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SHORT COMMUNICATION

Prospects of Sodic soil Amelioration for Increased crop Production in India

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ABSTRACT
Sodic soils are characterized by occurrence of excess sodium to a level that can adversely affect soil structure and nutrients availability for plants. The plants, growing in sodic soil, generally exhibit accumulation of Na^+ and inhibit uptake of other essential nutrients, especially Ca, N and P which exerts poor growth and yield. In India, about 6.9 mha area is subjected to salt stress of which about 1.37 mha is in Uttar Pradesh. Challenges of food security in India require conversion of vast unutilized land to cultivable land to support increased area under productive agriculture. Although the use of chemical amendments, like gypsum successfully improves chemical properties of these soil, but fails to restore nutritional and biological properties of reclaimed soils. As a cost-effective and environmentally acceptable strategy, sodic soil can also be reclaimed through organic bio-amelioration. The incorporation of organic amendments to sodic soil enhances microbial activity that transforms the organic materials into long chain aliphatic compounds capable of binding and stabilizing soil aggregates. Bioamelioration method has great advantage over chemical amendments like (1) improvement of soil hydraulic conductivity, (2) greater plant nutrient availability in amended soil, (3) environmental services through soil carbon sequestration. It is concluded that bioamelioration approach for sodic land reclamation would not only improve the soil fertility, but also make able the reclaimed sodic soil for agriculture that can fulfil the food requirements of growing population.
Keywords: Sodic soil, Agriculture, Organic amendment, Bioamelioration

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INTRODUCTION

Salt stress is one of the major edaphic factors limiting crop production and eco-environmental quality in saline and/or sodic soils throughout the world. About 6.9 mha of land are classified as unsuitable for agriculture due to the salt-affected problem in India [1]. This problem manifests itself especially in arid and semiarid regions of India with poorly drained soils because of continual addition of salts with irrigation practices. As an important category of salt-affected soils, sodic soils are characterized by the occurrence of excess amount of exchangeable sodium, which can adversely affect the soil structure and nutrients availability for plants. Accumulation of excess sodium or neutral salts in soils originates either through the weathering of parent minerals or by man-made activities involving irrigation with saline, or by sodic water. These excessive amounts of salts adversely affect soil physical and chemical properties, as well as the microbiological processes and on plant growth. Tejada and Gonzalez, [2] showed that increasing electrical conductivity in sodic soils decreases structural stability and bulk density of soil. Rietz and Haynes, [3], found that an increase in soil sodicity inhibited several soil enzymatic activities, such as arginine ammonification, allkaline phosphatase, β-glucosidase and microbial respiration. Several site-specific methods have been used to ameliorate sodic soils. These method include such as physical amelioration (deep ploughing, subsoiling, sanding, and profile inversion), chemical amelioration (amending of soil with various amendments: gypsum, calcium chloride, and limestone), electro-reclamation (treatment with electric current) [4]. Among all amelioration methods, chemical amendments mainly gypsum have been extensively used. Gypsum application successfully reduces exchangeable sodium percentage (ESP) of sodic soils, but fails to improve the physical and biological properties of the soil. Alternatively, phytoremediation dealing with growing of certain crops, resistant of ambient soil salinity and sodicity levels without the application of amendments, were also effectively ameliorate the sodic soils. However it reduces sodicity very slowly and requires calcite to be present in the soil. Recently, organic bioamelioration approach has proved to be an efficient, low cost and environmentally acceptable strategy to ameliorate sodic and saline-sodic soils. Input of organic matter conditioner such as mulch, manures, compost and recyclable organic waste/residues have been investigated for their effectiveness in sodic soils amelioration. It has been demonstrated that the application of organic matter to sodic soils can accelerate Na^+ leaching, decrease the exchangeable sodium percentage and increase infiltration rate and aggregate stability of amended soils [5]. Furthermore, the applications of organic matter enhance the soil microbial biomass and soil enzymatic activities [6]. However, low quality uses of organic bioameliorants may causes potential threat thereby release of organic and inorganic pollutant in the soil which can adversely affect organisms and ecosystems. Therefore, it is of the utmost importance to have stringent quality requirements for the materials to be applied in order to achieve the beneficial effects. This review article evaluates the effectiveness of organic bioamelioration approach used in sodic soils amelioration in terms of the impacts they have on the physico-chemical and biological properties of the amended soil as well as with respect to the effect have on crop productivity and environmental sustainability.

ORGANIC BIOAMELIORATION OF SODIC SOIL

Soil physical and chemical effects

The extent of changes in soil physical properties of sodic soils with the incorporation of organic bioameliorants was quite remarkable, which is connected with an increase in organic carbon content. In sodic soils, Na^+ constitutes a highly dispersive agent resulting in dispersion of soil aggregates. The addition of organic matter promotes the flocculation of clay particle, which is an essential condition for the aggregation of soil particles. The improvements in soil aggregate stability with organic bioameliorants and the resulting improvement in soil porosity also attributed to the presence of microbial mucilage/polysaccharides, and other exudates in rhizosphere which adsorbed onto clay surfaces and bind soil particles into aggregates [7]. Addition of organic bioameliorants in sodic soils enriches the rhizosphere with micro and macro-nutrient and counteracts nutrient depletion [8]. The higher increase in organic C content of soil with the application of organic bioameliorants may also shows a greater capacity to retain nutrients in forms that can easily be taken up by plants and support rich microflora beneficial to crops growth.

Biological effects

The incorporation of compost and poultry manure into salt-affected soil stimulates soil microbial biomass and enzymatic activity due to the high quantity of readily utilizable energy sources introduced [9]. The enhanced soil enzyme and biological activity are believed to be direct indicator of the enhancement of soil fertility resulting from the incorporating of organic matter by compost and sewage sludge [6] which helps in increase the N and P uptake by crops. Incorporation of organic materials influences the enzymatic activities in the soil because the added organic fraction may contain intra and extracellular enzymes [8] which stimulate microbial activity in soil. Pascual *et al.* [10] also observed a sharp increase in microbial metabolic quotient (qCO2) in an arid soil amended with municipal solid waste.

Crop productivity

Finding of previous study showed that incorporation of organic bioameliorants improve the growth and yield of major crops (*Triticum aestivum* L. and *Oryza sativa* L.) under the sodic condition [11, 12]. The incorporation of organic bioameliorants into sodic soils significantly increase the root growth and yield of wheat (*Triticum aestivum* L.) crop, due to continuing supply of readily-available nutrients, that resulting from the large quantities of mineralizing organic matter in the rip line [13] In addition, there would be polysaccharides and mycelial exudates released from the mineralization of organic matter seem to play an important role in plant growth promotion [14].

Environmental aspects

Sodic soils now lost a significant fraction of their original carbon pool. The soil C pool, which consists of both organic and inorganic C, is not only important with regard to productivity but also plays an important role in the global C cycle by sequestering C. Carbon sequestration involves the capture of C from the atmosphere and its transfer into stable pools within the soil. The SIC in the form of $CaCO_3$ is virtually immobile due to its insolubility in alkaline soil in arid and semi-arid environments. By improving vegetative cover, these soils could be ameliorated with two-fold gains. Firstly, the vegetation itself will sequester soils with organic carbon and secondly, dissolution of $CaCO_3$ through root exudates, will improve soil drainage with better soil structure. Organic bioamelioration approaches enhance the organic carbon status of sodic soils thus provide the better soil condition for crop production and suggested the greater scope of organic carbon sequestration by restoring salt-affected soils [15]. So with growing interest in C sequestration, the sodic soils play a crucial role in stabilizing the atmospheric concentration of CO_2.

CONCLUSION

It conclude that salt-affected soil needs organic matter supplements which would help in stimulating soil microbial populations that are essential for stability and resilience of the degraded ecosystem. Organic matter also helps in providing nutrition supplements which in turn supports higher plant growth and yield. Sodic soil could be a useful resource of economic value than an environmental burden, if we restore these soils with bio-ameliorants. This would not only increase the plant/ crop productivity, but also support the environmental services through soil carbon sequestration.

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