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Use of Integrated Approaches to Manage Inferior Soil and Water Resources for Rice Production

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Abstract: Wire house pot culture experiments were conducted to monitor the effects of organic amendments and effective microorganisms (EM) on the reclamation of a saline soil material, using canal and brackish water rice crop (*Oryza sativa* L.). Application of green manure and farm yard manure with EM decreased the electrical conductivity (EC_e) and sodium adsorption ratio (SAR) of soils irrigated with canal and brackish water. Green manuring with EM had a significant effect on the vegetative growth of rice, panicle bearing tillers, straw and grain yield. In rice leaves Na^+ concentration was increased.

Key words: Farmyard manure, Green manure, effective microorganisms, brackish water, canal water, salt-affected soil.

Introduction

Undesirable increases in salinity in soil or water is a problem that has confronted civilizations for centuries. But it is not merely a problem of the past. Salinity problems are containing to have a significant impact on society, primarily because of consequent damage to sources of water supply and to agricultural productivity. Land salinization is one of the major decertification processes in Pakistan. Salt affected soils in Pakistan are extended to 6.67 m ha^{-1} (Khan, 1998).

Much evidence indicates that organic manure's facilitate the reclamation of salt-affected soils (Dhawan *et al.*, 1958; Rashid *et al.*, 1986; Swarup, 1991; Ghafoor *et al.*, 1996; Ilyas *et al.*, 1997) and that plant growth is also beneficially affected (Swarup, 1992; Qadir *et al.*, 1996a). Incorporation of organic manures in soil improve the water penetration into soil, even irrigated with high SAR waters. The beneficial effects of organic manures are derived from the evolution of CO_2. Swarup (1992) experimented different organic manures in salt-affected conditions, whereby he found that an increase in nutrient availability was due to CO_2 production, which reduced the pH_s and redox potential (Eh) of the soil. Increased availability of nutrients resulted in the enhancement of yield and mineral uptake of rice.

The expenses of reclamation measures lead the scientists to emphasise on biological methods of soil and water management. In this regard EM technology is an alternate for higher crop production and improved soil quality. Green manure with EM improved the physical properties of top soil (Karim *et al.*, 1992a) and increased the yields and nutrient uptake of rice (Muhammad, 1994). Salt affected soils treated with EM also show better results. EM treated compost can be recommended as an efficient soil amendment in ameliorating a slightly saline soil (Pairintra and Pakdee, 1994). A wire-house study was undertaken to evaluate the effects of organic amendments with EM on the reclamation of salt-affected soil using rice culture.

Materials and Methods

A sandy clay loam soil material was air dried, ground and passed through 2 mm sieve. The experiment consisted of a Complete Randomized Design (CRD) with 3 replications and 5 amendments. Four treatments were organic amendments where FYM and green manure were applied with and without EM. *Sesbania aculeata* was used as green manure and both farmyard manure and green manure were applied at the rate of 10 t ha^{-1} in pots filled with 12 kg of soil. The pots had no leaching provisions. After 20 days 9 uniform rice (*Oryza sativa* L.) seedlings were transplanted 3 per hill in a triangular fashion in all the pots.

Nitrogen was applied in the form of urea at 150 Kg ha^{-1} in two splits, one-half at sowing time and other half at tillering stage. Phosphorus was applied as super phosphate and K as potassium sulphate at the rate of 67 and 62 kg ha^{-1} respectively to all the treatments just before transplantation and were mixed with the surface soil. Two sets of the study were conducted with the same treatments but irrigated with water having different levels of EC, SAR and RSC (Table 1) i.e. one irrigation water was fit according to the criteria for the suitability of irrigation water (U.S Salinity Laboratory Staff, 1954) and in second experiment unfit or brackish water was used. Following plant harvest, the soil was sampled at 0-15 cm depth. Chemical composition of the saturated soil extract and the sodium adsorption ratio were determined. Na^+ and K^+ determinations were made by flame photometry. Ca plus Mg was determined by titration with EDTA. CO_3 and HCO_3 analysis was carried out by titration with acid using phenolphthalein and methyl orange as indicators as described by Chapman and Pratt (1961). Chloride concentration was determined by chloride analyzer.

Rice tissues and Y-leaf blades (Second leaf below the panicle) were sampled at flower emergence and plant harvest stages. Frozen leaf samples were thawed and crushed thoroughly using a glass rod and centrifuged at 1500 rpm for 15 minutes. The supernatant cell sap was removed by micropipette and stored in opendroff tubes. After dilution with distilled water, subsequent analysis for Na^+, K^+ and Cl^- was done.

Data for yield and yield components and the composition of soil and saturation extracts were subjected to analysis of variance and Duncan Multiple Range Test.

Results and Discussion

Soil Characteristics: The effect of amendments along with EM on the properties of soils, irrigated with canal and brackish water are shown in Table 2. The Na^+ (SAR) in soil water tends to increase while soluble salts (ECe) tend to decrease the pH_s (Cruz-Romero and Coleman, 1975; Bajwa *et al.*, 1983; Minhas, 1996). Consequently, pH_s, attains values in response to the interactive effect of ECe and SAR of the soil-water system. In control and EM alone the pH remained more or less constant after harvesting. incase of canal water irrigation. In case of EM treatment no change in pHs might be because of poor microbial count due to lack of carbon as an energy source (Hussain *et al.*, 1999). Incase of canal water irrigation, the FYM and GM amendments caused statistically significant decrease in pH up to 8.33 and 8.26 respectively. Because during the decomposition of green

Table 1: Original soil and irrigation water analysis

Analysis of	SAR (m mol $L^{-1})^{½}$	EC/EC_e (dSm^{-1})	pH_s	RSC
Soil	25.86	6.08	8.36	---
Canal Water	2.20	0.30	---	0.6
Brackish Water	12.32	2.67	---	9.40

Table 2: Influence of organic amendments with EM on the soil characteristics

	pH_s		EC_e		SAR	
Amendments	Canal Water	Brackish water	Canal water	Brackish water	Canal water	Brackish water
None (Control)	8.39e	8.80d	6.10f	8.65f	19.08e	32.86dc
EM only	8.38e	8.80d	6.04e	8.30e	19.00e	31.33d
FYM	8.33d	8.74c	5.96d	8.17d	18.07d	30.01d
FYM+ EM	8.32c	8.70bc	5.80bc	8.10c	17.60c	27.46c
GM	8.26b	8.68b	5.80b	7.98b	16.90b	22.18b
GM+ EM	8.21a	8.60a	5.24a	7.80a	15.18a	20.18a

*EM Effective emicorrganisms
*FYM Farm yarn manure
*GM Green manure
*EC Electrical conductivity in dSm^{-1}
*SAR Sodium adsortpion ratio (m mol $L^{-1})^{1/2}$

Table 3: Influence of Soil amendments with EM added to salt-affected soil on yield and yield components of rice plant.

Treatment	Height (cm)	Straw wt/pot	Grain wt/pot	No of tillers/pot	Panicle bearing tillers
			g		
With canal water					
None	47.90d	94.10d	33.60d	42e	39.00f
EM only	47.30d	96.28cd	48.40c	48d	41.60e
FYM	50.80c	99.10c	47.60c	49d	44.00d
FYM+EM	55.60b	111.80b	53.80b	58c	51.00c
GM	54.5-b	112.00b	54.80b	64b	58.60b
GM+EM	61.40a	122.00a	60.80a	75a	64.00a
With brackish water					
None	30.60e	60.00f	20.00f	20.00b	17.00c
EM only	32.60d	63.00e	26.00e	21.00b	17.00c
FYM	34.70c	67.60d	29.20d	21.00b	18.00c
FYM +EM	36.80b	73.00c	33.40c	23.33b	20.00b
GM	37.00b	76.00b	36.00b	25.00ab	22.00b
GM+EM	40.20a	80.10a	41.00a	28.00a	25.00a

Table 4: Chemical composition of rice irrigated with canal and brackish water

Treatment	Na		K		Cl	
	Canal	Brackish	Canal	Brackish	Canal	Brackish
Non	64.00d	68.00c	221.00d	240.00c	172.00c	185.00c
EM only	60.00c	67.00c	223.00d	243.00c	170.00c	184.00c
FYM	61.00c	67.00bc	230.00c	244.00c	164.00bc	184.00bc
FYM + EM	58.00b	65.00b	239.00b	251.00b	160.00b	180.00b
GM	58.00b	64.00b	239.00b	256.00b	159.00b	178.00b
GM + EM	52.200a	60.00a	256.00a	264.00a	150.00a	170.00a

manures, considerable amount of organic acids are liberated, which bring down the soil pH to some extent besides forming a number of salts with sodium on exchange complex. The results are in line with those of Palaniappon and Budha (1992). In case of brackish water irrigation FYM and GM application alone or with EM showed decreasing trend in soil pHs. This might be due to active role of lactic acid bacteria and photosynthetic bacteria which liberated lactic acid and H^+, respectively while getting carbon from organic sources. Zia *et al*. (1999) also reported the superiority of organic amendments with EM to lower down pH_s. Changes in EC_e are shown in Table 2. All the treatments showed a decreasing trend in EC_e but along with EM, the results were pronounced. This might be due to the reason that dispersion effect of Na^+ was mitigated by the appliecation of organic amendments (Naidu and Rengasamy, 1993; Abbas, 1996). The high amount (due to infiltration rate and improved physical properties of soil) of water passing through soils helped to leach soluble salts and decreased EC_0 (Oster, 1982; Hussain *et al*., 1986; Shainberg *et al*., 1989). Ahmad (1999) and Karim *et al.* (1992b) also reported that the use of EM culture with organic amendments improves physical properties of the soil. These under the brackish water treatments showed less effectiveness of all the amendments although EC_e is decreased as compared to control.

The SAR is associated with the sodic hazards of irrigation waters. Sodium (SAR/ESP) in soils tends to disperse the soil resulting in decreased water intake rate and root penetration. Changes in soil SAR are shown in Table 2. All amendment treatments eventually lowered the SAR, reflecting their effectiveness in dissolving and penetrating Na^+ in soil. Green manure along with EM gave better results both with canal and brackish water irrigation. Here the superiority of GM+EM treatment may be due to high Ca^{+2} contents and microbes, which further enhanced mineralization rate. Studies conducted by Zia *et al*. (1999) and Shukla and Pandey (1988) are also in line with the results. Hussain *et al*. (1991) also reported that microbes (EM) increase the availability of nutrients. The valance dilution effect (Eaton and Sokoloff, 1935) has definitely been responsible in the reclamation of the soils particularly with FYM and GM application. It is also established fact that once the soil is put under cultivation of crops, some Ca^{+2} is made available through the dissolution of soil line under the action of plant roots and soil microorganisms (Alderfer, 1964; Ahmad *et al*., 1990; Qadir *et al*., 1996b). The effectiveness of organic amendments has also been shown by Chand *et al*. (1977), Haider and Hussain (1976) and Naidu and Rengasamy (1993) during soils reclamation. Soils with adequate organism matter are efficient in maintaining proper nutrient level, IR and soil pH.

Crop Growth and Yield: The plant is a sensitive indicator of the efficiency of reclamation reported by Overstreet *et al.* (1951). Data showing the influence of organic amendments appliedwith and without EM on yield and yield components of rice plants is presented in Table 3. Plants growth and grain yield were increased significantly with all the treatments however maximum increase was observed in green manured pots with EM. Green manure alone and FYM + EM were found equally beneficial.

Green manuring along with EM was also effective in case of irrigation with brackish water. The CO_2 released during decomposition of GM solubilizes soil $CaCO_3$ to make Ca^{2+} more available for countering the sodic hazard of irrigation waters.

$$CaCO_3 + CO_2 + H_2O = Ca(HCO_3)_2$$
$$X\text{-}Na^+ + Ca\,(HCO_3)_2 = X\text{-}Ca^{+2} + 2NaHCO_3$$

Yield decline in controlled pots may be attributed to the accumulation of salts injurious to the crop and nutritional imbalances (Pearson, 1960; Munns *et al.*, 1982; Maas and Hoffman, 1977). Organic amendments with EM performed better that might be due to high solubility effect as well as high contents of Ca,P plus other nutrients and microbes, which further enhanced their availability. Hussain *et al.* (1991) and Zia *et al.* (1999) also reported similar results.

Yield was lower in brackish water irrigation treatments, which might be due to the reason that the EC_e remained high (>6.0 dSm^{-1}) than that at which 50 percent yield reduction is expected (Van Schilfgaarde, 1994; Aslam, 1987; Bresler *et al*., 1982).

Chemical Composition of Rice: Effects of various treatments on the chemical composition of plants are given in Table 4. Application of organic amendments in canal irrigated as well as brackish water applied soils, helped plants to take up lesser quantity of hazardous ions i.e. Na^+ and Cl^- which improved the uptake beneficial element i.e. K. Similar results have been reported by Madaliar and Sharma (1965), who reported that manures when decompose in soils release CO_2 which mitigates alkalinity besides making it more permeable. The CO_2 so released solubilizes soil $CaCO_3$ to make Ca^{+2} more available for countering the sodic hazard of irrigation water. Organic amendments worked more efficiently when applied along with EM. Green manuring was found better than FYM and EM. EM applied alone could not perform effectively probably due to lack of carbon as an energy source.

Conclusions

Considering all the parameters, it is evident that organic manures i.e. FYM and GM are beneficial for the reclamation and management of salt affected soil and brackish water for sustaining crop growth and yield. With the addition of EM, the effectiveness of organic amendments can be improved further.

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