical constituents and micro nutrients, while brassinosteroid (BRs) when applied exogenously through roots and foliarly at the concentration of 0.25 and 0.50 ppm caused the enhancement i.e. having more bio chemicals and micro nutrients as compared to their respective saline media. It is concluded that salt stress had adverse effects on different bio chemicals concentrations and micro nutrients, and they were significantly enhanced by the applications of brassinosteroid (BRs). BRs overcome the dangerous effects of salt concentrations i.e. they cause different metabolic changes in the plants which lead to the boosted up growth and development of plants. Brassinosteroids' (BRs) applications by either way i.e. foliarly or irrigation in roots mostly cause increases in the concentrations of almost all the studied biochemicals and micro nutrients parameters. However, the application of brassinosteroids (BRs) given through roots was more effective than application given through foliarly. Based on our results, further studies on the modulate action of BRs under saline soils in tomato cultivation will contribute to improving productivity on this crop.

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