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Effect of Customized Fertilizer Formulations on Brinjal (*Solanum melongena* L.) under Sodic Soil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Customized Fertilizer Formulation (CFF) applications on growth and yield of Brinjal (*Solanum melongena* L.) varieties Manaparai local and CO-2 under sodic soils were studied with eleven CFF combinations. No Significant observations in growth yield and yield parameter was recorded due to the combined application of CFF and organic amendments on sodic soils. The symptoms of salt injury were well pronounced in brinjal cv. Manaparai local when compared to brinjal cv. CO2 though the sodic soil reclamation was done with gypsum @1.1 t/Ha. The salt injury was further confirmed with electrolyte leakage study conducted at field level. However, the treatment T_{11} i.e. CFF2 100% macro nutrients as straight fertilizers, liquid micronutrient formulation and composted Press mud @ 5 t/ha was found to have the brinjal fruit yield of 1.39 t/ha in cv. CO2 which was not a desirable yield. This might be due to the yield reduction per unit increase in salt content.

Keywords: Brinjal; customized fertilizer; sodic soil; salt injury; scorching.

1. INTRODUCTION

Brinjal is cultivated over approximately 500,000 to 600,000 hectares in India.Major cultivation areas include West Bengal, Uttar Pradesh, Maharashtra, Tamil Nadu, and Gujarat.

India produces around 1.5 to 2 million metric tons of brinjal annually. The productivity of brinjal ranges from 10 to 15 tons per hectare, though this can vary based on farming practices, pest management, and environmental conditions. FAO [1] Brinjal is widely reported to be sensitive to salinity /sodicity [2]. High sodicity suppresses plant growth due to sodium toxicity and nutrient imbalance in plants, as well as low availability of mineral nutrients in the soil. Salt stress is the cause of the slow growth and growth of plants and leads to changes in yield and quality in a variety of crops. Plants provide a complex response to salt and changes in the morphology, physiology and metabolism of plants are observed. However, there is a dire need to enhance its yield and introduced more varieties which could thrive well under stressful habitats including saline stress.

Balanced fertilization well beyond NPK is needed to break stagnation in crop yield. However, there is need to design new products to provide the customized solutions and enhance the overall use efficiency of all the plant nutrients. To get the maximum yields, crops should be provided with nutrients at optimal rate throughout the growth cycle in the most efficient manner. Customized fertilizers being crop, soil and area specific show a good promise to maintain soil health by ensuring appropriate fertilization [3]. Customized fertilizers facilitate the application of the complete range of plant nutrients in the right proportion and to suit the specific requirements of a crop in different stages of growth and are more relevant under site specific nutrient management practices. Therefore, an experiment was conducted to study the influence of customized fertilizers on growth and yield parameters of brinjal under sodic soil.

2. MATERIALS AND METHODS

Field experiments were conducted during Kharif 2022 at Horticultural College & Research Institute for Women, Tiruchirappalli district, Tamil Nadu and at Bhaganur village, Manikandam block, Tiruchirappalli district during 2023. The soil of the experimental field was fine mixed isohyperthemic, sodicVerticUstropept, Alathur series with sandy clay loam texture, characterized by high pH 9.3, EC 0.83 dS m^{-1} and ESP 33.5 per cent. The initial status of available N, P_2O_5 and K_2O of the experimental site were 180.6, 12.5 and 139.2 kg/ha, respectively and low in organic carbon (0.39%). The field was reclaimed with required quantity of gypsum based on Gypsum Requirement (GR) (1.2 t /ha) along with continuous ponding of the field with rain water followed by draining. This procedure was repeated three times and the ESP was reduced from 33.5 to 12.53. The customized fertilizer formulation prepared for brinjal crop were imposed based on the treatment structure. The experiment was laid out in a Randomized Block Design with eleven treatments replicated thrice. Customized Fertilizer formulations were prepared based on the blanket recommendation for brinjal (100:50:30 kg N, P and K /ha) through straight fertilizers, micro nutrient formulation for vegetable crops and gypsum as filler material. Three levels of CF I CF II and CF III viz., 75%, 100% and 125% of CFF were compared with 100% RDF through straight fertilizers.

2.1 Treatment Structure

T_1 – Absolute control (RDF)
T_2 – CFF1 75% macro nutrients as straight fertilizers
T_3 – CFF2 100% macro nutrients as straight fertilizers
T_4 – CFF3 125% macro nutrients as straight fertilizers
T_5 – T_2 + Micronutrients
T_6 – T_3 + Micronutrients
T_7 – T_4 + Micronutrients
T_8 – T_5+ Organics *i.e* composted Press mud @ 5 t/ha
T_9 – T_6 + Organics *i.e* composted Press mud @ 5 t/ha
T_{10} –T_7+ Organics composted Press mud @ 5 t/ha)
T_{11} – T_3 +Liquid MN formulation + Organics *i.e* composted Press mud @ 5 t/ha

RDF: 50:50:30 kg N, P and K /ha was applied as basal dose and N 50 kg/ha on 30 days after transplanting.

Twenty-five days old pro tray seedlings of brinjal cv. CO 2 and Manaparai local with a spacing of 75 cm row to row and 60 cm plant to plant were transplanted in the plots followed by irrigation for proper establishment of the seedlings. Brinjal cv. Manaparai local is the most common brinjal cultivar and is widely consumed as a fresh vegetable in Tamil Nadu. Observations were taken on growth parameters, yield attributes, soil available nutrients and nutrient uptake pattern were also recorded at critical stages of crop growth.

2.2 Electrolyte Leakage Study

The salt injured brinjal leaves were collected at seedling stage to determine EC, Na and K content. The leaf salt injury was further confirmed by electrolyte leakage study. Ten discs of salt injured leaf (0.5 cm diameter) were cut from the fully expanded leaves and the samples were washed three times with deionized water to remove surface-adhered electrolytes. Leaf discs were placed in test tubes containing 5 mL of deionized water and incubated for 24 h. Subsequently, the initial electrical conductivity of the solution (EC_1) was determined using EC meter. The samples were then incubated in a water bath at 95°C for 20 min. to release all electrolytes, cooled down to 25°C and their final electrical conductivity (EC_2) was measured, and the results were expressed as percentage [4-6]. The following formula was used to measure the electrolyte leakage. These leaf samples were washed with tap water and then distilled water in turn, then dried in an oven and powdered. For the measurements of mineral content, plant samples were digested in tri acid extract and finally diluted to 25 ml with distilled water. Extracts were filtered and stored in plastic vials until analysed.(Jackson,1973).

$$EL = (EC1/EC2) \times 100\ (\%)$$

Table 1. Initial soil characteristics of the experimental field

Soil pH	8.9
Soil EC (dSm^{-1})	0.83
Soil Texture	Sandy clay loam
Organic carbon (%)	0.36
Available –N (kg ha^{-1})	121
Available –P (kg ha^{-1})	15.7
Available –K (kg ha^{-1})	105.8
Cation Exchange Capacity (c.mol (p+) kg^{-1}	14.8
Exchangeable Sodium (m.eq/100 g of soil)	3.45
Exchangeable Sodium Percentage (ESP)	23.3

3. RESULTS AND DISCUSSION

3.1 Effect of CFF on Growth and Yield Parameters of Brinjal

Poor crop establishment due to scorching of leaves was noticed in brinjal Manaparai local variety under sodic soil. Plant height did not vary due to different treatment combinations of CFF on brinjal. At 75 DAT the highest plant height (69.50 cm) was observed from the treatment T_{11} i.e. CFF2 (100% macro nutrients as straight fertilizers) + Liquid MN formulation + Organics (composted Press mud @ 5 t/ha) and the lowest plant height (61.0 cm) was observed from treatment T_2 (Treatments detail). The most values of root length (16.80 cm) and dry weight (78.36 g) were recorded with treatment T_{11} and the least values were recorded for T_2 i.e. CFF1 (75% macro nutrients as straight fertilizers). Number of branches also varied due to various treatment combinations of CFF. Maximum branches were observed in T_{11} were 6 and 7.3 at both 45 and 60 DAT, respectively. At 75 DAT the maximum number of branches (8.3) was recorded from the treatment combination T_{11} while the minimum number of branches (6.7) was recorded in T_2.

There was no significant variation or response in growth and yield parameters to customized fertilizer application up to 100% customized fertilizer dose and beyond this level. There was no improvement in growth and yield parameters with each successive addition of fertilizers. This was due to increased application of customized fertilizer on sodic soil. Further, RDF as per package of practice and 50% customized fertilizer dose recorded on par growth and yield parameters due to application of more or less equal quantity of nutrients in both the treatments. While comparing the performance of two varieties, brinjal cv. CO-2 was found to be good compared to Manaparai local for growth parameters andyield attributes under sodic soil.

Among the different CFF treatments, T_{11} i.e. CFF2 (100% macro nutrients as straight fertilizers) +Liquid MN formulation + organics (composted Press mud @ 5 t/ha) was found to have the highest brinjal fruit yield of 1.39 t/ha which was not a desirable yield. This might be due to the yield reduction per unit increase in salt content. Salinity or sodicity can decrease root water uptake through its osmotic effect, and subsequently induce water stress as reported by Zhang et al. [7-10].

The developed CFF was not performed well under sodic soils in terms of plant growth, yield attributes and yield for brinjal cv. Manaparai local. The results revealed that application of CFF2 i.e 100% macro nutrients as straight fertilizers, liquid micro nutrient formulation and composted Press mud @ 5 t/ha were found to have the highest brinjal fruit yield of 1.39 t/ha which was not a desirable yield. This might be due to the yield reduction per unit increase in salt content. Salts in the soil water solution can reduce evapotranspiration by making soil water less ‘‘available’’ for plant root extraction. Salts have an affinity for water and hence additional force is required for the crop to extract water from a saline soil. The presence of salts in the soil water solution reduces the potential energy of the soil water solution [11].

3.2 Electrolyte Leakage Studies

The results revealed that the increased concentration of salts in the scorched leaf bits by having high EC values in the leaf bit solution collected from CFF applied plots (0.85 dS/m) compared to the leaf bit solution (0.31 dS/m) collected from RDF applied plots. Further research are needed to confirm the Na/K efflux ratios.

Table 2. Effect of treatments on growth parameters of brinjal (Average of 5 plants)

Treatments	Plant height (cm)	Root length (cm)	Dry weight (g)	No. of primary branches		
				45 DAT	60 DAT	75 DAT
T_1	64.50	14.81	75.56	4.1	5.3	6.8
T_2	61.00	13.65	60.35	3.5	5.0	6.7
T_3	63.00	14.50	76.45	4.3	5.9	7.8
T_4	65.50	15.89	73.45	3.5	5.6	7.5
T_5	65.50	14.85	67.55	3.9	5.8	7.6
T_6	66.00	15.95	69.43	3.5	5.6	7.0
T_7	65.80	14.95	73.35	3.9	5.3	6.9
T_8	66.00	14.38	67.55	3.8	5.0	6.8
T_9	64.50	11.30	62.43	5.6	5.8	7.3
T_{10}	63.50	13.50	73.45	5.0	6.5	7.5
T_{11}	69.50	16.80	78.36	6.0	7.3	8.3
Sed	1.00	0.34	1.81	0.10	0.13	0.13
CD (P=0.05)	2.07	0.70	3.57	0.21	0.27	0.27

Table 3. Results of electrolyte leakage study

Treatment	EC1	EC2	EL (%)	Na (ppm)
Control	0.31	0.43	72.09	11
CFF applied plots	0.73	0.85	85.88	45

3.3 Effect of CFF on Yield Attributes of Brinjal

The more number of flowers plant $^{-1}$ was observed in the treatment T_{11} (27.6) and the less number of flowers were produced in the treatment T_1 (18.2). The maximum number of fruits plant^{-1} was recorded in the treatment T_{11} (17.5) and the treatment T_2 (9.2) recorded minimum number of fruits plant^{-1}. The highest fruit yield plant^{-1} was registered in the treatment T_{11} (2.02 kg plant^{-1}) and the treatment T_2 recorded (0.915 kg plant^{-1}) the lowest fruit yield plant^{-1}. This approach aligns with recent findings that emphasize the importance of holistic nutrient management strategies for optimizing crop performance in degraded soil environments [12].

The results highlight the critical role of combining customized fertilizers with organic amendments in improving Brinjal growth and yield in sodic soils. The CO-2 variety's superior performance underscores its suitability for challenging soil conditions, while T11 treatment demonstrated that integrating liquid micronutrients and organic compost can significantly boost fruit yield. This approach aligns with recent findings that emphasize the importance of holistic nutrient management strategies for optimizing crop performance in degraded soil environments [13].

The ineffectiveness of CFFs alone in improving plant growth and yield in sodic soils suggested that while they are a valuable component of soil management, their efficacy is greatly enhanced

Table 4. Effect of treatments on yield attributes and yield of brinjal var. CO-2 (Average of 5 plants)

Treatments	No.of flowers /plant	No.of fruits/plant	Fruit yield/plant (g)	Fruit Yield T/ha
T_1	18.4	9.2	990	0.66
T_2	18.2	9.4	915	0.61
T_3	21.4	11.1	997	0.66
T_4	19.5	9.3	1385	0.92
T_5	22.3	11.5	1685	1.12
T_6	19.5	9.3	1135	0.76
T_7	20.8	10.5	1565	1.04
T_8	20.9	10.4	1985	1.32
T_9	24.5	14.5	1935	1.29
T_{10}	24.5	15.2	2085	1.35
T_{11}	27.6	17.5	2023	1.39
Sed	0.45	0.26	29.04	0.02
CD (P=0.05)	0.93	0.54	60.22	0.04

Table 5. Effect of treatments on post harvest soil nutrient status under brinjal var.CO2 under sodic soils (Mean of 3 replications)

Treatments	pH	EC (dSm^{-1})	ESP	OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1	8.4	1.12	18.5	0.36	134	16.5	178
T_2	8.3	1.13	18.9	0.36	142	13.2	189
T_3	8.1	1.09	19.5	0.34	139	20.8	180
T_4	8.5	1.16	17.5	0.38	138	12.3	183
T_5	8.6	1.23	18.4	0.39	143	13.5	185
T_6	8.4	1.09	18.3	0.34	148	13.2	182
T_7	8.5	1.02	18.2	0.36	147	14.1	185
T_8	8.3	1.31	17.5	0.37	151	12.3	184
T_9	8.2	1.32	18.3	0.39	158	11.3	175
T_{10}	8.1	1.13	19.1	0.38	148	11.8	170
T_{11}	8.3	1.15	18.5	0.39	149	12.5	182
Sed	0.21	0.02	0.37	0.009	3.35	0.23	3.94
CD (P=0.05)	NS	0.04	0.77	0.019	6.96	0.48	8.17

when combined with organic inputs that improve soil structure and nutrient availability [14,15]. Future research should focus on refining CFF formulations and exploring additional organic and inorganic combinations to further enhance their performance in challenging soil conditions.

3.4 Effect of CFF on Post Harvest Soil Nutrient Status under Sodic Soils

The post harvest soil pH was in the range of 8.1 to 8.5, EC value ranged from 1.09 to 1.32 (dSm^{-1}), OC ranged from 0.34 to 0.39% and post harvest soil ESP ranged from 17.5 to 19.5%. Soil analysis revealed increased levels of essential nutrients and improved pH balance in plots receiving T_{11} treatment, contributing to enhanced crop productivity and soil health [9].

4. CONCLUSION

The study on the performance of brinjal varieties CO-2 and Mananparai local in sodic soils of Tiruchirapalli from June 2022 to October 2023 revealed that the CO-2 variety demonstrated superior growth parameters and yield compared to the Mananparai local variety. The treatment T11, which combined 100% macro nutrients as straight fertilizers, a liquid micronutrient formulation, and composted press mud at 5 t/ha, yielded 1.39 t/ha of brinjal, indicating the potential of tailored fertilization strategies to enhance productivity in challenging sodic conditions.

These findings underscore the importance of customized fertilizer applications in improving crop performance and mitigating the adverse effects of sodicity. Future research should focus on exploring additional brinjal varieties and assessing the long-term sustainability and cost-effectiveness of these fertilizer formulations. Overall, the study suggests significant economic and environmental benefits for farmers, including enhanced yields, improved soil health, and greater crop diversification in sodic soils.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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