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Effect of Salinity and Alleviating Role of PGRs and Nutrients for Improving the Morphological Traits of Tomato Cultivars under Salinity Condition

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ABSTRACT

Salinity has deleterious effects on many crops, especially in morphology of the plants. A research was conducted to study the effect of salinity on tomato genotypes (PKM 1 and TNAU THCO 3) and alleviation by using plant growth regulators (PGRs) and nutrients in the Department of Crop Physiology, TNAU, Coimbatore. Salinity was imposed by using NaCl at 100 mM concentration. The responses of two tomato genotypes under salinity were studied. Among two genotypes, PKM 1 was affected more by salinity than TNAU THCO 3. Foliar application of plant growth regulators like brassinolide (0.5 ppm), salicylic acid (100 ppm), benzyl amino purine (50 ppm), ascorbic acid (100 ppm), glutathione (50 ppm), KNO_3 (0.5%) + $FeSO_4$ (0.3%) + Borax (0.2%) and nutrient PGR concoction (K_2SO_4 (0.5%) + $CaSO_4$ (0.5%) + Borax (0.2%) + NAA (20 ppm) were carried out at 20 and 40 DAT. Significant variations and adaptability among stressed and non-stressed plants were observed in both the genotypes. The study revealed that, among the treatments, brassinolide showed the premier observations like plant height (73.40 cm), root length (18.60 cm), root volume (133.25 cc), leaf area (1275.54 cm^2) and total dry matter production (TDMP) (88.42 g $plant^{-1}$) followed by salicylic acid when compared to control. Among the two genotypes used in this study, TNAU THCO 3 responded better for the application plant growth regulators and nutrients than PKM 1 under salinity.

INTRODUCTION

Salinity stress is one of the most atrocious environmental factors restricting the productivity of crops in arid and semi-arid regions. Crops grown in the arid and semi-arid regions are often exposed to adverse environmental factors such as high soil salinity. One of the most sensitive phases of a plant's life to salinity is that of seed germination. Absence of germination in saline soil is often due to the high concentration of salt where the seeds are sown. The reason is that the salt solution moves upward following the evaporation at soil level (Homa Mahmood & Massoumeh Bemani 2007). The reduction in the plant growth in the saline environments may be due to either water relations or the toxic effects of Na^+ and Cl^- ions on the cell expansion and metabolism. Na^+ influx into the root cells elevates the cytoplasm Na^+ concentration and causes toxicity symptoms, which prevent the uptake of water which is necessary for plant growth and development. Salinity decreased the germination percent, root length, callus size, coleoptile length and seedling growth in rice (Bera et al. 2006) and causes the nutrient imbalance in soil and plant which creates deficit of essential nutrients in plants.

Applications of plant growth regulators (PGRs) and nutrients are used to stress alleviation through enhancing the plant growth and improve yield (Mostafa & Abou Al-Hamd 2011). Hence, the present investigation was carried out to mitigate the salinity stress effect by using foliar application of plant growth regulators and nutrients.

MATERIALS AND METHODS

Research was carried out with two tomato genotypes viz., PKM 1 and TNAU THCO 3 with the salinity concentration of 100 mM NaCl in pot culture at glass house, Department of Crop Physiology, TNAU, Coimbatore. Red sandy soil was used for pot culture experiment by using red soil, sand and vermicompost in the ratio of 3:1:1. Uniform size pots (23 cm × 25 cm) were filled with 10 kg of soil. Twenty five days aged seedlings were transplanted and one plant was maintained in each pot. Salinity was imposed from transplanting onwards till the end of the harvest. The crop was applied with the recommended dose of fertilizers [75:100:50 kg NPK/ha, borax (10 kg/ha) and $ZnSO_4$ (50 kg/ha)] at 30 days after transplanting. Other operations like plant protection measures were carried out as per the recommended practices of Tamil Nadu Agricultural University, Coimbatore.

The experiment was laid out in completely randomized block design with three replications. The salinity was imposed with 100 mM NaCl water for irrigation from transplanting onwards. Nine treatments viz., T_1 - Absolute control (without salinity), T_2 - Control (water spray), T_3 - Brassinolide (0.5 ppm), T_4 - Salicylic acid (100 ppm), T_5 - Benzyl amino purine (5 ppm), T_6 - Ascorbic acid (100 ppm), T_7 - Glutathione (50 ppm), T_8 - KNO_3 (0.5%) + $FeSO_4$ (0.3%) + Borax (0.2%), T_9 - Nutrient PGR Concoction K_2SO_4 (0.5%) + $CaSO_4$ (0.5%) + Borax (0.2%) + NAA (20 ppm) were given as foliar spray at 20 and 40 DAT.

Plant height was measured from the ground level to the tip of the growing point and expressed in cm. The plant was uprooted and the root was taken with minimum damage and the length from the cotyledonary node to the root tip was measured and expressed in cm. The root volume was estimated by water displacement method and expressed in cubic centimetre. Leaf area per plant was measured using a Leaf Area Meter (LICOR, Model LI 3000) and expressed as cm^2 $plant^{-1}$. The plants were uprooted, after washing the root portion, first shade dried and then oven dried at 80°C for 48 hrs. The total dry matter production (TDMP) of the whole plant was recorded and expressed as g $plant^{-1}$. The data collected were subjected to statistical analysis in completely randomized block design following the method of Gomez & Gomez (1984).

RESULTS AND DISCUSSION

Plant height is an important trait for growth and increased plant height would allow greater biomass production and yield potential in crops. Salt stress showed a greater effect on reduction in plant height might be due to turgor loss. In the present study, under saline condition, significant reduction of plant height in PKM 1 (25%) and TNAU THCO 3 (14%) was observed. Among the treatments, brassinolide showed its superiority in plant height (70.23 and 76.58 cm) followed by salicylic acid (68.72 and 74.85 cm) in PKM 1 and TNAU THCO 3 respectively (Table 1). Ashraf et al. (2010) reported that the foliar application of brassinolide appeared to have close relationship with IAA. Typically these two hormones acted synergistically. Although in many cases, brassinolide acts in a similar manner to auxins, gibberellins and cytokinins under salt stress. The enhancement of growth by the application of salicylic acid might be due to its role in cell division and cell elongation (Hayat et al. 2010). These findings were in conformity with the present study.

Root length defines the extent to which a plant explores soil for water and mineral nutrients. The decrease of root length and root surface area under salt stress might be due to the increment of osmotic pressure and ionic effect in soil, which leads to reduction of root growth. In the present study, under 100 mM salt stress condition, 20 per cent (PKM 1) and 24 per cent (TNAU THCO 3) of root length was reduced over absolute control. Root length was high in brassinolide (18.85 cm in PKM, 18.36 cm in TNAU THCO 3), subsequently followed by salicylic acid (16.87 and 17.92 cm) and the low value of root length was recorded in Glutathione (14.75 cm and 16.73 cm) irrespective of the tomato genotypes (Table 1). This shows that the root length is accelerated by the foliar spray of growth regulators and nutrients. According to the results obtained by Wang et al. (1993), foliar spray of brassinolide stimulates hypocotyl elongation by increasing wall relaxation without a concomitant change in wall mechanical properties.

Root volume was higher in brassinolide (134.45 cc and 132.05 cc) followed by ascorbic acid (129.19 cc and 137.47

Table 1: Effect of plant growth regulators and nutrients on plant height (cm) and root length (cm) of tomato genotypes under salinity.

Treatments	Plant height (cm)			Root length (cm)		
	PKM 1	TNAU THCO 3	Mean	PKM 1	TNAU THCO 3	Mean
Absolute control	76.32	81.98	79.15	19.00	22.56	20.78
Control (water spray)	47.55	61.12	54.33	14.69	16.66	15.67
Brassinolide (0.5 ppm)	70.23	76.58	73.40	18.85	18.36	18.60
Salicylic acid (100 ppm)	68.72	74.85	71.78	16.87	17.92	17.39
Benzyl amino purine (50 ppm)	61.34	68.82	65.08	15.80	17.50	16.65
Ascorbic acid (100 ppm)	66.83	71.30	69.07	17.10	18.45	17.77
Glutathione (50 ppm)	56.85	65.00	60.92	14.75	16.73	15.74
KNO_3 (0.5%) + $FeSO_4$ (0.3%) + borax (0.2%)	65.21	70.53	67.87	15.69	16.91	16.30
Nutrient PGR concoction [K_2SO_4 (0.5 %) + $CaSO_4$ (0.5 %) + borax (0.2 %) + NAA (20 ppm)]	66.12	70.39	68.26	16.49	17.78	17.13
Mean	64.35	71.17	67.76	16.58	18.09	17.33
	V	T	V x T	V	T	V x T
SE (d)	0.35	0.75	1.07	0.09	0.19	0.27
CD (P=0.05)	0.72	1.53	2.17	0.18	0.39	0.55

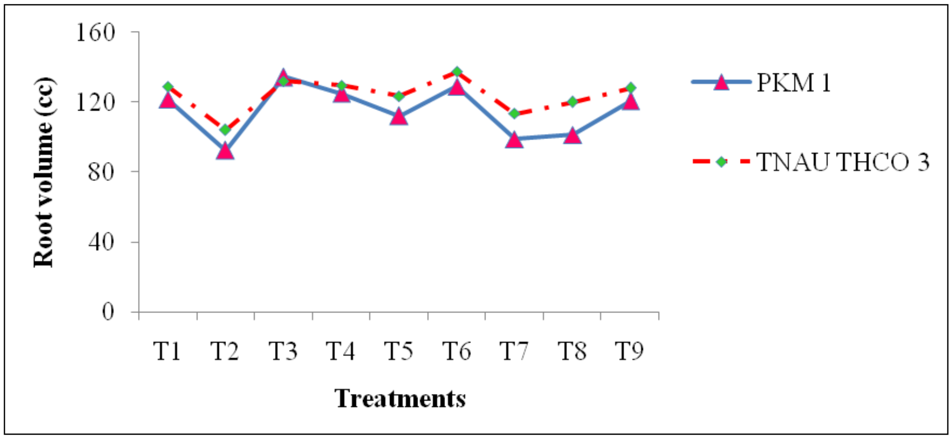

Fig. 1: Effect of plant growth regulators and nutrients on root volume (cc) of tomato genotypes under salinity.

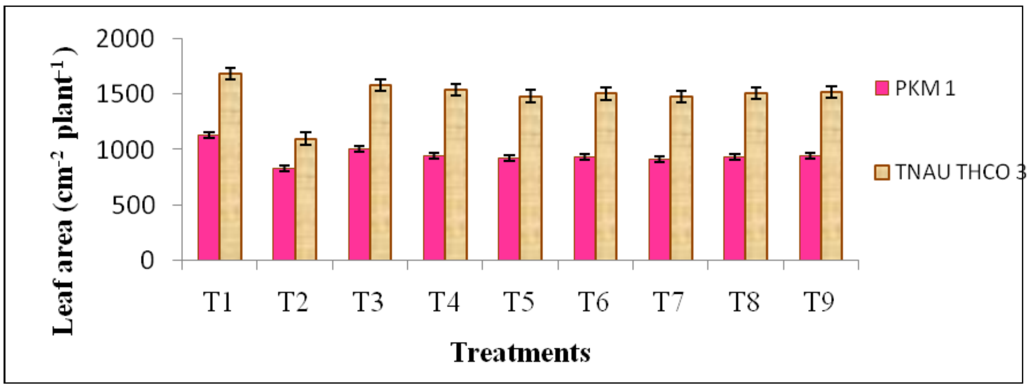

Fig. 2: Effect of plant growth regulators and nutrients on leaf area (cm^{-2} $plant^{-1}$) of tomato genotypes under salinity.
Treatments: T_1 -Absolute control, T_2 - Control (Water spray), T_3 - Brassinolide (0.5 ppm), T_4 - Salicylic acid (100 ppm), T_5 -Benzyl amino purine (50 ppm), T_6 - Ascorbic acid (100 ppm) - T_7 - Glutathione (50 ppm), T_8 - KNO_3 (0.5%) + $FeSO_4$ (0.3%) + Borax (0.2%) and T_9 - Nutrient PGR Concoction K_2SO_4 (0.5 %) + $CaSO_4$ (0.5 %) + Borax (0.2 %) + NAA (20 ppm)

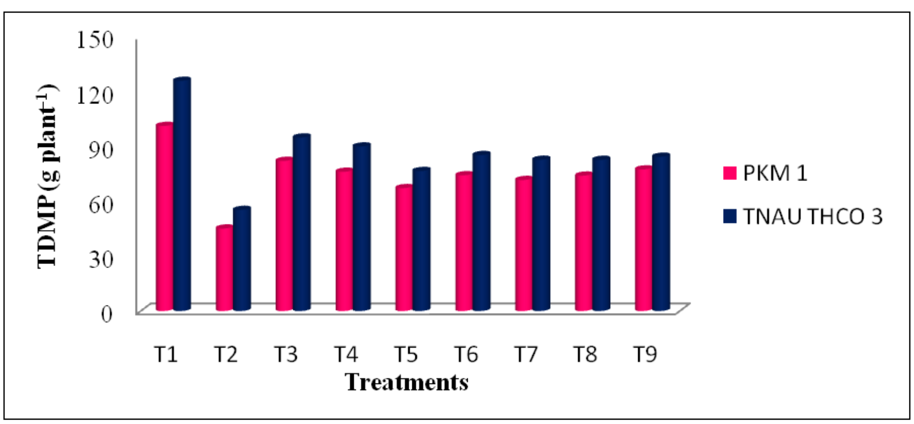

Fig. 3: Effect of plant growth regulators and nutrients on TDMP (gram $plant^{-1}$) of tomato genotypes under salinity.
(Treatments: T_1 -T_9 as per Fig. 2)

cc) and salicylic acid (125.19 cc and 129.79 cc) in PKM 1 and TNAU THCO 3 respectively (Fig. 1). The studies concluded with the finding of Misra & Saxena (2009) that exogenous application of salicylic acid significantly increases plant growth by increasing root growth and volume in lentil plants grown under saline medium of 100 mM NaCl.

Leaf area is a fundamental determinant of the total photosynthesis of a plant. The reason for leaf area reduction by salt stress is inhibition of leaf area expansion due to tugor loss and premature leaf senescence due to production of reactive oxygen species. Salt stress caused 26.8 per cent reduction of leaf area in PKM 1 and 34.7 per cent in TNAU THCO 3. Evaluating the treatments under salt stress, brassinolide recorded supremacy in leaf area (1007.1 and 1584.9 cm^2) in PKM 1 and TNAU THCO 3 respectively (Fig. 2). The findings could be supported by the observations of Shen et al. (1990) that furnished 28 per cent of leaf area improvement in tomato CO 3 variety due to foliar spray of 0.5 ppm brassinolide.

According to Shakirova et al. (2003), the positive effect of salicylic acid on growth and yield can be due to its influence on other plant hormones. Salicylic acid altered the auxin, cytokinin and ABA balances in wheat and increased the growth and yield under both normal and saline conditions. In addition to that, foliar application of salicylic acid increase the leaf area in sugarcane, was reported by Zhou et al. (1999).

A common adverse effect of abiotic stress on crop plants is the reduction in the total dry matter production. Irrespective of the genotypes, 56 per cent of TDMP was reduced due to salinity in the present study. Exogenous application of plant growth regulating chemicals can have a primitive effect through alleviating the adverse effects of stress. In the present investigation, foliar spray with PGRs and nutrients showed a positive role on TDMP improvement under salinity. The highest TDMP was recorded in brassinolide (82.04 g $plant^{-1}$ in PKM 1, 94.80 g $plant^{-1}$ in TNAU THCO 3) followed by salicylic acid (76.08 g $plant^{-1}$ in PKM 1, 89.88 g $plant^{-1}$ in TNAU THCO 3) and benzyl amino purine (71.61 g $plant^{-1}$ in PKM 1, 82.65 g $plant^{-1}$ in TNAU THCO 3) (Fig. 3). The present study corroborates with early findings by Khripach et al. (2000) and it also explained the increase in total dry weight of the plant by application of brassinolide, under various stress conditions. Salicylic acid and its derivatives showed protection of maize plants from the detrimental effects of salinity, and increased dry weight of the plant (Tuna et al. 2007).

CONCLUSION

The results revealed that the salt stress causes detrimental effect on morphological traits such as plant height, root length, root volume, leaf area and TDMP. From these findings, it can be inferred that, ameliorants like brassinolide performed better followed by salicylic acid. Among the genotypes used in this study, TNAU THCO 3 responded well for PGRs and nutrients under salinity than PKM 1. However, further studies are required to confirm the results by molecular evidence in future.

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