

Original Research Article

Effect of amendments on physicochemical and biological properties of sodic soil and yield of rice

ABSTRACT

Sodic soils are low in available nutrients, organic carbon, microbial population and enzyme activities. Amendments application not only used to improve the soil physico-chemical properties and also increase soil organic carbon and biological activity. Field experiment was conducted in sodic soil using rice (CO 52) as a test crop with various amendments viz., gypsum+ green manure, green leaf manure and press mud. The influence of amendments on reclamation as well as availability of plant nutrients and biological activity were studied. The microbial population viz., bacteria, fungi and actinomycetes and enzyme activity viz. dehydrogenase, phosphatase and urease were increased on reclamation over control. Higher microbial population and greatest enzyme activities were observed in the Gypsum+ GM applied treatments followed by GLM and press mud applied plots. Sodic soil reclamation using various amendments resulted in enhanced crop yield, physicochemical and biological properties of soil.

Keywords: Gypsum +GM, GLM, Press mud, Microbial population, Enzyme activity.

1. INTRODUCTION

Salt affected refers to soils that are saline or sodic. Many countries of arid and semi-arid climates having salt affected soils. Sodicity not only affect the chemical and physical properties of soils, but also inhibit several soil enzyme activity, such as alkaline phosphatase, β -glucosidase and microbial respiration[1]. Sodic soil are normally poor in biological properties with low organic carbon content and lower microorganism[2]. Microbial activity plays an important role in organic matter decomposition, nutrient mineralization[3]. Sodic soils reclamation not only increased the nutrients and also increased the microbial activity[4]. Hence this study was undertaken to investigate the influence of amendments on microbial and enzyme activity of sodic soil.

2. MATERIALS AND METHODS

The soil of the experimental site belongs to Madukhur series, clay loam in texture, highly sodic (pH 9.98), low in EC (0.35 dS m^{-1}), low in organic carbon (0.46%), low in available nitrogen (221 kg ha^{-1}), medium in available phosphorus (11.2 kg ha^{-1}) and potassium (126 kg ha^{-1}) having ESP of 29.6%. The microbial population viz., bacteria, fungi, actinomycetes of initial soil was $12.05 \times 10^7 \text{ CFU g}^{-1}$ soil, $2.56 \times 10^2 \text{ CFU g}^{-1}$ soil, $1.28 \times 10^3 \text{ CFU g}^{-1}$ soil and the enzyme activity viz., Actinomycetes ($\times 10^3 \text{ CFU g}^{-1}$ soil), Dehydrogenase ($\mu\text{g TPF g}^{-1} \text{ hr}^{-1}$), Urease ($\mu\text{g NH}_4\text{-N g}^{-1} \text{ hr}^{-1}$) and Phosphatase ($\mu\text{g nitrophenol g}^{-1} \text{ hr}^{-1}$) were 1.28, 1.06, 1.37, 2.91 respectively. The amendments gypsum @ 50% GR+GM @ 6.25 t ha^{-1} , GLM @ 12.5 t ha^{-1} and press mud @ 10 t ha^{-1} were used as amendments for the reclamation of sodic soil by adopting standard reclamation procedure and the treatments without amendment was maintained as control. Different levels of ZnSO_4 application were imposed as sub-plot treatments. The treatments were replicated thrice. Each treatment was super imposed with recommended levels of NPK fertilizers ($150:50:50 \text{ N, P}_2\text{O}_5 \text{ and K}_2\text{O kg ha}^{-1}$). The growth and yield attributes of rice were recorded. Post harvest soil samples were analyzed for pH, EC, ESP, microbial and enzyme activity.

3. RESULTS AND DISCUSSION

3.1 Soil pH

The soil pH directly influencing soil physical, chemical and biological properties. Application of amendments resulted in highly significant decrease in soil pH (Table 1). pH of the soil ranged from 9.95 to 8.34. Maximum reduction in soil pH was recorded in gypsum+ GM applied plots (8.45). The reduction in soil pH on application of gypsum+ GM was attributed to the displacement of exchangeable Na by the calcium ions of gypsum which get leached out due to drainage provided[5]. The addition of GM after gypsum leads to further reduction in pH by producing organic acids during decomposition which solubilizes the native Ca. The GLM proved its superiority over press mud in reducing the soil pH. The fresh organic materials present in the GLM might have readily decomposed and released higher amount of organic acids.

3.2 Soil EC

In spite of higher amount of gypsum application, only small increase in EC was observed which might be due to very low solubility of gypsum (2.8 gL^{-1}). Decomposition of organic materials released organic acids or acid forming compounds that reacted with the sparingly soluble salts already present in the soil and either converted them in to soluble salts or at least increased their solubility resulting in slight increase in EC.

3.3 Exchangeable Sodium Percentage

Amendments application decreased the ESP with desirable reduction being noticed in gypsum+ GM treated plots followed by GLM and press mud. A decrease in ESP of 14.8, 4.4 and 3.5% was noted due to gypsum+ GM, GLM and press mud application respectively over the control. In case of gypsum, the reduction in ESP was attributed to replacement of exchangeable Na by Ca of the gypsum[6]. The application of organic amendments also reduced the soil ESP from initial level which may be due to increase in exchangeable Ca and Mg ions due to solubilization during decomposition of organic matter and also due to supply of beneficial cations like K, Ca and Mg from the GLM and press mud.

3.4 Soil microbial population

The bacterial, fungal, actinomycetes population of post harvest soil was markedly influenced due to application of treatments. The bacterial population ranged from 12.39 to $16.83 \times 10^7 \text{ CFU g}^{-1}$ of soil. The minimum ($2.84 \times 10^2 \text{ CFU g}^{-1}$) and maximum ($4.66 \times 10^2 \text{ CFU g}^{-1}$) fungal population being observed in control and Gypsum+ GM applied treatments. The actinomycetes population ranged between 1.34 to $3.26 \times 10^3 \text{ CFU g}^{-1}$ of soil.

Microbial activity had a direct impact on the plant nutrient availability as well as other properties related to soil productivity[7]. The microbial population viz., bacteria, fungi and actinomycetes were also increased on reclamation over control (Table 2). This may be due reduced adverse nature of sodic soil in terms of reduced pH, ESP and exchangeable Na and increased favorable conditions for microbes[8]. Higher Bacterial, Fungal, Actinomycetes population was observed in the Gypsum+ GM applied treatments followed by GLM and press mud applied plots. The application of zinc sulphate does not possess significant changes in microbial population.

3.4 Soil enzyme activities

Significant increase in the soil enzyme activity was observed on application of amendments. The table 2 represents the dehydrogenase activity of post harvest soil which was varied from 1.15 to $1.64 \mu\text{g TPF g}^{-1}\text{hr}^{-1}$

¹. The urease activity and phosphatase activity in the post harvest soil ranged between 1.45 to 2.22 $\mu\text{g NH}_4\text{-N g}^{-1} \text{hr}^{-1}$ and 3.84 to 5.63 $\mu\text{g nitrophenol g}^{-1} \text{hr}^{-1}$.

Enzyme activity in soil is directly correlated with soil microbial population[9]. Dehydrogenases is considered to play an essential role in initial stages of the oxidation of soil organic matter by transferring hydrogen and electrons from substrates to acceptors[10]. The phosphatases hydrolyze organic P to inorganic P, catalyze the rate limiting steps of P nutrient cycling and therefore, phosphatase activity plays a significant role in P availability to plants from native organic P compounds[11]. The enzyme urease was associated with N mineralization. These three enzymes play a significant role in the bio-transformation of nutrients in soil, and thus influence the nutrients availability in soil and uptake by crops. There is always a positive correlation exists between N mineralization and urease as well as P mineralization and phosphatase activity[11].

Greatest activities of dehydrogenase, phosphatase and urease were observed with the gypsum+ GM followed by GLM and press mud treatments. Generally, organic manure addition found to enhance the microbial activities which in turn favoured the synthesis of various enzymes in soil [12]. The application of zinc sulphate had no significant changes on enzyme activities.

3.5 Grain and straw yield

The results of the field experiment revealed that sodic soil on reclamation with amendments, increased the yield significantly (Table 3). The yield of crop is a function of many factors, which includes soil, crop and climatic factors, and the effective management of monetary and non- monetary inputs. In other words, the final economic yield of a crop is determined by various growth parameters. There are so many factors which may have to be manipulated to increase the above said favorable environment and providing a better soil condition with respect to its physical, physicochemical, chemical and biological properties.

Among the amendments, highest yield (5511 kg ha^{-1}) was recorded in the Gypsum+ GM applied treatments owing to creation of favourable micro climate, increased availability of essential nutrients which in turn increased the yield. Next to Gypsum+ GM, higher yield was noted in GLM and press mud applied treatment over the control. The organic amendments not only reclaimed the sodic soil but also enhanced soil organic carbon content and biological properties[13].

4. CONCLUSION

The results of field experiment concluded that application of amendments enhanced physicochemical properties, microbial population and enzyme activities of soil. Greatest biological activities were observed with the gypsum+ GM followed by GLM and press mud treatments. Application of amendments to sodic soil significantly increased the yield parameters(DMP and grain and straw yield) of rice.

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Comment [KA1]: See suggestions for improvement below the references

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Table 1. Effect of amendments and *zinc sulphate on pH, EC and ESP of post harvest soil

	pH	EC (dS m ⁻¹)	ESP (%)
Control	9.95	0.35	29.7
Gypsum + GM	8.45	0.41	14.8
GLM	8.95	0.37	25.2
Press mud	9.13	0.37	26.2
S Ed	0.1	0.006	0.36

CD(0.05)	0.25	0.01	0.91
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* Effect of zinc sulphate was non-significant.

Table 2. Effect of amendments and * zinc sulphate application on microbial population and enzymes activity of post harvest soil

Treatments	Bacterial ($\times 10^7$ CFU g^{-1} of soil)	Fungal ($\times 10^2$ CFU g^{-1} of soil)	Actino mycete s ($\times 10^3$ CFU g^{-1} of soil)	Dehydrogenas e (μg TPF $g^{-1}hr^{-1}$)	Urease (μg NH_4-N $g^{-1} hr^{-1}$)	Phosphatas e(μg nitrophenol $g^{-1} hr^{-1}$)
Control	12.39	2.84	1.34	1.15	1.45	3.84
Gypsum+GM	16.83	4.66	3.26	1.64	2.22	5.63
GLM	16.05	4.24	2.85	1.59	2.04	5.23
Press mud	15.64	4.10	2.75	1.55	2.02	4.93
S Ed	0.23	0.06	0.04	0.02	0.3	0.07
CD(0.05)	0.57	0.15	0.1	0.05	0.07	0.19

*Effect of zinc sulphate was non-significant.

Table 3. Effect of amendments on yield ($kg ha^{-1}$) parameters of rice

Treatments	Mean
Grain yield	
Control	2846
Gypsum+ GM	5511
GLM	4972
Press mud	4904

Mean	4558
Straw yield	
Control	3382
Gypsum+ GM	6563
GLM	5930
Press mud	5818
Mean	5423

	S Ed	CD (0.05)
Grain yield	74.1	182
Straw yield	88.2	217

Title

Current: Effect of amendments on physicochemical and biological properties of sodic soil and yield of rice **Comment:** The title is clear but could be made more concise and specific. Including the type of amendments used could also add clarity. **Suggested:** Effect of Gypsum, Green Manure, and Press Mud Amendments on Sodic Soil Properties and Rice Yield

Abstract

Current: The abstract is verbose and lacks clarity. It includes redundant phrases and lacks concise information about the methodology and results. **Comment:** Simplify the abstract to clearly state the objective, methods, key results, and implications of the study. **Suggested:** Condense the abstract to provide a brief overview of the problem, methodology, key findings, and implications in a structured format. For example:

- **Objective:** To evaluate the effects of various soil amendments on the physicochemical and biological properties of sodic soil and rice yield.
- **Methods:** Field experiments using gypsum, green manure, green leaf manure, and press mud on rice (CO 52) in sodic soil.
- **Results:** Significant improvements in soil properties and rice yield, with the highest effectiveness observed in gypsum + green manure treatments.
- **Implications:** The study suggests practical amendments for improving sodic soil quality and crop productivity.

Introduction

Current: The introduction is not well-organized and includes some information that could be moved to the literature review. **Comment:** Provide a clear background on the issue of sodic soils, the importance of soil amendments, and the specific objectives of the study. Avoid mixing literature review content with the introduction. **Suggested:**

1. Begin with a broad introduction to the problem of sodic soils and their impact on agriculture.
2. Highlight the importance of soil amendments in improving soil quality.
3. State the specific objectives and hypotheses of the study.
4. Provide a brief overview of the experimental approach.

Literature Review

Current: References in the introduction seem scattered and not well-integrated into the text.

Comment: Develop a separate literature review section to discuss previous studies and the gap this study is filling. Ensure all references are integrated smoothly into the discussion. **Suggested:**

1. Summarize key findings from previous research on soil amendments and sodic soil reclamation.
2. Discuss different types of amendments and their reported effects on soil properties and crop yield.
3. Identify gaps in the existing literature that this study aims to address.
4. Provide a rationale for selecting gypsum, green manure, green leaf manure, and press mud as amendments.

Materials and Methods

Current: The methods section provides detailed descriptions but could benefit from better organization and clarity. **Comment:** Clearly organize the section with subheadings for each part of the experimental design. Include specific details on the experimental setup, treatments, and measurement techniques. **Suggested:**

1. **Study Site:** Describe the location and characteristics of the experimental site.
2. **Experimental Design:** Outline the experimental setup, including the number of replicates and treatment plots.
3. **Amendments and Treatments:** Detail the types and quantities of amendments used.
4. **Data Collection:** Explain the methods used to collect data on soil properties, microbial populations, enzyme activities, and crop yield.
5. **Statistical Analysis:** Describe the statistical methods used to analyze the data.

Results

Current: The results section provides a lot of data but lacks interpretation and context. **Comment:** Present the results in a clear and logical order, using tables and figures to summarize key findings. Include brief interpretations of the results. **Suggested:**

1. Organize results by specific outcomes (e.g., soil pH, EC, ESP, microbial populations, enzyme activities, crop yield).
2. Use tables and figures to present data clearly.
3. Include brief interpretations of what the results mean in the context of the study's objectives.

Discussion

Current: The discussion section lacks depth in interpreting the results and comparing them with theoretical expectations or other studies. **Comment:** Expand the discussion to include a deeper analysis of the results, comparing them with existing literature and discussing potential reasons for any discrepancies. **Suggested:**

1. Interpret the key findings in detail.
2. Compare the results with those of previous studies.
3. Discuss possible mechanisms underlying the observed effects of the amendments.

4. Address any unexpected findings and their implications.
5. Suggest practical applications of the findings for soil management.

Conclusion

Current: The conclusion is brief and does not fully encapsulate the findings and their implications.

Comment: Summarize the key findings, their implications for the field, and potential areas for future research. **Suggested:**

1. Provide a concise summary of the main findings.
2. Highlight the practical implications of the results for sodic soil management.
3. Suggest recommendations for future research to build on this study

UNDER PEER REVIEW