J. Agric. Res. Technol., 50 (2) : 153-157 (2025) https://doi.org/10.56228/JART.2025.50204

Studies on Salt Tolerant Tripartite Inoculation with Azotobacter, Phosphate Solubilizing and Potash Mobilizing Bacteria and its Effect on Growth and yield of Brinjal (*Solanum melongena* L.)

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(Received : 18.07.2024 Accepted : 03.02.2025)

Abstract

The investigation on "Studies on Salt Tolerant Tripartite inoculation with *Azotobacter*, Phosphate solubilizing and Potash mobilizing bacteria and its effect on growth and yield of Brinjal (*Solanum melongena* L.)" was conducted during *kharif*, 2023-2024; under laboratory condition and field work was conducted at research farm, at Department of Plant Pathology and Microbiology M.P.K.V. Rahuri, with an objective to study the effects of Salt tolerant *Azotobacter*, Phosphate Solubilizing and Potash Mobilizing bacteria under graded level of phosphatic fertilizer dose on growth parameters and fruit yield (q ha^{-1}). Seed treatment and seedling deep treatment were used of salt tolerant Azotobacter, PSB and KMB. Significant effect on of plant height, fresh weight and dry weight of plant, number of fruits $plant^{-1}$, fruit yield of Brinjal recorded at harvesting stage were significantly highest in the treatment T_5 i.e. application of 100% P_2O_5 along with the tripartite inoculation of *Azotobacter*, PSB, and KSB recorded fruit yield (430.27 q ha^{-1}) outperforming other treatments , followed by T_4 and T_8 demonstrating superior performance and statistically on par with treatment T_5. The lowest results were obtained from treatment T_1 i.e absolute control. These results highlight the effectiveness of the salt tolerant tripartite inoculation with Azotobacter, PSB and KMB in improving brinjal productivity in saline condition and important promising eco friendly strategies for salinity management as part of sustainable agriculture practices.

Key words : Brinjal (*Solanum melongena* L.), Tripertite inoculation, Salt tolerant bacteria.

Brinjal (*Solanum melongena* L.) is an important vegetable crop having chromosome number 2n=24, belonging to solanaceae family also called as an egg plant and aubergine (French word) in Europe. It can be grown in different agro-climatic zones and adapted to the subtropical and tropical regions in the world. Brinjal is considered a native to India, Central Asia and grown widely in India, Indonesia, Philippines and several African countries. The scale of brinjal production in financial year 2023, in India is estimated to have amounted to approximately 12.61 million metric tons. This was a slight diminution from the preceding financial year. Over 760 thousand hectares of agricultural land in the country was used for vegetable cultivation in country during financial year 2023.

Brinjal is the most common vegetable crop and grown in different regions of country. It is mostly cultivated for vegetables and medicinal purposes. Fruits of brinjal crop are used for the cooking purpose and dried shoots are used as fuel in rural areas. The thorough phytochemical study of brinjal plant reveals that it contains different essential compounds viz., flavonoids, tropane, aspartic acid, lanosterol, alkaloids steroids, glycoalkaloids, nasunin, solasodine, oxalic acid, tryptophan and ascorbic acid which is present in the leaves and fruits of the plant. These compounds help to cure various diseases like antiplatelet hypo-lipidemic, anti-inflammatory, hypotensive, anti-asthmatic and cancer etc (Muhammad and Senay 2019).

Soil salinity is a major problem in global agricultural productivity with an estimated 50 per cent of arable land predicted to become

salinized by 2050 and has emerged as a serious issue for food security (Giannelli *et al*. 2023). Salt affected soil occurs in all continents and almost all climatic conditions. Their distribution is relatively more in arid and semi arid regions as compared to humid regions. Currently it is estimated that about 62 million hectares or 20 per cent of the word irrigated land is affected by salinity. The excess amount of deposition of soluble salt in cultivable land directly affects the crop yield. The various physiological and metabolic process of plants are inhibited by the uptake of high amount of salt (Egamberdieva *et al*. 2019).

The salinity stress can be mitigated using beneficial microorganisms known as plant growth- promoting rhizobacteria (PGPR) could play an important role. This group of rhizospheric bacteria could effectively colonize plant roots and maintains soil fertility by offering a favorable alternative to inorganic fertilizers and pesticides. The effectiveness of PGPR to increase the growth of various crops under salt stress conditions. Salt Tolerant Plant Growth Promoting Rhizobacteria (ST- PGPR) are the group of salt tolerant bacteria that enhances plant growth and yield via various plant growth promoting substance as well as bio fertilizers. Their adaptive responses toward salt stress are to the efficiency to produce osmoprotectants, compatible solutes, and specialized transporters. Artificial fertilizers have the negative impact on soil fertility and environment, the use of beneficial soil microorganism such as ST- PGPR for sustainable and safe agriculture has increased globally during the last couple of decades.

Eggplant may be stated as moderately sensitive to salinity by the classification scheme indicated by Maas and Hoffman (1977). Eggplant growth has been shown to be sensitive or moderately sensitive to salinity depending on varieties or cultivars and environmental conditions. However, few studies have been conducted to overcome problems associated with salinity using eggplant inoculation with different Bacillus strains, and there have been no studies conducted to evaluate overcoming salinity problems by treatment with Bacillus brevis in addition to Xanthobacter autotrophicus and Enterobacter aerogenes in vegetable crops.

Materials and Methods

Field experiment : Field work was conducted at research farm, at Department of Plant Pathology and Microbiology M.P.K.V. Rahuri (M.S), India to study the impact of brinjal growth through salt tolerant tripartite inoculation of Azotobacter, Phosphate Solubilizing and Potash Mobilizing Bacteria.

Seed treatment : The seeds of brinjal were treated with salt tolerant rhizobacteria @ 25 mL kg^{-1} of seeds. At the time of sowing seeds were dried in shade for 30 minutes and were sown in nursery. After one month transplanting of seedling was done in the field. At the time of transplanting deeping of seedlings of brinjal in the salt tolerant bacterial suspension of Azotobacter, PSB and KSB and MPKV Consortium @ 25 mL of each per litre of water for 30 min.

Experimental details : Field experiment was carried out with the following details:

1. Crop : Brinjal (*Solanum melongena* L.)
2. Variety : Phule Arjun (F_1 Hybrid)
3. Season : *Kharif* 2022-2023
4. Experimental Design : Randomized Block Design (R.B.D.)
5. Replication : 3
6. Treatment : 8
7. Spacing : 75 x 75 cm
8. Soil Type : Medium deep soil
9. Fertilizer Dose : 150:75:75 (N, P_2O_5 & K_2O) kg ha^{-1}

Treatment details are T_1 - Absolute control, T_2 - 25% P_2O_5 + Salt tolerant *Azotobacter*, PSB, KSB, T_3 - 50% P_2O_5 + Salt tolerant Azotobacter, PSB, KSB, T_4 - 75% P_2O_5 + Salt tolerant *Azotobacter*, PSB, KSB, T_5 - 100% P_2O_5 + Salt tolerant *Azotobacter*, PSB, KSB, T_6 - 100% P_2O_5 + Without salt tolerant Azotobacter, PSB, KSB, T_7 - 75% P_2O_5 + MPKV consortium and T_8 - 100 % P_2O_5 + MPKV consortium.

Observations : The plant observation recorded during this study included Plant height (cm), fresh weight of shoot (g), dry weight of shoot (g), number of fruits plant^{-1}, fruit weight(g), fruit yield and NPK uptake by brinjal were recorded.

Statistical analysis : The observations recorded during course of investigation were subjected to statistical analysis by adoption appropriate Model "Analysis of variance". According to the procedure described by (Panse and Sukhatme, 1985). Critical difference (CD) with in the treatment was calculated in order to compare the treatment at 5% level of significance.

Result and discussion

A field experiment was conducted with eight treatment and three replication with randomized block design. There were significant differences were observed between various treatments due to the applications of salt tolerant Azotobacter, PSB and KMB under graded levels of phosphorus on all growth and yield attributing parameters.

The highest plant height at 50% flowering (63.27 cm) and harvesting (95.20 cm)was recorded by T_5 respectively. The treatments T_4 and T_8 statistically on par with the treatment T_5 recorded the plant height at flowering as (60.80 cm, 58.33 cm), respectively and at the harvesting as (92.53 cm, 90.96 cm), respectively. The lowest growth result were shown by treatment T_1 which was absolute control. The current finding with previous research conducted by the scientist i.e Abd El-Azeem *et al.*, (2012), Bhambure *et al*. (2018).

Similarly highest root length at flowering (25.80 cm) and harvesting (53.50 cm), fresh weight of shoot (701.40 g), dry weight of shoot (138.90g) were in the treatment T_5 at harvesting. The another parameters such as total N (160.67 Kg ha^{-1}), P (56.03 Kg ha^{-1}), K (154.40 Kg ha^{-1}) uptake and microbial count such as *Azotobacter* (56.60 cfu g^{-1} soil), PSB (61.77 cfu g^{-}1 soil), KMB (98.63 cfu g^{-1} soil) were recorded highest by the treatment T_5 at harvest.

The highest number of fruit plant^{-1} were recorded for Treatment T_5 - (100% P_2O_5 + Salt tolerant *Azotobacter*, PSB, KMB) (45/ plant), were T_4 - (75% P_2O_5 + Salt tolerant *Azotobacter*, PSB, KMB.) and treatment T8- (100% P_2O_5 + MPKV consortium) recorded number of fruits per plant as (45.00) and (44.66) respectively. The absolute control recorded minimum number of fruits per plant as (35.00) among all the treatments. Additionally, treatment T_5 recorded the highest fruit weight (65.03g). The present finding are align with the previous research conducted by Oosten *et al*. (2018) revealed that tomato inoculated with A. chrococcum 76A under both moderate (50 mM NaCl) and sever (100mM NaCl) salt stresses increased growth parameters i.e fresh fruit weight and number plant^{-1} as compared to the control.

The treatment T_5 - (100% P_2O_5 + Salt tolerant *Azotobacter*, PSB, KMB.) recorded maximum fruit yield as 430.27 q ha^{-1}. The treatment T_4 - (75% P_2O_5 + Salt tolerant Azotobacter, PSB, KMB) (428.57 q ha^{-1}) and treatment T_8 - (100% P_2O_5 + MPKV consortium) (426.50 q ha^{-1}) were at par with treatment T_5 respectively. The treatment T_5

recorded maximum percent increase over absolute control as (11.72%) followed by treatment T_4 (11.27%) and treatment T_8 (10.74%). The treatment no T_1 i.e Absolute control recorded minimum yield (385.13 q ha^{-1}) among all treatments.

The combination of salt tolerant tripartite inoculation along with graded level of phosphatic fertilizer significantly enhanced yield production of brinjal in saline condition. The treatment T_5 which combined 100% P_2O_5 with salt tolerant tripartite inoculation of Azotobacter, PSB and KMB, proved to be statistically superior to the rest of treatments and was comparable to T_4 and treatment T_8. The lowest growth and yield performance was recoded in T_1 i.e absolute control. Current finding align with previous research studied by Mayank *et al*. (2004); Upadhyay and Singh (2015); Tahir *et al*. (2019); Kalozoumis *et al.* (2021;, Rafique *et al*. (2022); Ali *et al.* (2021); Rokade and Patil (1992) support these finding and illustrate the benefit of utilizing tripartite inoculation of salt tolerant rhizobacteria along with NPK fertilizers for enhancing brinjal growth and yield in saline condition.

The results in general concluded that application of salt tolerant *Azotobacter*, PSB and KMB to the seed and seedling of brinjal along with 100% P_20_5 showed maximum growth and yield parameters such as plant height, root length, fresh weight of shoot, dry weight of shoot, number of fruits $plant^{-1}$, total NPK uptake by plant and microbial count as compared to other treatment. These finding emphasize the potential of salt tolerant tripartite inoculation of *Azotobacter*, PSB and KMB to boost brinjal growth, making valuable approach for improving crop productivity without deteriorating the soil fertility and also sustain the environment.

Treat-ments	**Plant height at 50% flowering (cm)**	**Plant height at harvest (cm)**	**Fresh wt. of plant (g) at harvest**
T_1	40.97	58.07	570.87
T_2	49.23	75.37	607.27
T_3	52.77	78.27	635.27
T_4	60.80	92.53	698.16
T_5	63.27	95.20	701.40
T_6	56.93	86.90	663.86
T_7	54.33	85.56	661.33
T_8	58.33	90.96	695.16
S. Em. ±	1.85	2.44	12.08
C.D. at 5%	5.63	7.41	36.64

Treat-ments	**Dry weight of plant (g) at harvest**	**No. of fruits $plant^{-1}$**	**Fruits weight (g)**	**Fruit yield (q ha^{-1})**	
				Fruit yield (q ha^{-1})	**% increase over absolute control**
T1	96.57	35.00	52.97	385.13	-
T2	104.50	36.33	55.47	405.43	5.27
T3	113.73	39.50	57.00	410.57	6.60
T4	137.53	45.00	63.17	428.57	11.27
T5	138.90	46.00	65.03	430.27	11.72
T6	127.26	41.23	59.13	420.50	9.10
T7	124.53	40.83	58.83	419.56	8.93
T8	134.53	44.66	62.40	426.50	10.74
S. Em. ±	3.49	1.30	1.89	2.90	-
C.D. at 5%	10.59	3.97	5.74	8.80	-

Treatments	Nutrient uptake (kg ha^{-1})			Microbial count (x 10^6 cfu g^{-1} of soil)		
	N	P	K	*Azotobacter* sp.	PSB	KMB
T_1	77.63	42.47	74.73	32.73	42.40	69.83
T_2	138.93	46.97	127.53	36.43	45.30	73.87
T_3	142.13	47.83	132.07	40.50	47.73	77.97
T_4	156.77	54.76	150.43	54.87	59.27	95.33
T_5	160.67	56.03	154.40	56.60	61.77	98.63
T_6	146.33	51.10	142.43	50.13	56.96	90.96
T_7	145.87	50.76	141.06	49.26	53.86	88.16
T_8	151.06	53.50	148.80	52.53	58.06	94.36
S. Em.±	4.24	1.30	3.51	1.37	1.55	2.49
C.D. at 5%	12.87	4.56	10.67	4.16	4.72	7.56

References

Abd El-Azeem, S. A., Elwan, M. W., Sung, J. K. and O. K, Y. S. 2012. Alleviation of salt stress in eggplant (*Solanum melongena* L.) by plant-growth-promoting rhizobacteria. Communications in Soil Science and Plant Analysis, 43(9), pp.1303-1315.

Ali, A. M, Awad, M. Y, Hegab, S. A, Gawad, A. M. A. E., and Eissa, M. A. 2021. Effect of potassium solubilizing bacteria (*Bacillus cereus*) on growth and yield of potato. Journal of Plant Nutrition , 44 (3), 411-420.

Bhambure, A. B., Mahajan, G. R., and Kerkar, S. 2018. Salt tolerant bacterial inoculants as promoters of rice growth and microbial activity in coastal saline soil. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 88(4), 1531-138.

Egamberdieva, D., Wirth, S., Bellingrath-Kimura, S. D., Mishra, J. and Arora, N. K. 2019. Salt tolerant plant growth promoting rhizobacteria for enhancing crop productivity of saline soils. Frontiers in Microbiology, 10: 2791.

Giannelli, Gianluigi, Silvia Potestio, and Giovanna Visioli. 2023. The contribution of PGPR in salt stress tolerance in crops: Unravelling the molecular mechanisms of cross-talk between plant and bacteria. Plants 12.11: 2197.

Kalozoumis, P., Savvas, D., Aliferis, K., Ntatsi, G., Marakis, G., Simou, E.,and Karapanos, I. 2021. Impact of plant growth-promoting rhizobacteria inoculation and grafting on tolerance of tomato to combined water and nutrient stress assessed via metabolomics analysis. Frontiers in Plant Science, 12: 670236.

Mayank, S., Tirosh, T. and Glick, B. R. 2004. Plant growth-promoting bacteria confer resistance in tomato plants to salt stress. Plant Physiology and Biochemistry. 42(6): 565-572.

Maas, Eugene V., and Glenn J. Hoffman 1977. Crop salt tolerance current assessment. Journal of the irrigation and drainage division 103.2: 115-134.

Panse. V. G and Sukhatme P.V.,1985. Statistical Methods for Agricultural Workers.

Rafique, M. Z., Nadeem, A. M., Xia, W., Ikram, M., Shoaib, H. M., and Shahzad, U. 2022. Does economic complexity matter for environmental sustainability? Using ecological footprint as an indicator. Environment, Development and Sustainability, 24(4), 4623-4640

Rokade, S.M. and Patil, P.L. 1992. Phosphate solubilizing micro-organisms – A Review- Indian Jornal of Maharashtra Agriculture University.17(3): 458-465

Tahir, M., Ahmad, I., Shahid, M., Shah, G. M., Farooq, A. B. U., Akram, M., and Zakir, A. 2019. Regulation of antioxidant production, ion uptake and productivity in potato (*Solanum tuberosum* L.) plant inoculated with growth promoting salt tolerant *Bacillus* strains. Ecotoxicology and Environmental Safety, 178: 33-42.

Upadhyay, S.K., Singh, D.P. and Saikia, R. 2009. Genetic diversity of plant growth promoting rhizobacteria isolated from rhizospheric soil of wheat under saline condition. Current Microbiology., 59(5) : 489-496.