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Growth of Castor (*Ricinus Communis* L.) on Newly Reclaimed Saline-Sodic Soil as an Indicator of Soil Quality Improvement

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Abstract: The present study was conducted in two phases; 1st phase includes soil reclamation experiment and 2nd phase includes the growth performance of castor on post reclaimed saline sodic soil. The effects of Leaching (control), gypsum, FYM and FYM+Gypsum, later decomposed for 4, 8 and 12 weeks along with non-decomposed were assessed on reclamation of saline sodic soil. After 2 months of the reclamation process in columns the castor bean was grown on post reclaimed soil. The results suggested that the combination of FYM+Gypsum, produced the highest mean and relative plant growth, similarly the longest decomposition period, i.e. 12 weeks decomposition produced highest mean plant growth and relative ratios. It has been concluded that the reduction in EC and SAR does not ensure the productivity of reclaimed soil. The simple SQII developed showed that plant growth can be a good indicator of productive soil after reclamation.

Keywords: Saline sodic soil, Decomposition periods, Soil quality improvement index, plant growth, FYM+Gypsum

1. INTRODUCTION

The crop growth and productivity is greatly reduced by soil salinity and sodicity. About 560×10^6 hectares of sodic and saline-sodic soils present worldwide (Tanji, 1990), require efficient and successful reclamation. The plant growth on such soils is adversely affected by root zone salt built up (Buchanan *et al*., 2005). The reclamation of such soils, is dependent on the displacement of Na^+ from productive soil horizons by Ca^{++} thus gypsum, as source of soluble Ca^{++} has been used as amendment by several workers (Hanay *et al*., 2004; Amezketa *et al*., 2005; Wong *et al*., 2008; Wong *et al*., 2009).

The Several workers (Li and Keren 2009; Mehmoodabadi *et al*., 2013) have used organic manures successfully for reclamation of saline sodic soils. Most of the studies show that organic manure as well as inorganic amendments are applied directly i.e. without prior decomposition (Prapagar *et al*., 2012; Tejada *et al*., 2006; Liang *et al.*, 2005). Only a little work has been done on the effects of composted manures on soil restoration. Tejada *et al*., (2009) has observed the effects of composted green plant residue on restoration of Xelloric Calciorthid soils.

The different decomposition periods have been suggested for different manures for example, (Jouraiphy *et al.* 2005) found 60% decomposition of sewage waste and green plant waste after 135 days, Huang *et al.* (2006) observed 63 days of decomposition of pig manure along with saw dust, and Hsu and Lo (1999) decomposed pig manure for 122 days. But there is a lack of literature which may analyze the decomposition period of organic manure to be used for reclamation.

Improvement in physical, chemical and biological soil quality due to application of organic manures has been studied by several workers (Prapagar *et al*., 2102; Mehmoodabadi *et al*., 2013 etc). (Lee *et al*. 2006) found that soil quality index can be an effective tool to assess soil quality. Many other workers have integrated physical, chemical and biological indicators due to their close interaction with each other in soil (Sparling *et al*., 2004; Lee *et al*., 2006; Romaniuk *et al*., 2011). Among the biological indicators, however, plant growth and yield has been either ignored or less studied.

Thus, the present study is an approach to include plant growth characteristics to construct a simple SQI. Another objective of this study is to reveal the effectiveness of decomposition periods and compost, manures on saline sodic soil quality improvement.

2. MATERIALS AND METHODS

Soil Reclamation experiment

A soil column, made in polythene bags of 91.44×7.62 cm size, experiment was conducted to reclaim saline sodic soil at net house of the Institute of Plant Sciences, University of Sindh, Jamshoro. The soil used was sampled from natural saline-sodic fields adjacent to KB feeder Jamshoro (initial soil characteristics given in **(Table 1**). The soil was mixed thoroughly with treatment and incubated for 8 weeks (2 months). The soil amendments were gypsum, farm

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manure (Buffalo dung) and combination of both. The farm manure and mixture of farm manure and gypsum were decomposed prior to mixing with soil samples. For decomposition the 1 kg of farm manure and farm manure + gypsum (1:1) were filled with self sealing polythene bags. The bags were buried in 18" deep ditches dug in soil under natural environmental conditions. The moisture content was kept at 80% of compost throughout the decomposition period. The bags were kept for decomposition for 3 different periods, i.e. 4 weeks, 8 weeks and 12 weeks.

Table-1. Initial characteristics of soil and FYM used in experiments

Characteristic	Soil	FYM
Texture	Silty Clay laom	---
% Aggregates <0.25 mm 0.25-1.00 mm >1.00 mm	 86.0 12.0 2.0	---
ECe dSm^{-1}	8.68	0.24
pH	9.02	7.86
SAR mmol L^{-1}	78.25	0.56
*Organic Matter %	0.774	36.54
**Organic carbon C %	0.45	61.65
N g Kg^{-1}	0.9	185
Na Meq L^{-1}	176.23	0.67
Ca Meq L^{-1}	3.24	1.65
K Meq L^{-1}	0.67	2.34
* Determined by multiplying Organic Carbon with 1.72		
** Determined by modified Walkley-Blake method		

The experimental design

The experimental units were decomposition periods and treatments. The three decomposition periods i.e. 4, 8 and 12 weeks along with non-decomposed control and three treatments, i.e. Gypsum, Farm manure (Buffalo dung) and a combination of both along with leaching as control was used. The gypsum was used @ 100% soil requirements, Farm manure @ 20g Kg^{-1} soil (w/w) and farm manure+gypsum @ 10g Kg^{-1}+50% soil requirement. The experiment was conducted in RCBD with four replications to each experimental unit.

Soil analysis

The soil samples were collected and analyzed before and after reclamation. The samples were brought to the laboratory, air dried and crushed to pass 2.0 mm sieve. Further the samples were analyzed chemically. The Cations i.e. Na^+, K^+, Ca^{++} and Mg^{++} were analyzed by the method of Richrds (1954), (US soil salinity Staff handbook 60. 1954). The cations were extracted through normal 1 N ammonium acetate solution. The extracted Na^+ and K^+ were analyzed through Flame photometer (Ciba-Corning Inc) while, Ca^{++} and Mg^{++} were analyzed by titration with EDTA using ammonium chloride-ammonium hydroxide as buffer and Eriochrome black T as an indicator. The cation exchange capacity (CEC) cmol kg^{-1} was measured by Flame photometer (Richards, 1954). The SAR was measured by the equation:

$$SAR_{se} = \frac{Na}{\sqrt{\frac{Ca^{2+}\,Mg^{2+}}{2}}}$$

Organic carbon was determined by a modified Walkley-Black method (Nelson and Sommers, 1982) and organic matter was estimated from organic carbon by multiplying the organic carbon by 1.72. The Nitrogen was measured through Kjeldhal method.

Castor bean (Riccinus communis) growth experiment

After 02 months of incubation period the columns were cut horizontally and the soil (except quartz sand) was transferred without disturbing, to cemented pots of column size. The 10 seeds of castor bean (soaked in distilled water for 24 hours) were sown in each pot.

The growth indicators and soil quality improvement indices

The Shoot length, root length, root penetration ratio (the length of soil column to which root penetrated in treatment and control), shoot fresh weight and dry weights were calculated and analyzed. The cumulative growth ratio was used as soil quality improvement index (SQII) which assesses the soil quality improvement based upon plant growth and soil parameters. The SQII were calculated by;

SQII based upon growth parameters; $RGR_t \frac{\sum G_{ti}}{\sum G_c}$ (1)

SQII based upon soil salinity and sodicity changes; $RGR_t = \frac{\sum EC,SAR_{ti}}{\sum EC,SAR_c}$ (2)

SQII based upon soil organic matter changes; $RGR_t = \frac{\sum OM,OC_{ti}}{\sum OM,OC_c}$ (3)

Where, G_{ti} is sum of all growth parameters, i.e. shoot length, fresh weight, dry weight, root length and root penetration ratio under i^{th} treatment and G_c is sum of all growth parameters under control.

Statistical analysis

The data were subjected to one way and two way analysis of variance (ANOVA). The F-test was used to identify initial treatment main effects followed by the Tuekey's pairwise comparison least significant differences (LSD) test at p=0.05. All the analysis was done using Minitab V-16® (Minitab Inc.).

3. RESULTS AND DISCUSSION

Reclamation experiment

The results are presented in final to initial ratios calculated by dividing the the final value with initial.The mean ratios showed that there were highly significant differences ($p<0.001$) among decomposition periods **(Fig. 1 top)** as well as among the treatment for various soil parameters. The highest ECe and SAR were reduced in 12 weeks of decomposition followed by, 8 weeks while the lowest were found in non-decomposed and 4 weeks of decomposition. The highest EC and SAR were removed by Gypsum followed by FYM+ Gypsum **(Fig 1 bottom)**. These findings confirm the work of (Prapagar *et al*. 2012) (Gharaibeh *et al* 2009) and several other workers who observed gypsum as best sodium removal amendment from soil exchange sites.

The organic matter and organic carbon were highest in 12 weeks decomposition and lowest in non-decomposed followed by 4 weeks decomposition periods. Both organic matter and organic carbon increased many folds from the initial value **(Fig 1 top).** The highest values of organic matter were found in 12 week decomposition followed by 8 weeks, which highlights the importance of FYM decomposition prior to application. The FYM alone produced highest organic matter and organic carbon followed by FYM+Gypsum **(Fig. 1 bottom).**

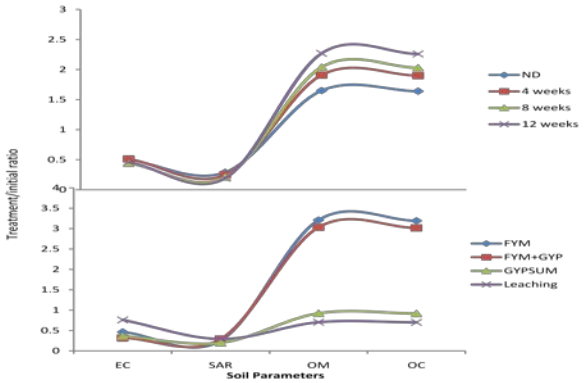

Fig.1. The treatment /initial plot showing the increase and decrease in soil parameters over initial. The ECe and SAR decreased significantly while OM and OC increased significantly than the initial value.

Castor growth experiment

The results of growth parameters are presented in **(Fig. 2 A-E).** The results showed that all the growth parameters of castor were significantly affected by both decomposition periods and treatment used for reclamation of saline sodic soil. All of the growth parameters remained unaffected in leaching and but, however, the FYM and FYM+Gypsum significantly produced higher growth and root penetration ratio. The non-decomposed and 4 week decomposition produced statistically non-significant differences. Similar results were found by (Behzad *et al*., 2011). The FYM+ Gypsum were most efficient amendment in terms

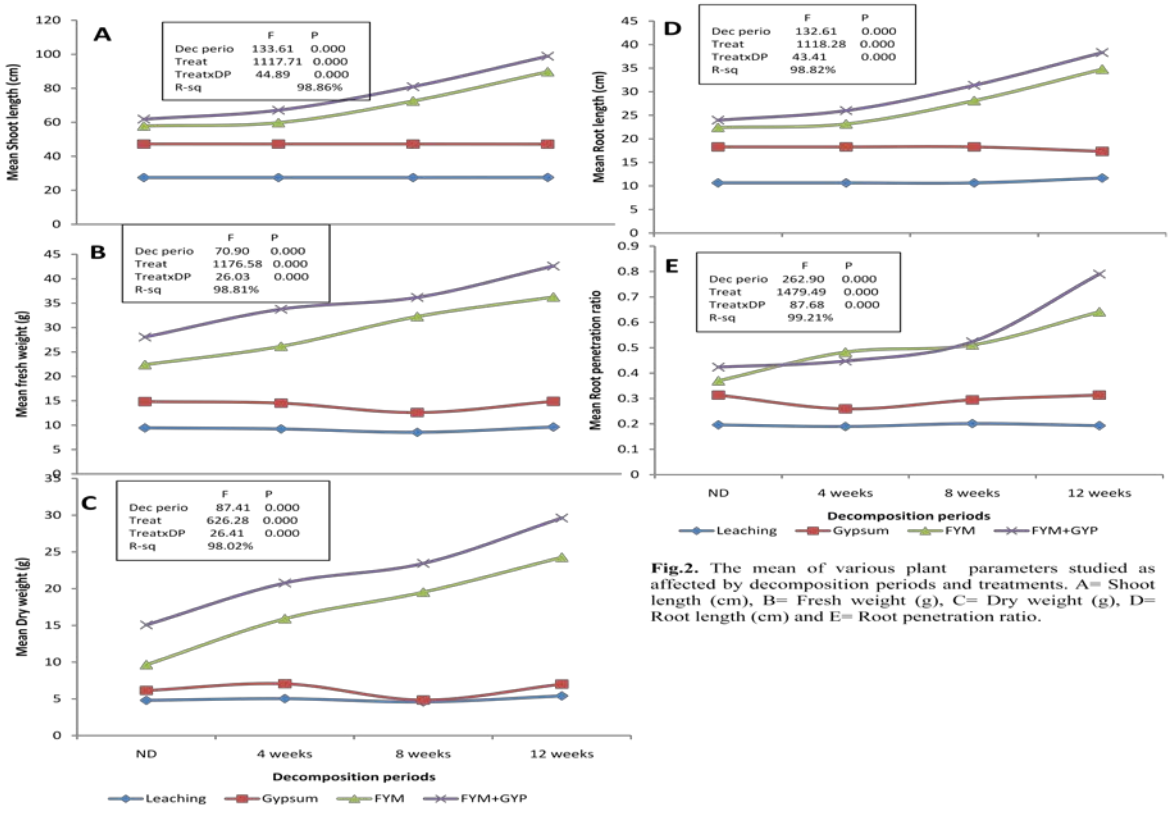

Fig.2. The mean of various plant parameters studied as affected by decomposition periods and treatments. A= Shoot length (cm), B= Fresh weight (g), C= Dry weight (g), D= Root length (cm) and E= Root penetration ratio.

of biomass production because it had dual effects. The prolonged decomposition of organic amendments (i.e. 8 and 12 weeks) produced higher biomass than non-decomposed and 4 week decomposition.

Soil quality improvement indices (SQII) The soil quality, in its specific context, is an assessment of soil function and use (Garrigues *et al*., 2012). Wilkins (1978), has suggested that treatment to control relative ratios of root length can be used as tolerance index to chromium stress. The SQII for treatment and decomposition period effects are presented in **(Fig.3 (A-B)** respectively. The straight line in **Fig. 3 A and 3 B** shows control which has been used to show the increment or decrement in treatment or decomposition period. The gypsum significantly reduced salinity ($p<0.001$) than leaching, FYM and FYM+Gypsum but produced significantly lowest plant growth. On the other hand organic matter was highest in the FYM+Gypsum and FYM while it was also lowest in gypsum treatment **(Fig 3 A).** The highest plant growth is associated with both removal of salinity in terms of Na^+ and increase of organic matter and organic carbon along with nutrients.

The SQII under decomposition periods has shown similar results and highest salinity reduction was found in 12 weeks of decomposition followed by 8 weeks while 4 weeks had lowest effects on salinity reduction. The growth was found highest in 12 weeks, followed by 8 weeks, similarly organic matter increment was also highest under 12 weeks of decomposition **(Fig 3 B).**

4. CONCLUSION

The SQII indicates that merely the lowering of salinity in terms of reduction in EC and SAR does not prove the quality of soil as plant growth was found lowest in gypsum and leaching. It is concluded thus, that organic manures if applied in combination with gypsum and decomposed for 12 weeks produce highest plant growth thus improve maximum soil quality.

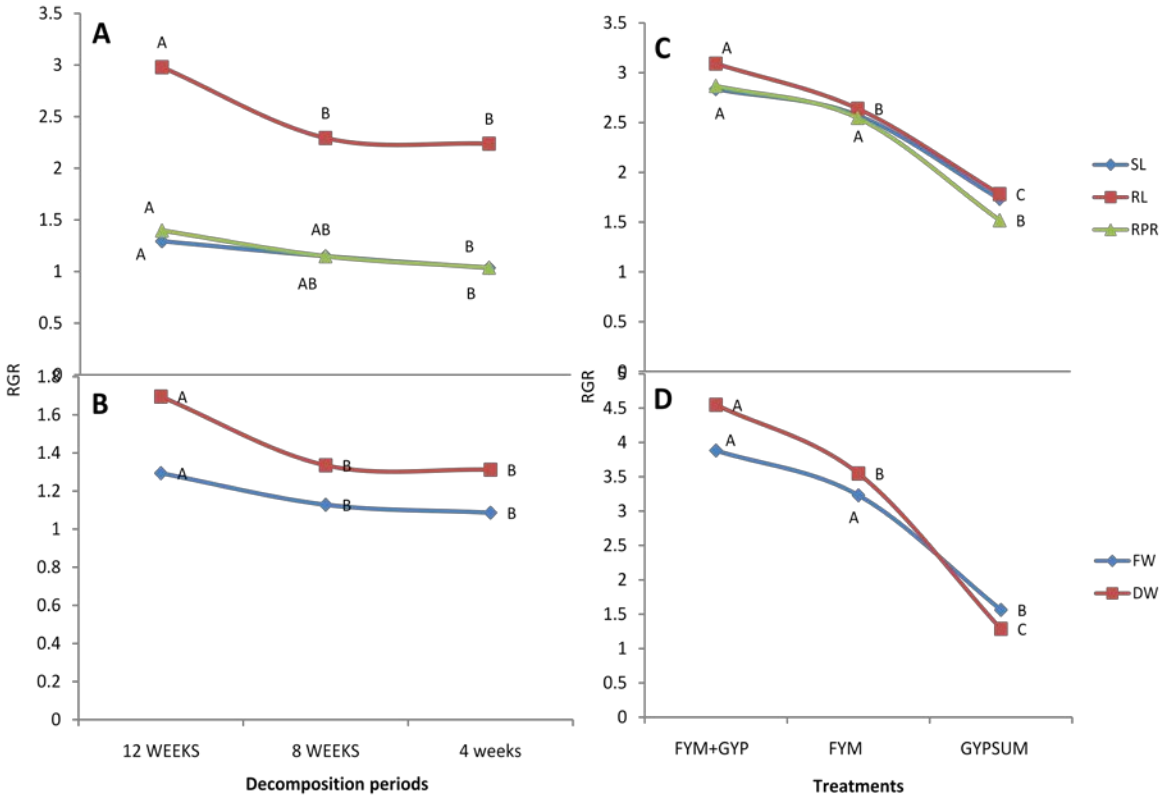

Fig. 3. The relative growth rates of shoot length (SL) cm, Root lenngth (RL) cm, Root penetration ratio (RPR), Fresh weight (FW) g and Dry weight (DW) g of castor seedings. The relative growth ratio is change in growth paprameters in treatments as compare to control. The A and B shows SL (Shoot length), RL (Root length), RPR (Root penetration ratio), FW (Fresh weight) and DW (Dry wieght) affected by decomposition periods respectively. The C and D SL (Shoot length), RL (Root length), RPR (Root penetration ratio), FW (Fresh weight) and DW (Dry wieght) treatments respectively. The significant differences are analyzed between decompsoition periods and treatments only. The data points shairng different letters are non-significant at $p<0.001$.

REFERENCES:

Behzad, M., G. Murtaza, Z. R. Muhammad, A. Ghafoor, A. Saqib and S. Muhammad, (2011) Reclamation of salt-affected soils using amendments and growing wheat crop. Soil Environ. 30(2): 130-136.

Buchanan, B., M. Owens, J. Mexal, T. Ramsey and B. Musslewhite, (2005) Long-term effects of cover soil depth on plant community development for reclaimed mined lands in New Mexico. National Meeting of the American Society of Mining and Reclamation, Breckenridge, CO June 19-23, 2005. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

Fattah, M. K. A., (2012) Role of gypsum and compost in reclaiming saline-sodic soils. IOSR journal of Agriculture and veterinary Sci. (IOSR-JAVS), vol. 1(3): 30-38.

Garrigues, E., M. S. Corson, D. Angers, H.M.G. Van der Werf, C.Walter, (2012) Soil quality in life cycle assessment: Towards development of an indicator. Ecol Indicators 18:434-442.

Gharaibeh, M. A., I. E. Nabil and F. S. Ola, (2009) Leaching and reclamation of calcareous saline-sodic soil by moderately saline and moderate-SAR water using gypsum and calcium chloride. J. Plant Nutr. Soil Sci. 172: 713–719.

Hanay, A., F. Buyuksanmz, F. M. Kiziloglu and M.V. Canbolat, (2004) Reclamation of saline-sodic soils with gypsum and MSW compost. Compost Science and Utilization 12 (4): 175–179.

Hsu, J. H. and S. L. Lo, (1999) Chemical and spectroscopic analysis of organic matter transformations during composting of pig manure. Environmental Pollution 104: 189-196.

Huang, G. F., Q.T.J. Wu, W. C. Wong and B. B. Nagar, (2006) Transformation of organic matter during co-composting of pig manure with sawdust. Bioresource Technology, 97: 1834–1842.

Jalali, M. and F. Ranjbar, (2009) Effects of sodic water on soil sodicity and nutrient leaching in poultry and sheep manure amended soils. Geoderma 153: 194–204.

Jouraiphy, A., A. Soumia, Mohamed El Gharous, R. Jean-Claude and M. Hafidi, (2005) Chemical and spectroscopic analysis of organic matter transformation during composting of sewage sludge and green plant waste. doi:10.1016/j.ibiod.2005.06.002

Lee C. H., Y.W. Mao, C. Zueng-Sang (2006) Using a soil quality index to assess the effects of applying swine manure compost on soil quality under a crop rotation system in Taiwan. Soil Science 171: No. 3.210-222.

Li, F. H. and R. Keren, (2009) Calcareous sodic soil reclamation as affected by corn stalkcapplication and incubation: a laboratory study. Pedosphere 19(4) 465–475

Liang, Y., S. Jin, N. Miroslav, and J. Yun, (2005) Organic manure stimulates biological activity and barley growth in soil subject to secondary salinization. Soil Biology and Biochemistry 37: 1185–1195.

Mahdy, A. M., (2011) Comparative effects of different soil amendments on amelioration of saline sodic soil. Soil & water res., 6(4): 205-216.

Nelson, D. W., and L. E. Sommer, (1982) Total carbon, organic carbon, and organic matter. p.. In A.L. Page (ed.) Methods of Soil Analysis. 2nd Ed. ASA Monogr. 9(2). Amer. Soc. Agron. Madison, WI. 539-579

Prapagar, K., S.P. Indraratne and P. Premanandharajah (2012) Effect of Soil Amendments on Reclamation of Saline-Sodic Soil. Tropical Agricultural Research 23 (2): 168 –176.

Richards, L.A. (1954) United States Salinity Laboratory Staff Agriculture Handbook No. 60 60Pp.

Romaniuk, R., G. Lidia, R. Rosario (2011) A Soil Quality Index to Evaluate the Vermicompost Amendments Effects on Soil properties. Journal of Environmental Protection, 2: 502-510.

Ruf, A., L. Beck, P. Dreher, K. Hund-Rinke, J. Ro¨mbke and J. Spelda, (2003) A biological classification concept for the assessment of soil quality: "biological soil classification scheme" (BBSK). Agriculture, Ecosystems & Environment 98: 263-271.

Sheoran, V., A. S. Sheoran and P. Poonia, (2010) Soil Reclamation of Abandoned Mine Land by Revegetation: A Review. International Journal of Soil, Sediment and Water, 3 (**2**): Article 13. Available at: http://scholarworks.umass.edu/intljssw/vol3/iss2/13

Sparling, G. P., L. A. Schipper, W. Bettjeman and R. Hill, (2004) Soil quality monitoring in New Zealand: practical lessons from a 6-year trial. Agriculture, Ecosystems & Environment 104: 523-534.

Tanji, K. K. (1990) Nature and extent of agricultural salinity. In: Agricultural salinity assessment and management, ed. KK Tanji, American Society of Civil Engineers, New York, 1–17.

Tejada, M., M. T. Hernandez, (2009). Soil restoration using composted plant residues: Effects on soil properties. Soil & Tillage Research 102: 109–117.

Wilkins, D. A. (1978) The measurement of tolerance to edaphic factors, by means of root growth. New Phytol. 80: 623-633.

Wong, V. N. L., R. C. Dalal, (2008) Salinity and sodicity effects on respiration and microbial biomass of soil. Biology and Fertility of Soils 44: 943–953.