Effect of Saline Water Irrigation and Organic Amendments on the Nutrient Availability, Microbial Population, Enzyme Activity and Yield of Brinjal in Coastal Saline Soil

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Abstract : A pot experiment was carried out in the department of Soil Science and Agricultural Chemistry, Annamalai University during March–July 2017, to study the effect of saline water irrigation and organic amendments on the nutrient availability, microbial population, enzyme activities and yield of brinjal in coastal saline soil. The texture of the soil was sandy and taxonomically classified as *Typic Udipsamments* with pH-8.38, EC-2.85 dS m^{-1} and represented low status of organic carbon (2.31 g kg^{-1}). The soil had low alkaline $KMnO_4$-N (134.56 kg ha^{-1}), low in Olsen- P (9.43 kg ha^{-1}) and medium in NH_4OAc-K (159.35 kg ha^{-1}). The fifteen treatments consisted of three levels of saline water *viz.*, S_0–Control (Bore well water), S_1-Saline water 1 (EC-3 & SAR-4) and S_2-Saline water 2 (EC-3 & SAR-6) and four different sources of organic amenments *viz.*, O_1-Control, O_2-Farm yard manure (FYM), O_3–Composted Calotropis (CCT) and O_4–Composted coirpith (CCP). The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications using selected saline tolerance brinjal variety CO-2 as test crop. The results revealed that the combined application of composted coirpith @ 12.5 t ha^{-1} with bore well water irrigated treatment (S_1O_4) recorded the highest soil nutrient availability and yield of brinjal.

Key Words: Coastal saline soil, salinity level, organic amendments, soil nutrient availability, microbial population, enzyme activity, brinjal, yield.

INTRODUCTION

The declining availability of fresh water has become a worldwide problem, which endorses the development of alternative, secondary quality water resources for agricultural use. Nowadays, the competition for freshwater in the development of urbanization, industry and agriculture caused the decline of fresh water for irrigation. The progressive decrease of fresh water resources is leading towards the inevitable use of saline water for irrigation purpose (Chowdary, 2014).

Coarse textured sandy soil dominates majority of the coastal regions and pose great challenge to sustainable crop production. Soil fertility is the most limiting factor for crop production in coastal sandy soil. Sandy soils have specific soil constraints *viz.*, light texture, poor exchange property, low nutrient and water retention capacity, low status of organic carbon and deficiency of both macro and micronutrients. These problems severely affect the productivity of crops in this region. Moreover, the continuous use of saline waters without amendments adversely affects the soil physico-chemical and biological properties and at the same time, it adversely affects the mineral composition, uptake and yield of crops under most situations (Ayers and Westcot, 1985 and Oster and Jayawardene, 1998). To counterbalance the harmful effects of saline waters, application of chemical amendments such as gypsum is commonly recommended. Several investigators reported that organic amendments or fertilization increased salt tolerance of some vegetable crops under saline water irrigation (Mondal, 2008; Sushantkumar, 2014). Hence the present investigation was carried out to study the effect of saline water irrigation and organic amendments on the nutrient availability, microbial population, enzyme activity and yield of brinjal in costal saline soil.

MATERIALS AND METHODS

The pot experiment was carried out in department of Soil Science and Agricultural Chemistry, Annamalai University during March–July 2017. The texture of the soil was sandy and taxonomically classified as *Typic Udipsamments* with pH-8.38, EC-2.85 dS m^{-1} and represented low status of organic carbon. The soil had low in alkaline $KMnO_4$-N and Olsen- P and medium in NH_4OAc-K. The fifteen treatments consisted of three levels of saline water *viz.*, S_0–Control (Bore well water), S_1-Saline water level-1 (EC-3 and SAR-4) and S_2-Saline water level-2 (EC-3 and SAR-6) as factor-A and four different sources of organic manures *viz.*, O_1-Control, O_2-Farm yard manure (FYM), O_3–Composted Calotropis (CCT) and O_4–Composted coir pith (CCP) as factor-B. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications using selected saline tolerance brinjal variety CO-2 as test crop. The calculated amount of different organics *viz.*, FYM, composted calotropis and composted coir pith was applied just before sowing. A uniform NPK dose of 50:25:15 mg kg^{-1} was supplied through urea, super phosphate and muriate of potash to all the experimental pots. The entire doses of NPK were applied as basal. The soil sample were collected and analyzed for available NPK and microbial population (bacteria, fungi and actinomycetes), enzyme activites (urease, phosphatase and dehydrogenase) using standard procedure of Jackson (1973). At harvest fruit and stover yield were separately recorded.

RESULTS AND DISCUSSION

Nutrient availability (Table 1)

Irrigation of brinjal with different salinity level and soil application of organics was significantly increased the available nutrient content of post harvest soil. Among the different levels of salinity tried, bore well water irrigation (S_1) recorded the highest available N content of 75.59 mg kg^{-1}, P content 6.78 mg kg^{-1} and K content 78.33 mg kg^{-1} at post harvest soil. This was followed by the treatments S_2 (EC-3 dS m^{-1} and SAR-4) and S_3 (EC-3 dS m^{-1} and SAR-6). Among the different organics studied, application of CCP @ 12.5 t ha^{-1} (O_4) registered highest mean available N content of 78.85 mg kg^{-1}, P content 7.14 mg kg^{-1} and K content 81.99 mg kg^{-1} in post harvest soil. This was followed by the treatment O_3, application of CCT @ 12.5 t ha^{-1} and application of FYM @ 12.5 t ha^{-1} (O_2). Interaction effect due to different saline water irrigation and organic manures through soil application an available NPK status of post harvest soil was significant. Brinjal irrigated with bore well water and addition of CCP @ 12.5 t ha^{-1} through soil (S_3O_4) registered

the highest alkaline $KMnO_4$-N (81.58 mg kg^{-1}), olsen-P (7.58 mg kg^{-1}) and NH_4OAc-K (86.35 mg kg^{-1}) at post harvest soil. However, it was found to be comparable with the treatment S_2O_4, which received CCP @ 12.5 t ha^{-1} through soil and irrigated with saline water (EC3 dS m^{-1} and SAR 6). The lowest nutrient availability registered in the treatment S_3O_1, irrigated with saline water without any organic amendment application.

The increased in NPK availability of soil with the addition of organic manure was reported by Sajal Poy (2014). In addition, the added organic manure as an energy source for a majority of the heterotrophic bacteria stimulated native beneficial microbial activity, thus resulting in higher N availability of soil under salt stress condition (Colla *et al*, 2006). The addition of organics along with recommended dose of NPK fertilizers reduced the K fixation and release of K due to the interaction of organic matter with clay besides the direct addition of potassium to available pool of the soil contributed for increased K availability. Organics also minimized the leaching loss of K by retaining K ions on exchange sites of the decomposition products. Similar results were also reported by Yasar (2003) and Cruz *et al.* (2002). Under saline condition sulphur oxidized biologically in the presence of organic matter in soil produce sulphuric acid which react with native $CaCO_3$ to from $CaSO_4$. Moreover, addition of organics also produced acid and decrease pH, which is a well known effects upon the availability of phosphorus in the soil. These findings are in agreement with El-Banna *et al*. (2004).

Microbial population (Table 2)

Application of different sources of organics significantly increased the microbial population of soil microorganism's *viz.*, bacteria, fungi and actinomycetes, while, salinity levels and their interaction effect was not significant. Among the various organics evaluated, CCP application @ 12.5 t ha^{-1} was significantly improved the microbial population *viz.*, bacteria (21.71×10^6/g soil), fungi ($14.61X10^5$/g soil) and actinomycetes (8.51×10^4/g soil) of soil at post harvest. This was followed by CCT and FYM applied treatments (O_3 and O_2). The lowest microbial population in soil was noticed in the treatment (O_1) without organics application *viz.*, bacteria (20.04×10^6/g soil), fungi (13.91×10^5/g soil) and actinomycetes (8.11×10^4/g soil) of soil at post harvest. Soil microbial population plays a vital role in providing soil nutrient cycling and organic matter turnover in coastal saline soil. The enhancement of soil microbial population is known to influence the crop productivity and nutrient cycling (Kodeeswaran, 2015). The application of organics as directly involved the growth and colonization of soil microorganisms can be influenced by physical, chemical and biological properties of the soil. Further, the availability of readily mineralized C and N and improvement in the physico-chemical properties of the soil due to the application of organics might have increased the microbial population of the soil. These results are in parity with the results reported by Lee and Bartlett (1996) and Garcia *et al*. (2002).

Enzyme activity (Table 3)

Application of different sources of organics significantly increased the enzyme activity *viz.*, urease, phosphatase and dehydrogenase activity of soil, while, salinity levels and their interaction effect was not significant. The application of various organics evaluated, application composted coir pith @ 12.5 t ha^{-1} recorded the highest urease activity (32.40 g NH_4-N/g soil/24 h), phosphatase activity(13.90 μg *p*-nitrophenol/g soil/h) and dehydrogenase activity (75.21 μg TTF/g soil/24 h). This was followed by the composted calotropis @ 12.5 t ha^{-1} was recorded urease activity (31.60 g NH_4-N/g soil/24 h), phosphatase activity (13.12 μg *p*-nitrophenol/g soil/h) and dehydrogenase activity (71.07 μg TTF/ g soil/24 h) and FYM @ 12.5 t ha^{-1} was recorded urease activity (30.37 g NH_4-N/g soil/24 h), phosphatase activity (12.37 μg *p*-nitrophenol/g soil/h) and dehydrogenase activity (68.40 μg TTF/g soil/24 h). The lowest urease activity (28.93 g NH_4-N/g soil/24 h), phosphatase activity (11.53 μg *p*-nitrophenol/g soil/h) and dehydrogenase activity (64.66 μg TTF/g soil/24 h) was noticed in control (without organics).

The enzyme activities like, urease, phosphatase and dehydrogenase were significantly and positively increased as the results of addition of various organic amendments. The increased urease activity might be due to biomaterials added to the soil as well as root exudates, which promoted the nitrogenous substances, which induced the synthesis of urease. These results are in conformity with Chang *et al.* (2007). According to Zachariah and Chhonkar (2004), an increase in the phosphatase activity indicates the changes and quality in soil phosphoryl substrates. The supply of readily metabolisable C in the applied organics have contributed for the increased phosphatase activity in soil (He and Lin, 1992). The dehydrogenase activity is considered to be an overall indicator of biological activity of soil. The increased dehydrogenase activity might be due to the incorporation of organic amendments to soil which stimulated the varied categories of microorganism and their activity in soil which has increased the dehydrogenase activity. This result was in accordance with the findings of Rao and Patkak (1996).

Yield (Table 4)

The fruit and stover yield of brinjal was significantly influenced by the application of different organic amendments and saline water irrigation. Among the different salinity levels water, bore well water irrigation (S_1) recorded the highest 1941.12 g pot^{-1} in fruit and 812.58 g pot^{-1} in stover yield, respectively. Among the organics evaluated significantly increased the yield of brinjal. However, the effect due to the application of composted coirpith was superior which recorded 2017.18 g pot^{-1} of fruit and 837.21 g pot^{-1} of stover yield, respectively. This was followed by application of composted calotropis (CCT) @ 12.5 t ha^{-1} which recorded 1910.87 g pot^{-1} of fruit and 791.94 g pot^{-1} of stover yield, respectively. The interaction effect the treatment (S_1O_4) supplied with CCP @ 12.5 t ha^{-1} through soil application and bore well water irrigated plants recorded the highest fruit yield (2100.01 g pot^{-1}) and stover yield (878.61 g pot^{-1}) which was 33.42 and 33.27 per cent decrease over higher salinity level and without organics treatment (S_3O_4). This was found to be onpar with treatment S_2O_4. The lowest yield was noticed in (S_3O_1) saline water (EC 3 dS m^{-1} and SAR 6) and without organics. The CCP application could be attributed to the supply of nutrients through mineralization and improvement in physico-chemical properties of the soil and resultant increase in growth and yield characters (Magd *et al.* 2008 and Kader and Linberg, 2010). The reduced pH, EC or soluble salt content and increased organic carbon resulted in increased nutrient availability in soil which made the plant to absorb more nutrients and increased the yield of brinjal, Walker and Bernal, (2008). Further, the number of fruits per plant was not affected in lower salinity, and the yield reduction was entirely due to smaller fruit and reduced DMP (Eltez *et al.*, 2002).

CONCLUSION

The present investigation clearly indicated that the beneficial role of organic manure application under saline water irrigation for improving the yield and nutrient availability of brinjal in coastal sandy soil. From the results of the study, if concluded that soil application of composted coirpith @ 12.5 t ha^{-1} and bore well water irrigation recorded would be beneficial.

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Table 1. Effect of different salinity levels and organic amendments on the available NPK content of the post harvest soil

O / S	Alkaline-$KMnO_4$-N ($mg\ kg^{-1}$)					Olsen-P ($mg\ kg^{-1}$)					NH_4-OAc-K ($mg\ kg^{-1}$)				
	O_1	**O_2**	**O_3**	**O_4**	**Mean**	**O_1**	**O_2**	**O_3**	**O_4**	**Mean**	**O_1**	**O_2**	**O_3**	**O_4**	**Mean**
S_1	69.53	73.63	77.64	81.58	**75.59**	5.95	6.54	7.07	7.58	**6.78**	70.34	75.48	81.18	86.35	**78.33**
S_2	67.63	71.62	75.62	79.57	**73.61**	5.56	6.13	6.72	7.21	**6.40**	66.27	71.88	77.17	82.36	**74.42**
S_3	63.62	67.46	71.47	75.47	**69.49**	4.89	5.54	6.07	6.63	**5.78**	61.36	66.90	72.02	77.27	**69.38**
Mean	**66.92**	**70.90**	**74.91**	**78.85**		**5.46**	**6.07**	**6.62**	**7.14**		**65.99**	**71.42**	**76.79**	**81.99**	

	N SE_D	N CD (p=0.05)	P SE_D	P CD (p=0.05)	K SE_D	K CD (p=0.05)
S	0.53	1.08	0.12	0.25	1.47	2.97
O	1.07	2.17	0.14	0.30	1.74	3.51
S × O	1.49	3.01	0.20	0.41	2.44	4.91

S- Salinity level : S_1–Control; S_2–EC-3 dS m^{-1} & SAR-4; S_3–EC-3 dS m^{-1} & SAR-6

O-Organic manures : O_1–Control; O_2–Farmyard manure @ 12.5 t ha^{-1}; O_3–Composted Calotropis @ 12.5 t ha^{-1} and O_4–Composted coir pith @ 12.5 t ha^{-1}

Table 2. Effect of different salinity levels and organic amendments on the microbial population of the post harvest soil

O / S	Bacteria (× 10^6/g soil)					Fungi (× 10^5/ g soil)					Actinomycetes (× 10^4/g soil)				
	O_1	**O_2**	**O_3**	**O_4**	**Mean**	**O_1**	**O_2**	**O_3**	**O_4**	**Mean**	**O_1**	**O_2**	**O_3**	**O_4**	**Mean**
S_1	20.31	21.27	21.10	22.39	**21.39**	13.92	14.01	14.71	15.06	**14.42**	8.19	8.31	8.49	8.62	**8.40**
S_2	19.96	20.13	21.31	21.48	**20.72**	13.69	13.98	14.13	14.78	**14.14**	8.13	8.23	8.37	8.53	**8.31**
S_3	19.87	20.06	20.18	21.27	**20.34**	13.54	13.83	13.97	14.01	**13.38**	8.01	8.14	8.21	8.39	**8.18**
Mean	**20.04**	**20.48**	**21.03**	**21.71**		**13.91**	**13.94**	**14.27**	**14.61**		**8.11**	**8.22**	**8.35**	**8.51**	

	Bacteria SE_D	Bacteria CD (p=0.05)	Fungi SE_D	Fungi CD (p=0.05)	Actinomycetes SE_D	Actinomycetes CD (p=0.05)
S	NS	NS	NS	NS	NS	NS
O	0.24	0.49	0.13	0.27	0.9	0.18
S × O	NS	NS	NS	NS	NS	NS

S- Salinity level : S_1–Control; S_2–EC-3 dS m^{-1} & SAR-4; S_3–EC-3 dS m^{-1} & SAR-6
O-Organic manures : O_1–Control; O_2–Farmyard manure @ 12.5 t ha^{-1}; O_3–Composted Calotropis @ 12.5 t ha^{-1} and O_4–Composted coir pith @ 12.5 t ha^{-1}

Table 3. Effect of different salinity levels and organic amendments on the enzymatic activities of the post harvest soil

O / S	Urease activity (µg NH_4-N/g soil/24 hr)					Phosphatase activity (µg *p*-nitrophenol/g soil/hr)					Dehydrogenase activity (µg TTF/g soil/24 hr)				
	O_1	O_2	O_3	O_4	Mean	O_1	O_2	O_3	O_4	Mean	O_1	O_2	O_3	O_4	Mean
S_1	30.04	32.02	33.42	34.61	**32.52**	12.87	13.56	14.50	15.02	**13.98**	67.63	72.15	74.66	78.67	**73.27**
S_2	29.39	30.50	31.74	32.10	**30.93**	11.15	12.16	12.85	13.82	**12.49**	64.84	67.40	70.34	74.55	**69.28**
S_3	27.39	28.59	29.64	30.51	**29.03**	10.58	11.39	12.03	12.87	**11.71**	61.53	65.65	68.21	72.41	**66.95**
Mean	**28.93**	**30.37**	**31.60**	**32.40**		**11.53**	**12.37**	**13.12**	**13.90**		**64.66**	**68.40**	**71.07**	**75.21**	

	Urease SE_D	Urease CD (p=0.05)	Phosphatase SE_D	Phosphatase CD (p=0.05)	Dehydrogenase SE_D	Dehydrogenase CD (p=0.05)
S	NS	NS	NS	NS	NS	NS
O	0.37	O.75	0.28	0.57	1.89	3.98
S × O	NS	NS	NS	NS	NS	NS

S- Salinity level : S_1–Control; S_2–EC-3 dS m^{-1} & SAR-4; S_3–EC-3 dS m^{-1} & SAR-6

O-Organic manures : O_1–Control; O_2–Farmyard manure @ 12.5 t ha^{-1}; O_3–Composted Calotropis @ 12.5 t ha^{-1} and O_4–Composted coir pith @ 12.5 t ha^{-1}

Table 4. Effect of different salinity levels and organic amendments on the yield of brinjal

O / S	Fruit yield (g pot^{-1})					Stover yield (g pot^{-1})				
	O_1	O_2	O_3	O_4	Mean	O_1	O_2	O_3	O_4	Mean
S_1	1782.27	1888.48	1993.69	2100.01	**1941.12**	747.29	790.64	834.39	878.61	**812.58**
S_2	1712.15	1819.56	1924.47	2030.79	**1871.69**	700.58	746.90	792.13	838.49	**769.52**
S_3	1598.93	1705.16	1814.36	1920.59	**1759.76**	657.37	703.68	749.31	794.54	**726.22**
Mean	**1697.78**	**1804.33**	**1910.84**	**2017.18**		**701.74**	**747.07**	**791.94**	**837.21**	
	SE_D		CD (p=0.05)			SE_D		CD (p=0.05)		
S	47.76		96.01			1.80		40.11		
O	49.31		99.12			20.42		41.06		
S × O	51.72		103.97			21.24		42.71		

S- Salinity level : S_1–Control; S_2–EC-3 dS m^{-1} & SAR-4; S_3–EC-3 dS m^{-1} & SAR-6

O-Organic manures : O_1–Control; O_2–Farmyard manure @ 12.5 t ha^{-1}; O_3–Composted Calotropis @ 12.5 t ha^{-1} and O_4–Composted coir pith @ 12.5 t ha^{-1}