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Liming practice impact on post-harvest soil properties for maize-greengram cropping system in acid soil of Odisha

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Abstract

A field experiment was conducted for two years by taking four crops to study the “Liming practice impact on post-harvest soil properties for Maize-Greengram cropping system in Acid soil of Odisha” in the village MV-13 in Malkangiri district of Odisha during both *Kharif* and *Rabi* in the year 2017 and 2018. The soil was ameliorated with three different sources of liming materials (paper mill sludge, Stromatolyte and Calcium Silicate @ 0.2 LR) added with soil test based dose/nutrient expert with FYM. Results indicated the post-harvest soil properties indicated that The two years of cropping harvest of four crops made soil more acidic which was not received any lime application in different POPs. Integrated use of liming materials with FYM and fertilizers (STD/NE) maintaining the available macro and micro nutrients where was decline occurs in without liming practices. The continuous application of only fertilizers decline the nutrient status and creats acidity in post harvest soil. The application of liming practice with NE gives better results compare to the STD alone.

Keywords: Liming, fertilizers, acid soils, macronutrients, micronutrients and heavy metals etc.

Introduction

In world around 50 % of soils are affect by acidity potentially arable land and in humid tropics (Von Uexkull and Mutert, 1995) ^[15]. In India soil acidity affects around one third of cultivated land (Mandal 1997) ^[7]. This acidic soils develop physical, chemical, nutritional and biological constraints in soil i.e high infiltration rate, low water holding capacity, high permeability, low pH, low cation exchange capacity, low base saturation, high Al, Fe and Mn saturation and high P fixing capacity (Pattanayak and Mishra, 1989). Liming of acid soils is the way to reduce the acidity and raise the pH, base status, CEC, inactive Al, Fe and Mn in soil (Panda and Koshy, 1982; Mishra and Pattanayak 2002) ^[10, 8].

Paper mill sludge is a industrial by product of paper production that disposal of this material presents a problem for the mill (Mahood and Elliot, 2006) ^[6]. Its neutralizing value was 65-79 per cent and 22 to 35 per cent Ca content. Natural source stromatolyte is a low grade limestone contains 28.32 per cent CaO, 12 per cent MgO and 0.5 per cent P₂O₅ (Pattanayak, 2013) ^[11]. The total reserve of this lime stone is about 40 MT. Calcium silicate is a industrial by product granular in nature received from USA through Harsco India Ltd, Hyderabad. Lime application along with integrated nutrient management is often recommended to increase the phytoavailability of essential materials and ameliorate the other acidity induced fertility constraints on such soils (Hayan, 1984) ^[3].

Materials & Methods

The experimental soil was loamy sand in texture with 76 per cent sand, 14 per cent silt and 10 per cent clay with 1.71 mgm⁻³ of bulk density. The experimental soil was strongly acidic in reaction having pH 4.15. The electrical conductivity was 0.09 dsm⁻¹ and organic carbon (OC) status was low i.e 2.9 gkg⁻¹ with lime requirement of 4.5 tCaCO₃ha⁻¹. The available macronutrients like Nitrogen (N), Phosphorous (P), Potassium (K) and Sulphur (S) in soil were 180 (low), 116 (very high), 105 (low) and 30 (medium) kg/ha respectively. The available micronutrients like Iron, Manganese, Cuppor, Zinc and Boron in soil were 62 (adequate), 7.8 (adequate), 0.39 (adequate), 0.58 (low) and 0.14 (low) mg/kg respectively. The available heavy metals like Lead, Cadmium and Chromium in soil were 0.86 (non toxic), 0.004(non toxic) and 60 (non toxic) mg/kg respectively.

The cation exchange capacity (CEC) of experimental soil was $6.29 \text{ cmol(P}^+)\text{kg}^{-1}$ soil with 3.0, 1.9, 0.10 and $0.18 \text{ cmol(P}^+)\text{kg}^{-1}$ soil of exchangeable Ca^{+2} , Mg^{+2} , Na^+ and K^+ respectively. The exchange acidity of soil was $1.08 \text{ cmol(P}^+)\text{kg}^{-1}$ with $0.40 \text{ cmol(P}^+)\text{kg}^{-1}$ exchangeable H^+ and $0.68 \text{ cmol(P}^+)\text{kg}^{-1}$ exchangeable Al^{+3} . Three different sources of liming materials i.e Paper mill sludge (PMS), Calcium silicate (CS) and Stromatolyte (ST) were applied with soil test based recommended dose (STD) and Nutrient Expert (NE) integrated with FYM. Two test crops Maize (cv. Hishel) and Greengram (cv. IPM-02-03) were taken in cropping system received 10 treatments, replicated thrice and imposed over statistically laid out field with Randomised Block Design (RBD) in the field. The initial and post-harvest soils were collected, dried under shade, grinded with wooden hammer, sieved through 2mm sieve and preserved in polythene bags with proper labels for analysis. The texture of the experimental soil was determined by Bouyoucous Hydrometer method as described by Piper (1950) [13], pH by pH meter as described by Jackson (1973) [4], exchangeable H^+ and Al^+ by Lin and Coleman (1980) method described by Page *et al* (1982) [9], Lime requirement by Woodruff Buffer Method, CEC by successive extraction of soil with neutral 1 N ammonium acetate described by Page *et al* (1982) [9], OC by wet digestion procedure of Walkley and Black described by Page *et al* (1982) [9], available N by alkaline KMnO_4

method described by Subbiah and Asija (1956) [14], P by Bray's 1 method (Bray and Kurtz, 1945) [11] described by page *et al* (1982) [9], K by extracting the soil with neutral normal ammonium acetate solution and estimated by flame photometer, S by turbidimetric method (Chesin and Yien, 1951) [2] and available micronutrients (Fe, Mn, Cu, Zn and B) and heavy metals (Pb, Cd and Cr) by DTPA method (Lindsay & Novel, 1978) [5] described by Page *et al* (1982) [9].

Results and Discussion

The post harvest soil properties has been analysed after growing of four crops in two years. The analysis of different parameters has been presented below.

Soil reaction

The initial soil before experiment was strongly acidic in reaction having pH 4.15. In the control treatment further acidification occurs by two years of cropping with four crops. Application of organic source (FYM) only acidify the soil compare to initial status. Application of fertilizers based on STD/NE integrated with or without FYM turned the soil more acidic. Combine application of liming materials with STD/NE package helped to ranging the pH from 4.43 to 4.67 after two years of cropping even though soil is strongly acidic in range (Fig-1).

Fig 1: Change in soil reaction of post harvest soil

Soluble salts content:

The initial soluble salt content of the initial soil was 0.09 dsm^{-1} .

But in post harvest soil the EC varied between 0.03 to 0.05 dsm^{-1} which decreased during two years of cropping (Fig-2).

Fig 2: Soluble salts content in post harvest soil

Organic carbon

Initially the soil was deficient in Organic carbon status (2.9 gkg^{-1}).

After harvest of four crops the status was more or less

maintained which ranged from 3.0 to 4.6 gkg^{-1} soil. The combine application of liming materials with fertilizers and FYM helped maintaining higher organic carbon status (Fig-3).

Fig 3: Organic carbon content in post harvest soil

Alkaline KMnO_4 extractable N

The initial soil was deficient in oxidisable N (180 kg ha^{-1}). Which further decreased under control and FYM treatment.

Combine application of liming materials with fertilizers and FYM increases the oxidisable N (Fig-4).

Fig 4: Alkaline KMnO_4 extractable N in post harvest soil

Bray's-1 available P

The initial P status was very high (116 kg ha^{-1}). So, that 25 % less P applied to the experimental soil. In control treatment

the P status was medium but in post harvest soil P varied between 38 to 57 kg/ha. The combine application of liming materials with fertilizers maintaining higher P status (Fig-5).

Fig 5: Bray's-1 available P in post harvest soil

Ammonium acetate extractable K

The initial K status was low (105 kg ha^{-1}). Without application of liming materials did not meet the demand of four crops and

in post harvest status was declined. But combining application of liming materials improved the soil condition and restrict the depletion (Fig-6).

Fig 6: Ammonium Acetate Extractable K in post harvest soil

CaCl₂ extractable S

The initial S status was medium (30 kg ha^{-1}). Without liming practice declined the status compared to initial which was

ranged from 5 to 23 kg ha^{-1} . Except stromatolyte application in most cases, it was low in status (Fig-7).

Fig 7: Available S in post harvest soil

DTPA extractable Fe

The initial Fe status was adequate (62 mg kg^{-1}) which was beyond the critical limit of 6.5 mg kg^{-1} soil. After crop

cultivation basic cations were removed which encouraged Fe availability except limed soil, where the content of Fe decreased between 52 and 58 mg kg^{-1} soil (Fig-8).

Fig 8: DTPA Extractable Fe in post harvest soil

DTPA extractable Mn

The experimental soil Mn was not limiting (7.8 mg kg^{-1} soil) which beyond the critical limit (4.0 mg kg^{-1} soil). After

cropping in post harvest soil Mn content was more or less maintained where as application of liming materials maintain the low status of Mn (Fig-9).

Fig 9: DTPA Extractable Mn in post harvest soil

DTPA extractable Cu

In experimental soil initial Cu content was $<0.4 \text{ mg/kg}$. After crop

production application of different package of practices maintain lower Cu status in post harvest soil (Fig-10).

Fig 10: DTPA Extractable Cu in post harvest soil

DTPA extractable Zn

Initial Zn content in experimental soil was $<0.6 \text{ mg/kg}$. Except control treatment its application meet the crop

requirement then decreased in post harvest soil receiving STD & NE package (Fig-11).

Fig 11: DTPA Extractable Zn in post harvest soil

DTPA extractable Pb

The experimental soil Pb content was 0.86 mg/kg.

The liming practices depletion of status occur by crop removal which is ranging from 0.51 to 0.66 mg/kg (Fig-12).

Fig 12: DTPA Extractable Pb in post harvest soil

DTPA extractable Cd

The initial Cd content in experimental soil was 0.004 mg/kg where as critical limit is 3 mg Cd/kg soil. In crop production

different package of practices did not allow the Cd to accumulate beyond the initial level (Fig-13)

Fig 13: DTPA Extractable Cd in post harvest soil

DTPA extractable Cr

The initial Cr content in experimental soil was 60 mg/kg which was less than the critical limit of 100 mg/kg soil.

Irrespective of the treatments only calcium silicate increases the Cr status compared to initial (Fig-14).

Fig 14: DTPA Extractable Cr in post harvest soil

Conclusion

The two years of cropping harvest of four crops made soil more acidic which was not received any lime application in different POPs. Integrated use of liming materials with FYM and fertilizers (STD/NE) maintaining the available macro and micro nutrients where was decline occurs in without liming practices. The continuous application of only fertilizers decline the nutrient status and creates acidity in post harvest soil. The application of liming practice with NE gives better results compare to the STD alone.

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