

Effect of saline water irrigation and organic amendments on the growth and quality characters of cluster bean

Abstract

The pot experiment was carried out to test the salinity tolerance level of MDU - 1 in the presence of organic manures. A pot experiment was conducted in the pot culture yard of the Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Cuddalore District, during January-May, 2024. Crop was raised using selected salinity tolerant Cluster bean variety MDU - 1 as test crop. The experimental soil was sandy loam in texture and taxonomically classified as *Typic Ustifluvent*. The treatments consisted of three levels of salinity viz., S₁-Control (bore well water), S₂(EC-2.5 dS m⁻¹) and S₃(EC-5.0 dS m⁻¹) and four different sources of organic manures viz., O₁-Humic acid (HA), O₂-FYM, O₃-Vermicompost (VC) and O₄-Composted coirpith (CCP). The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications. The results of the pot experiment clearly indicated the response of cluster bean to saline water irrigation and soil application of different organic manures. Among the three levels of salinity tried, the treatment S₁, irrigated through bore well water recorded the highest response in respect of growth and quality characters of *Cluster bean* as compared to saline water irrigation treatment S₂ and S₃. All the sources of organics evaluated proved significant to increase the growth and quality characters of *cluster bean*. However, the effect was much pronounced with vermicompost applied treatments as compared to humic acid, composted coirpith and FYM. Among the various treatment combinations, application of vermicompost at 12.5 t ha⁻¹ through soil and irrigated with bore well water (S₁O₃) excelled the other treatments in respect of the growth, yield and nutrient uptake by cluster bean. However, this was followed by the treatment S₁O₁, which received soil application of humic acid at 30 kg ha⁻¹ and irrigated with bore well water. Further, the quality parameters like crude protein, crude fibre and gum content in cluster bean pods were also positively improved by the application of vermicompost @ 12.5 t ha⁻¹ through soil and irrigated with bore well water (S₁O₃). However, it was followed by treatment S₂O₃ (VC+saline water irrigation). Hence, soil application of vermicompost @ 12.5 t ha⁻¹ and saline water (EC-2.5 dS m⁻¹) irrigation to salinity tolerant cluster bean variety MDU-1 was identified as the best treatment combination for sustainable cluster bean production under saline water irrigation.

Keywords : Saline water, organic amendments, Cluster bean, farming community

Introduction:

Salinity is a major problem throughout the world when excess soluble salts adversely affect soil behaviour by changing its physico-chemical properties and in turn have a strong bearing on the activity of plant growth especially during the early seedling stage. Efforts have to be made to identify crop species which can be able to tolerate increasing soil salinity levels. Such a selection of salinity resistance crops is one of the wider objectives required primarily to increase crop productivity on salt affected lands, thereby enhancing food and income generation option for the poor section of the farming community (Ramanjineyulu et al., 2024; Banti, and Victor Debbarma, 2023). “The most crucial and important stage in the life cycle of species growing in saline environment is the period of seed germination and early development of the seedling” (Ranganathan and Rajalakshmi, 2006). “Salinity stress negatively impacts agricultural yield throughout the world affecting crop production” (Shuji *etal.*, 2002). “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 fresh water 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). 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). Application of organic manures and increased rate of nutrient application for crops in such soils hold promise in improving the fertility and productivity of crops. Several investigators reported that application of organic manures like FYM, compost and or green manuring is one of the easiest methods to mitigate the adverse-effects of use of poor quality of waters like saline or sodic water. Hence the present investigation was carried out to study the effect of saline water irrigation and organic amendments on the growth, quality and nutrient uptake of cluster bean.

Materials and Methods:

The pot experiment was carried out in department of Soil Science and Agricultural Chemistry, Annamalai University during January– May 2024. The texture of the soil was sandy loam and taxonomically classified as Typic ustifluvent with pH-7.9, EC - 0.86 dS m⁻¹ and represented low status of organic carbon (4.2 g kg⁻¹). The soil had low in available nitrogen (174.36 kg ha⁻¹), low in available phosphorus (7.6 kg ha⁻¹) and medium in available potassium (118.3 kg ha⁻¹). The Twelve treatments consisted of three levels of saline water viz., S₁ – control (Bore well water), S₂-Saline water (EC- 2.5) and S₃-Saline water (EC- 5.0) as

factor-A and four different sources of organic manures viz., O₁- Humic Acid (HA), O₂-Farm yard manure (FYM), O₃ – Vermicompost (VC) and O₄-Composted coirpith (CCP) as factor-B. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications using selected saline tolerance clusterbean variety MDU-1 as test crop. The calculated amount of different organics viz., Humic Acid, FYM, vermicompost and composted coir pith was applied just before sowing. A uniform NPK dose of 25:50:25 mg Kg⁻¹ was supplied through urea, super phosphate and muriate of potash to all the pots. The entire dose of NPK were applied as basal. Various growth components like plant height, number of branches plant⁻¹, chlorophyll content, leaf area index (LAI) and dry matter production (DMP). Quality parameters like crude protein, crude fibre, and gum content. The plant samples were collected and analyzed for the concentration of nutrients like N, P and K were estimated using the standard procedure as outlined by Jackson (1973) and uptake were calculated.

Result and Discussion:

Growth characters

Irrigation with different salinity level water and application of different organic amendments favourably influenced the growth characters of clusterbean. Among the three levels of saline water irrigation treatments tried, the treatment S₁, irrigated through bore well water recorded the highest plant height, number of branches per plant, chlorophyll content, leaf area index and Dry matter production (76.92, 11.57, 50.85, 1.14 and 90.58 cm). This was followed by the salinity level S₂ and S₃ saline water irrigation. Irrespective of the salinity levels, all the organic amendments evaluated significantly improved the growth characters of clusterbean. Application of vermicompost @ 12.5 t ha⁻¹ (O₃) recorded the maximum plant height, number of branches per plant, chlorophyll content, leaf area index and Dry matter production (77.26, 10.73, 52.76, 1.17 and 92.42 cm) of clusterbean. This was followed by the treatments (O₁), applied with humic acid @ 30 kg ha⁻¹ and application of composted coirpith @ 12.5 t ha⁻¹ (O₄). The interaction effect due to different saline water irrigation and organic manures on the plant height was significant. Application of vermicompost @ 12.5 t ha⁻¹ by soil application and bore well water irrigation (S₁O₃) recorded the maximum plant height, number of branches per plant, chlorophyll content, leaf area index and Dry matter production, number of branches per plant, chlorophyll content, leaf area index and Dry matter production (82.30, 12.30, 54.70, 1.25 and 96.25 cm) of clusterbean. However, this was followed by the treatment (S₁O₁). All the growth characters viz., plant height, chlorophyll, leaf area index, dry matter production and number of branches at all the growth stages of clusterbean were significantly decreased with increasing levels of salinity. "The decreased growth with the increasing salinity level was possibly due to adverse soil chemical and physical properties,

which hindered plant growth and biomass production". These results are in harmony with those obtained by Kadam *et al.* (2007); Jamaluddin *et al.* (2016) and Patel *et al.* (2024). The results of the study clearly brought out the usefulness of all the organic amendments evaluated in improving the growth and yield of clusterbean. Among various organic amendments, the application of vermicompost accounted for a significantly superior effect in promoting all the growth characters of clusterbean for saline water irrigation. Increased growth of clusterbean with the application of organics might be due to the improvement in nutrient availability and soil property due to the decomposition products such as polysaccharides, polyurenoids, amino acids, humic and growth promoting substances. The earlier report of Rangarajan (1991) corroborates the present findings. Arancon *et al.* (2004) reported that "leaf area increases in vermicompost treated strawberry" (*Fragaria ananassa* Duch.) is due to an increase in microbial population in vermicompost. (Gomes *et al.*, 2011; Xing *et al.*, 2013) who reported "the chlorophyll concentrations of leaves significantly decreased by salinity stress". However, inconsistent results were reported by Junga *et al.* (2011), Akhzari *et al.* (2012) and Chaudhary *et al.* (2021) who stated salinity stress caused increasing chlorophyll concentrations of leaves. Results of the present study are consistent with Berova and Karanatsidis, (2009) and Seerangan *et al.* (2019) "who stated chlorophyll contents increased significantly with vermicompost application". The improved growth characters due to organic manures in saline water irrigated plants might be due to the improved nutrient availability, microbial activity, reduced soluble salts in soil-water, lowered osmotic potential of the soil water and lower leaf water potential required to sustain transpiration. Therefore, plants spent more energy for making osmotic adjustments as reported by Leone *et al.* (2000). Similar results were observed by Abidi *et al.* (2002), Ashraf *et al.*, (2004) and Aslam *et al.*, (2020). "Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B. The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality" (Theusnissen *et al.*, 2010) and (Tharun Kumar *et al.*, 2022).

Quality parameters

The quality parameters of clusterbean viz., Crude protein, Crude fibre and gum content were significantly increased with saline water irrigation and soil application of organic manures. Among the different levels of salinity water tried, the treatment S₁, irrigated through borewell water recorded the highest crude protein (3.14 percent), fibre (13.65 per cent), and gum content (19.47 per cent) of clusterbean. This was followed by the treatments S₂ (EC-2.5 dS m⁻¹) and S₃ (EC-5.0 dS m⁻¹) saline water irrigation. Among the various organic manures evaluated, application of vermicompost @ 12.5 t ha⁻¹ (O₃) was significantly superior in increasing the crude protein (3.24 percent), crude fibre (12.73 percent), and gum content (19.09 percent). This was followed by the treatments

applied with humic acid (HA) @ 30 kg ha⁻¹ (O₁) and application of composted coirpith @ 12.5 t ha⁻¹ (O₄). These treatments recorded the mean crude protein of 3.04 and 2.90 percent, crude fibre content 12.16 and 11.56 percent and gum content 17.86 and 16.56 per cent, respectively. Interaction effect due to saline water irrigation and soil application of organic manures on quality characters of cluster bean was significant. Application of VC @ 12.5 t ha⁻¹ through soil and borewell water irrigation (S₁O₃) to cluster bean fruits registered the highest quality characters like crude protein (3.36 percent), crude fibre (14.70 per cent) and gum content (21.40 per cent). This was closely followed by the treatment (S₁O₁) which received humic acid @ 30 kg ha⁻¹ and irrigated with borewell water. This might be due to improved nutrient environment in the rhizosphere as well as its utilization in the plant system, leading to enhanced translocation of nutrient, vitamins and proteins in pods. Another reason might be due to the increased activity of nitrate reductase which helped in synthesis and sustains amino acid proteins as reported by Chinaswamy and Marikulandi (1966); Lopes *et al.* (1996); Yadav and Vijayakumari (2004); Meena *et al.* (2016); Nagar *et al.* (2017). "Application of organic manures through soil might have increased the nutrient availability which resulted in better accumulation of N content and hence the increased protein content in pods". These results are in accordance with earlier reports of (Olaniyi *et al.*, 2010); (Nithya *et al.*, 2024); Elayaraja *et al.* (2024). "Irrigation with saline water to humic acid supplied with cluster bean also recorded the high protein content, crude fibre content and gum content. This might be due to the direct effect of humic substances depend on biochemical action on cell wall, membrane or cytoplasm, mainly hormonal acting in manner similar to plant growth substances and agricultural humic substances are reputed drought tolerance, enhance nutrient uptake and overall plant performance resulting in increasing quality characters of cluster bean". These results are in partly with results reported by Bhuvaneshwari *et al.* (2020).

NPK uptake

Irrigation of cluster bean with saline water and organics positively increased the uptake of nitrogen by both pod and stover of cluster bean. Among the different levels of salinity tried, the treatment S₁, irrigated through bore well water recorded the highest mean NPK uptake of (513.07, 209.53, 324.98) and (286.42, 77.72, 155.20) mg pot⁻¹ in pod and stover respectively. This was followed by the treatments S₂ (EC-2.5 dS m⁻¹) and S₃ (EC-5.0 dS m⁻¹) saline water irrigated plants by recording the N uptake by pod and stover respectively. Among the various organics evaluated, vermicompost application @ 12.5 t ha⁻¹ (O₃) recorded the highest mean NPK uptake by pod (537.04, 225.93, 339.64 mg pot⁻¹) and stover (297.39, 82.80, 161.70 mg pot⁻¹). This was followed by the treatments, the application of humic acid @ 30 kg ha⁻¹ (O₁), application of CCP @ 12.5 t ha⁻¹ (O₄) and FYM 12.5 t ha⁻¹ (O₂). Regarding the interaction, the application of

vermicompost @ 12.5 t ha⁻¹ and irrigated with borewell water irrigation (S1O3) recorded the highest nitrogen uptake of (585.39, 245.33, 372.88) and (342.82, 90.69, 177.28 mg pot⁻¹ in pod and stover respectively. However, it was followed by the treatment pairs like S1O1, S2O3. The lowest nitrogen uptake by clusterbean pod and stover was noticed in the treatment S3O2 (saline water irrigation and FYM 12.5 t ha⁻¹). The addition of organics through soil and saline water irrigated plants enhanced the uptake of nutrients by clusterbean. This might be due to increased availability of nutrients, minimized soluble salt concentration due to slow and steady release of organic acid during decomposition of organic matter and improvement of favorable soil conditions as created by addition of organic amendments. Similar results were earlier made by El-Missery. (2003). Further, increased major (N, P and K) and micro (Fe, Cu, Zn and Mn) nutrients uptake by crops with application of organics along with saline water irrigation maybe due to improvement of the soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrients from larger rhizosphere. Moreover, organic manures, during decomposition release nutrients, which became available to the plants and increased NPK concentration. The higher nutrients uptake with organic manure might be attributed to solubilization of native nutrients better availability of fertilizers, chelation of micronutrient complex with intermediate organic compounds, their mobilization and accumulation of nutrients by crop plants. These results are in parity with results reported by Salwa *et al.* (2010); Grzebisz *et al.* (2010) and Chesti *et al.* (2015). "Vermicompost contains higher nutrient contents compared to conventional compost and they are more balanced so that their uptake by plant roots is more effective for plant growth stimulation" (Vinothini *et al.* 2016). "The increase in N, P and K concentration might be due to PGPR nitrogen fixation, the enhancement of plant growth by mycorrhizal colonization and enhanced uptake of phosphorus has been reported by Cavender *et al.*, 2003. Increased plant uptake might be related to increased nutrient availability on the soil" (Roy *et al.*, 2006) due to vermicompost application that resulted in increasing soil pH, Physico-chemical properties.

Conclusion:

The present investigation clearly indicated that organic manure application under saline water irrigation improving growth, quality parameters and nutrient uptake of clusterbean. From the results of the study, it was concluded that the soil application of vermicompost @ 12.5 t ha⁻¹ and saline water (EC-2.5 dS m⁻¹) irrigation to saline tolerant clusterbean variety MDU-1 was significantly improved the growth and nutritional quality characters of clusterbean.

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Table 1. Effect of different salinity levels and organic amendments on the plant height, number of branches per plant and chlorophyll content of Cluster bean.

O S	Plant Height(cm)					Number of Branches					Chlorophyll(mg100g ⁻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	79.40	70.90	82.30	75.10	76.92	11.90	10.70	12.30	11.40	11.57	52.40	46.90	54.70	49.40	50.85
S ₂	72.90	65.30	76.80	69.39	71.09	9.90	8.90	10.20	9.50	9.62	51.50	45.40	53.20	48.70	49.70
S ₃	69.10	61.80	72.70	66.20	67.45	9.40	8.19	9.70	8.90	9.04	48.30	43.10	50.40	45.90	46.92
Mean	73.80	66.00	77.26	70.23		10.40	9.26	10.73	9.34		50.73	45.13	52.76	48.00	
	SEd		CD(p=0.05)			SEd		CD(p=0.05)			SEd		CD(p=0.05)		
S	1.13		2.34			0.16		0.33			0.77		1.59		
O	1.31		2.70			0.18		0.38			0.89		1.84		
S×O	2.27		4.68			0.32		0.66			1.54		3.19		

S-Salinity level: S₁–Borewell Water Control; S₂–EC-2.5dSm⁻¹; S₃–EC-5.0dSm⁻¹

O-Organic manures: O₁–Humic Acid 30@kg ha⁻¹; O₂–Farmyard manure@12.5tha⁻¹; O₃–Vermicompost@12.5tha⁻¹ and O₄–Composted coir pith@12.5tha⁻¹

Table 2. Effect of different salinity levels and organic amendments on the leaf area index and dry matter production of Cluster bean.

O S	Leaf Area Index					Dry Matter Production (g pot ⁻¹)				
	O ₁	O ₂	O ₃	O ₄	Mean	O ₁	O ₂	O ₃	O ₄	Mean
S₁	1.16	1.05	1.25	1.11	1.14	93.49	83.64	96.25	88.95	90.58
S₂	1.12	1.02	1.15	1.05	1.08	88.33	78.64	92.39	83.72	85.77
S₃	1.07	0.96	1.13	1.01	1.04	83.15	73.41	88.63	77.12	80.57
Mean	1.11	1.01	1.17	1.05		88.32	78.56	92.42	83.26	
	SEd					SEd				
	CD(p=0.05)					CD(p=0.05)				
S	0.016				0.035	1.36				2.80
O	0.019				0.040	1.57				3.24
S × O	0.033				0.070	2.72				5.61

S-Salinity level :S₁– Borewell Water Control; S₂–EC-2.5 dSm⁻¹; S₃–EC-5.0 dSm⁻¹

O-Organic manures: O₁–Humic Acid 30@kg ha⁻¹; O₂–Farmyard manure@12.5tha⁻¹; O₃–Vermicompost@12.5tha⁻¹ and O₄–Composted coir pith @ 12.5 t ha⁻¹

Table 3. Effect of different salinity levels and organic amendments on the quality parameters of Cluster bean

O \ S	Crude Protein (%)					Crude Fibre (%)					Gum Content (%)				
	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	3.21	2.91	3.36	3.08	3.14	14.10	12.90	14.70	13.3	13.65	20.10	17.30	21.40	18.90	19.47
S ₂	3.05	2.76	3.23	2.90	2.98	12.40	11.10	12.90	11.70	12.02	17.60	14.28	18.70	16.29	16.71
S ₃	2.84	2.62	3.13	2.74	2.84	10.80	9.00	10.60	9.70	9.82	15.90	13.00	17.19	14.30	15.15
Mean	3.04	2.76	3.24	2.90		12.16	10.86	12.73	11.56		17.86	14.92	19.09	16.56	
	SEd		CD(p=0.05)			SEd		CD(p=0.05)			SEd		CD(p=0.05)		
S	0.046		0.096			0.192		0.397			1.278		0.573		
O	0.053		0.111			0.222		0.458			0.321		0.662		
S × O	0.093		0.192			0.385		0.795			0.556		1.147		

S-Salinity level :S₁– Borewell Water Control; S₂–EC-2.5 dSm⁻¹;S₃–EC-5.0 dSm⁻¹

O-Organic manures:O₁–Humic Acid 30@kg ha⁻¹;O₂–Farmyard manure@12.5tha⁻¹;O₃–Vermicompost@12.5tha⁻¹andO₄ –Composted coir pith @ 12.5 t ha⁻¹

Table 4. Effect of different salinity levels and organic amendments on the nitrogen uptake by Cluster bean

S \ O	Nitrogen uptake-Fruit (mg pot ⁻¹)					Nitrogen uptake-Stover (mg pot ⁻¹)				
	O ₁	O ₂	O ₃	O ₄	Mean	O ₁	O ₂	O ₃	O ₄	Mean
S ₁	537.14	437.52	585.39	492.26	513.07	312.12	235.43	342.82	255.34	286.42
S ₂	485.33	387.73	535.56	430.24	459.71	262.83	207.64	287.26	230.92	247.16
S ₃	427.26	342.28	490.19	387.52	411.81	227.54	182.20	262.10	207.26	219.77
Mean	483.24	389.17	537.04	436.67		267.49	208.42	297.39	231.17	
	SEd		CD(p=0.05)			SEd		CD(p=0.05)		
S	7.62		15.73			4.20		8.67		
O	8.80		18.16			4.85		10.02		
S × O	15.24		31.46			8.10		17.35		

S-Salinity level :S₁- Borewell Water Control; S₂-EC-2.5 dSm⁻¹;S₃-EC-5.0 dSm⁻¹

O-Organic manures:O₁-Humic Acid 30@kg ha⁻¹;O₂-Farmyard manure@12.5tha⁻¹;O₃-Vermicompost@12.5tha⁻¹ and O₄-Composted coir pith @ 12.5 t ha⁻¹

Table 5. Effect of different salinity levels and organic amendments on the Phosphorus uptake by Cluster bean

O S	Phosphorus uptake-Fruit (mg pot ⁻¹)					Phosphorus uptake-Stover (mg pot ⁻¹)				
	O ₁	O ₂	O ₃	O ₄	Mean	O ₁	O ₂	O ₃	O ₄	Mean
S ₁	222.11	180.67	245.33	190.02	209.53	84.54	65.26	90.69	70.42	77.72
S ₂	201.25	160.48	227.08	180.19	192.25	72.13	57.70	82.28	65.11	69.30
S ₃	177.79	140.25	205.40	162.00	171.36	62.88	50.38	75.44	60.88	62.39
Mean	200.38	160.46	225.93	177.40		73.18	57.78	82.80	65.47	
	SEd					SEd				
	CD(p=0.05)					CD(p=0.05)				
S	3.16				6.52	1.15				2.37
O	3.65				7.53	1.32				2.27
S × O	6.32				13.05	2.30				4.75

S-Salinity level :S₁– Borewell Water Control; S₂–EC-2.5 dSm⁻¹; S₃–EC-5.0 dSm⁻¹

O-Organic manures: O₁–Humic Acid 30 @ kg ha⁻¹; O₂–Farmyard manure @ 12.5 t ha⁻¹; O₃–Vermicompost @ 12.5 t ha⁻¹ and O₄–Composted coir pith @ 12.5 t ha⁻¹

Table 6. Effect of different salinity levels and organic amendments on the Potassium uptake by Cluster bean

O S	Potassium uptake-Fruit (mg pot ⁻¹)					Potassium uptake-Stover (mg pot ⁻¹)				
	O ₁	O ₂	O ₃	O ₄	Mean	O ₁	O ₂	O ₃	O ₄	Mean
S₁	342.56	272.06	372.88	312.42	324.98	162.64	130.56	177.28	150.32	1545.20
S₂	312.98	240.72	342.29	272.52	291.12	147.18	112.12	165.72	130.44	138.86
S₃	272.32	220.53	303.76	245.20	260.45	130.55	90.93	142.11	115.01	119.65
Mean	309.28	244.43	339.64	276.71		146.79	111.20	161.70	131.92	
	SEd		CD(p=0.05)			SEd		CD(p=0.05)		
S	4.84		9.98			2.30		4.75		
O	5.58		11.53			2.66		5.49		
S × O	9.68		19.79			4.60		9.51		

S-Salinity level :S₁– Borewell Water Control; S₂–EC-2.5 dSm⁻¹; S₃–EC-5.0 dSm⁻¹

O-Organic manures: O₁–Humic Acid 30@kg ha⁻¹; O₂–Farmyard manure@12.5t ha⁻¹; O₃–Vermicompost@12.5t ha⁻¹ and O₄–Composted coir pith @ 12.5 t ha⁻¹

UNDER PEER REVIEW