International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 2111-2117

Received: 25-07-2017
Accepted: 26-08-2017

Rahul Dev Behera
Program Assistant, (Soil Science), KVK, Malkangiri, Odisha, India

Sipra Das
Program Assistant, (Soil Science), KVK, Keonjhar, Odisha, India

Sushanta Kumar Pattanayak
Professor and HOD, Dept. of Soil Sc. & Agri. Chemistry, OUAT, Bhubaneswar, Odisha, India

Correspondence
Rahul Dev Behera
Program Assistant, (Soil Science), KVK, Malkangiri, Odisha, India

Effective influence of various sources of liming materials on chemical properties of the soil for maize crop grown in acid soil of Khurda dist. of Odisha

Rahul Dev Behera, Sipra Das and Sushanta Kumar Pattanayak

Abstract
A comprehensive field experiment was conducted to study the "Effective Influence of various sources of Liming materials on Chemical properties of the soil for Maize crop Grown in Acid soil" in the villages Haladia, Jatni and Bajpur in khorda district of Odisha during *Kharif*, 2014.The soil was ameliorated with three different sources of liming materials (paper mill sludge @ 0.1LR, Stromatolyte@ 0.1 & 0.2 LR and Calcium Silicate @ 0.2 LR) added with soil test based dose with or without FYM. Application of liming materials irrespective of the sources neutralized soil acidity increased from a level of 4.94 to a level ranging from 5.11 to 5.55 and maintained for 14-35 days when lone sources are used. Combined use of liming materials with FYM increased the pH to a level ranging from 5.65-6.08, which was maintained for a period of 28-49 days after application. The acid neutralizing efficiency of liming materials followed the order: ST@0.2LR>CS@0.2LR>PMS@0.1LR>ST@0.1LR. Appliaction of lone sources of limingmaterialsalone increased the CEC from 6.39 to 7.37 cmol $(p^+)kg^{-1}$but the combine application of liming materials with FYM increased the CEC from 7.38 to 8.03 cmol (p^+) kg^{-1}.

Keywords: acid soil, liming materials, paper mill sludge, stromatolyte and calcium silicate etc

Introduction
Amelioration of acid soils with limingmaterials is a common management (Haby *et al.*, 1995; Quoggio *et al.*, 1995) [5, 15], but from other materialsare also used as acid soil amendment, such asgypsum and phosphate rocks (Hea *et al.*, 1996) [6] and some industrial by-products (Edward *et al.*, 1985; Vityakon *et al.*, 1995; Oguntoinbo, 1996; Stuczynski*et al.*, 1998; Curnoe *et al.*, 2006; Alves *et al.*, 2006; Mohammadi Torkashvand, 2010) [4, 19, 14, 3, 1, 10]. The main aim of soil liming is to neutralize acidic inputs and recovering the buffering capacity to the soil (Ulrich, 1983) [18]. The acidic soils develop physical, chemical, nutritional and biological constraints for crop production in terms of soil crusting (affecting seed germination), high infiltration rate, low water holding capacity, high permeability, low pH, low cation exchange capacity (due to dominance of 1:1 type of clay), low base saturation (16-67 %), high Al, Fe and Mn saturation percentage, high P fixing capacity (92 %) (Pattanayak and Misra, 1989) [13], poor availability of essential plant nutrients like Ca, Mg, P, Mo, B and Si, poor microbial activity and biologically mediated nutrient transformation processes, poor N_2 fixation due to poor *Rhizobial* activity etc. Restoration of lost basic cations, amelioration of acidity, supplymentation of different nutrients as per crop requirement, judicious use of chemical fertilizers, proportionate use of organics can help managing acid soils. Liming of acid soil is the way to raise pH, base status, cation exchange capacity, inactive Al, Fe and Mn in soil solution and reduce P fixation (Panda and Koshy, 1982 Misra *et al.*, 1989, Sahu and Patnaik, 1990, Mishra and Pattanayak, 2002) [8, 12, 16]. Paper mill sludge is a estimated that about 2 lakh metric tonnes of PMS with 65-79 % neutralizing value and 22 to 35 % Ca content are dumped around four mills located in Cuttack, Rayagada, Brajarajnagar and Jeypore of Odisha. "Stromatolytic Limestone", which is a low grade limestone with high silica content with limited industrial importance and contains 28.32% CaO, 12% MgO and 0.5% P_2O_5 (Misra, 2004 and Pattanayak, 2013) [9, 13]. The total reserve of this limestone in Odisha is about 40Mt. Calcium Silicate was granular in nature received from USA, through Harsco India Ltd, Hyderabad.

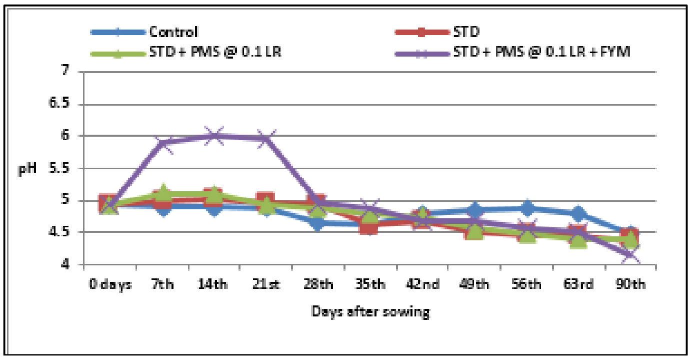
Materials and Methods

The soil of the experimental site was loamy sand in texture with 76 per cent sand, 14 per cent silt and 10 per cent clay with 1.75 Mg m^{-3} of bulk density. The soil was strongly acidic in reaction (pH_w 4.94). The organic carbon status was medium, i.e. 5.7 gkg^{-1} with lime requirement of 3.2 t $CaCO_3ha^{-1}$. The CEC of the experimental soil was 6.29 $cmol(p^+)kg^{-1}$ soil with 1.04, 0.60 and 0.44 $cmol(p^+)kg^{-1}$ soil of exchange acidity, acidity due to Al^{3+} and H^+ respectively. The available nitrgen, phosphorous, potassium and sulphur in soil were 169 (low), 105 (high),143 (medium) and 17 $kgha^{-1}$ (low) respectively. The available Boron and Zinc content were very low, i.e 0.15 and 0.41 $mgkg^{-1}$ soil respectively. Three different types of liming materials were used in the experiment. These were Paper Mill Sludge (PMS), Stromatolyte (ST) and Calcium Silicate (CS). Liming materials were applied mixed with and without FYM in the field. Absolute control treatment was included without any addition of external source of nutrients. The test crop Maize (Hishell-hybrid) received 10 treatments. Each treatment was replicated three times and imposed over statistically laidout field with Radomised Block Design (RBD) in the field.crop growth period. The initial and post harvestsois were also collected. The samples Representative composite soil samples were collected at 7 days interval from all the treatments during were dried under shade, grined with wooden hammer and sieved through 2mm sieve. The samples were preserved in polythene bags with proper labels for analysis. The sand, silt and clay content of the soil samples were determined by Bouyoucos Hydrometer method as described by Piper (1950). The bulk density of experimental soil was determined by core method as described by Black (1965). Soil pH was determined in 1:2.5 soil: water ratio by pH meter as described by Jackson (1973) [7]. The exchange H^+ and Al^{+3} were determined by following the methods Lin and Coleman (1980) as described by Page *et al.*, (1982) [11]. The lime requirement of the acid soil was determined by Woodruff Buffer method. The Cation Exchange Capacity of the soil was determined by successive extraction of soil with neutral 1N ammonium acetate as per the procedure outlined by Page *et al.*, (1982) [11]. The Organic carbon content of soil was determined by wet digestion procedure of Walkley and Black as outlined by Page *et al.*, 1982 [11]. Available nitrogen in soil was determined by alkaline $KMnO_4$ method (Subbiah and Asija, 1956). Available phosphorous in the soil was determined by Bray's 1 method (Bray and Kurtz, 1945) as out lined by page *et al.*, (1982) [11]. Available potassium was determined by extracting the soil with neutral normal ammonium acetate solution and estimated by flame photometer. Availablesulphur was determined by extracting the soil with 0.15 per cent $CaCl_2$ solution and determined colorimetrically by turbidimetric method using $BaCl_2$ (Chesin and Yien, 1951).

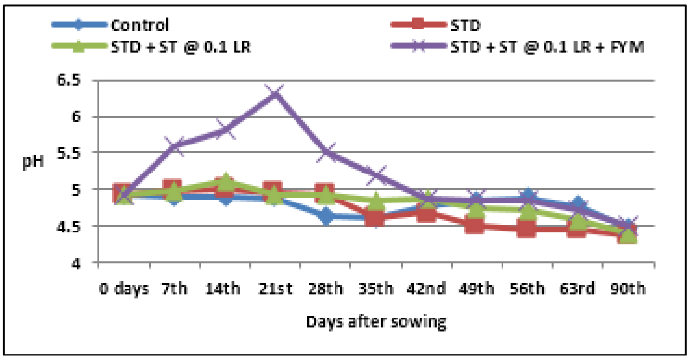
Result and Discussion

(a) Effect of liming materials on soil reaction during crop growth period

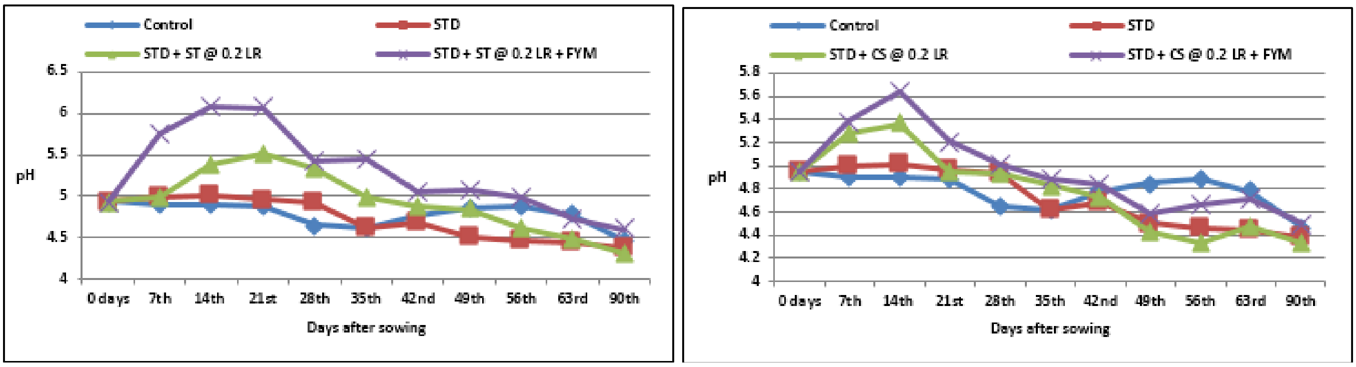
The initial soil pH was 4.94. The soil was strongly acidic in reaction. During crop growth period in control treatment the soil pH continued to decrease gradually till the harvest of the crop, which attended a level of 4.47 by the harvest of crop.(Fig-1.a).Upon addition of inorganic fertilizers alone (STD), the soil pH increased to a level of 5.01 by 14th DAS, there after decreased continuously till the harvest and attended the pH level of 4.38. Combined application of fertilizers and PMS @ 0.1 LR, raised the pH to a level of 5.11 by 7th DAS and maintained higher pH compared to STD alone up to 56th DAS, there after decreased (increased acidity) to the pH level of 4.39 by the harvest of the crop. Combining FYM application @ 5 tha-1 with STD and PMS @ 0.1 LR, helped in raising the pH from 4.94 to 5.88 by 7th DAS, 6.0 by 14th DAS, maintained high pH up to 21 days decreased there after gradually maintaining all along higher pH (even though acidic) compared to STD + PMS, except at harvest (pH 4.15),(Fig-1.a).The low grade lime stone (Stromatolyte – ST) when applied @ 0.1 LR mixed with STD raised the pH to 5.12 by 14th DAS, there after decreased the pH till the harvest of the crop, but maintained high pH than STD + PMS + FYM. Combined application of FYM with ST @ 0.1 LR helped raising the initial pH from 4.94 to 6.30 by 21st DAS, maintained for another 15 days (35 DAS) decreased there after till the harvest of crop but the pH remained above that due to STD + ST without FYM (Fig-1.b).Double the dose of stromatolyte was effective in maintaining higher pH (5.34) than ST @ 0.1 LR up to 28th DAS, decreased there after maintaining higher pH than ST 0.1 LR up to 49th DAS. After 49th DAS the soil pH decreased indicating development of more acidity by the harvest of crop. The effectiveness of ST applied @ 0.2 LR further increased by its combined application with FYM, which raised the pH to a level of 6.08/6.07 by 21st DAS and maintaining a pH level of 5.43 to 5.07 up to 49th DAS, decreased there after till crop harvest and all along higher pH was maintained than rest of the sources (Fig-1.c). The industrial by product Calcium silicate when applied @ 0.2 LR with STD, initially acted slowly, raised the pH to a level of 5.36 by 14th DAS, decreased thereafter. However, when applied mixed with FYM attended maximum pH level of 5.64 by 14th DAS, a level of pH ranging from 5.21 to 5.01 up to 28th DAS, decreased there after maintaining higher pH compared to STD + CS @ 0.2 LR (Fig-1.d).



(a) Paper mill sludge @0.1LR



(b) Stromatolyte @0.1LR

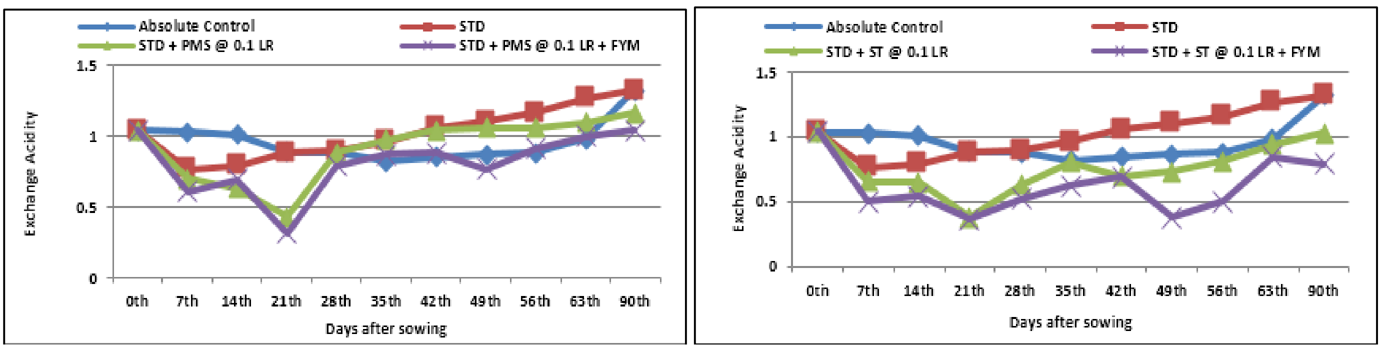


(c) Stromatolyte @0.2LR **(d) Calcium Slicate @0.2LR**

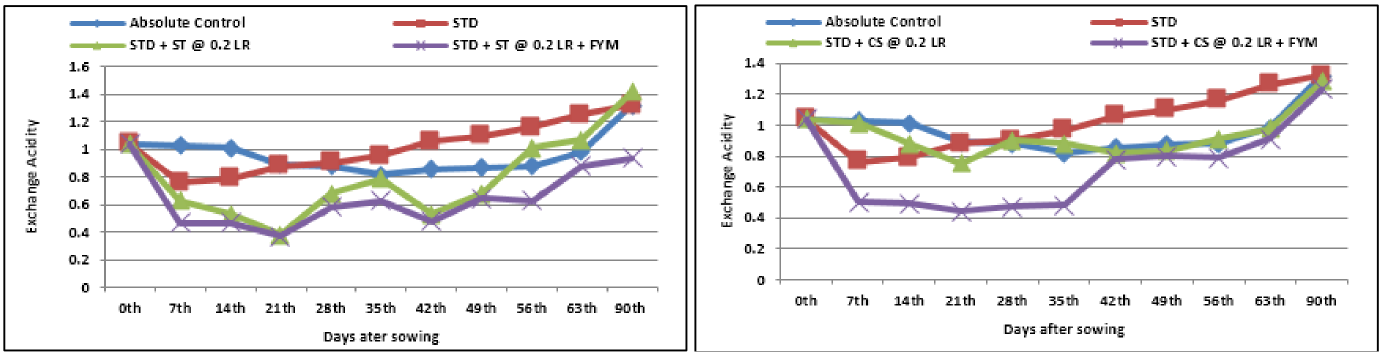
Fig 1: Change in soil reaction due to the application of liming materials with or without FYM

(b) Exchange Acidity in soil under the influence of addition of liming materials during crop growth period:-

The initial exchange acidity in soil was 1.04 cmol(P+)kg-1. Seven days after sowing of Maize seeds in absolute control treatment, this acidity remained at 1.03 cmol(P+)kg-1, there after decreased with crop growth, intercultural operations and water source from rain water (dilution effect) up to 35th DAS. There after gradually increased and attended a level of 1.32 cmol(P+)kg-1 soil by the harvest of the crop (Fig-2.a).In STD treatment, due to addition of external sources of nutrients; namely Urea, DAP and MOP temporarily decreased the acidity during 7 to 14 DAS, there after continued to increase gradually and attended a level of 1.32 cmol(P+)kg-1 by the harvest of the crop. Soil amelioration measure with the adiition of paper mill sludge (PMS) when used with STD, neutralized the acidity (both H+ and Al3+ ions), raised the pH, neutralized acidity to a level of 0.70 cmol(P+)kg-1 soil, which further decreased to a level of 0.43 cmol(P+)kg-1 soil by 21st DAS, there after increased gradually and attened a level of 1.16 cmol(P+)kg-1 soil by the harvest of the crop.Integrating organic addition through FYM helped alleviating the soil acidity condition through its buffering action, brought down exchange acidity to 0.6 cmol(P+)kg-1 soil level by 7th DAS and lowest level of 0.31 cmol(P+)kg-1 soil by 21st DAS, increased there after gradually and attended a maximum of 1.04 cmol(P+)kg-1 soil level (initial stage) by the harvest of the crop. During entire growing period the exchange acidity remained below the acidity levels achieved through the use of STD either alone or more specifically with PMS application (Fig-2.a). The acid neutralization efficiency of stromatolyte (ST) applied @ 0.1 LR dose was better than the PMS applied @ 0.1 LR. The acid neutralization efficiency of ST further increased and brought down the acidity to a level of 0.5 cmol(P+)kg-1 soil by 7th DAS, attended a minimum level of 0.28 cmol(P+)kg-1 soil by 21st DAS, There after gradually increased with crop growth till the harvest of crop. This source of liming material helped maintaining lower acidity level throughout growing period compared to PMS particularly when added with FYM. (Fig-2.b). Double dose of ST, when added with STD alone, neutralized soil acidity both H+ and Al3+ ions raised the pH, maintained lower acidity upto 49th DAS, increased there after, reached maximum of 1.42 cmol(P+)kg-1 soil by the harvest of the crop. The effectiveness of ST applied @0.2 LR, further increased, when applied mixed with FYM, maintaining lower acidity (low H+ and Al3+ ion conc) throughout the growing season, specially upto 56th day of growth (Fig-2.c).The calcium silicate (CS) when applied @ 0.2 LR was not effective as PMS or ST when applied with STD. Very slowly it started neutralizing the protons (H+ ions), Al3+ ions, ultimately the exchange acidity attending a minium level exchange acidity of 0.75 cmol(P+)kg-1 soil by 21st DAS, and increased there after till the harvest of crop. However when applied mixed with FYM, effectively neutralized the protons (H+ ions), Al3+ ions, ultimately the exchange acidity, raised the pH quickly, as a result of which the exchange acidity of 0.5 cmol(P+)kg-1 soil was achieved by 7th DAS, further lower down acidity up to 28th DAS, increased there after gradually and attended the maximum of 1.23 cmol(P+)kg-1 of soil by the harvest of the crop. All along lower level acidity was maintained in soil compared to STD + CS @ 0.2 LR (Fig-2.d).In general, PMS with STD was most effective up to 21st DAS, STD + PMS + FYM up to 28th DAS, STD + ST @ 0.1 LR/0.2 LR up to 49th DAS, and STD + ST @ 0.1 LR/+ FYM up to 56th DAS, the STD + CS @ 0.2 LR up to 21st DAS and STD + CS @ 0.2 LR + FYM up to 28th DAS.



(a) Paper mill sludge @0.1LR **(b) Stromatolyte @0.1LR**



(c) Stromatolyte @0.2LR **(d) Calcium Slicate @0.2LR**

Fig 2: Change in Exchange Acidity due to the application of liming materials with or without FYM

(c) Change in acidity due to Aluminium and Hydrogen during crop growth period

Before application of liming materials, the acidity due to H+ and Al3+ were 0.44 and 0.60 cmol(P+) kg-1 soil.In control treatment only the H+ ion acidity decreased and acidity due to Al3+ increased gradually during crop growth period.In the treatment where inorganic fertilizers were applied alone decrease in acidity due to H+ and Al3+ ions were observed up to 35th DAS and continued to increase till the harvest of the crop.Integrated use of PMS @ 0.1 LR, neutralised the acidity due to H+ and Al3+ up to 28th DAS, there after do not persist in the system to neutralise acidity as a result acidity increases. Combined application of FYM and PMS helped neutralising acidity due to H+ up to 21st DAS and acidity due to Al3+ up to 63rd DAS, increasing the efficiency of PMS (Table-1 and table-2).The low grade limestone Stromatolyte when applied @ 0.1 LR, continued to neutralise H+ acidity till the harvest of crop and maintained at a lower level all along compared to initial status. At the same time acidity due to Al3+ neutralised partially up to 35th DAS, increased there after.Combined application of FYM and ST @ 0.1 LR increased the effectiveness of liming material by restricting loss of Calcium and other basic materials, neutralised the acidity and maintained at lower level throughout the growing period. So also the acidity due to Al3+ was also neutralised considerably brought down to 0.34 cmol(P+) kg-1 soil level by 56th DAS, increased there after (Table-1 and table-2).Increasing the dose of Stromatolyte to 0.2 LR dose effectively neutralised protons (H+) for entire growing period and Al3+ ions up to 42nd DAS. Combining FYM and ST @ 0.2 LR effectively maintained both H+ ions and Al3+ ions at lower level compared to the initial status for the entire crop growing period (Table-1 and table-2).The industrial finished product ready to use calcium silicate applied @ 0.2 LR initially reacted slowly, effectively brought down the level of H+ well below the initial level for entire growing period. At the sametime, the acidity due to Al was controlled up to 35th DAS, increased there after. Integration of FYM with calcium silicate enhanced the efficiency for another 7 days i.e, up to 42nd DAS by effectively lowering the activity of H+ and Al3+ ions in the rhizosphere (Table-1 and table-2).

Table 1: Change in acidity due to Aluminium in soil

Treatments	Days after sowing (DAS)										
	0th	7th	14th	21th	28th	35th	42th	49th	56th	63th	90th
Absolute Control	0.6	0.68	0.6	0.4	0.54	0.57	0.68	0.69	0.74	0.78	0.93
STD	0.6	0.59	0.57	0.48	0.48	0.59	0.71	0.84	0.85	0.94	0.96
STD + PMS @ 0.1 LR	0.6	0.55	0.51	0.37	0.53	0.6	0.65	0.64	0.65	0.76	0.85
STD + PMS @ 0.1 LR + FYM	0.6	0.34	0.37	0.2	0.34	0.49	0.4	0.22	0.48	0.48	0.82
STD + ST @ 0.1 LR	0.6	0.46	0.43	0.34	0.34	0.48	0.62	0.68	0.68	0.71	0.74
STD + ST @ 0.1 LR + FYM	0.6	0.36	0.32	0.29	0.34	0.34	0.36	0.2	0.34	0.63	0.7
STD + ST @ 0.2 LR	0.6	0.46	0.4	0.34	0.46	0.58	0.43	0.68	0.74	0.79	0.88
STD + ST @ 0.2 LR + FYM	0.6	0.31	0.34	0.29	0.4	0.41	0.3	0.51	0.51	0.57	0.57
STD + CS @ 0.2 LR	0.6	0.56	0.47	0.4	0.55	0.58	0.7	0.71	0.77	0.82	0.96
STD + CS @ 0.2 LR + FYM	0.6	0.46	0.43	0.37	0.26	0.26	0.55	0.62	0.65	0.6	0.85

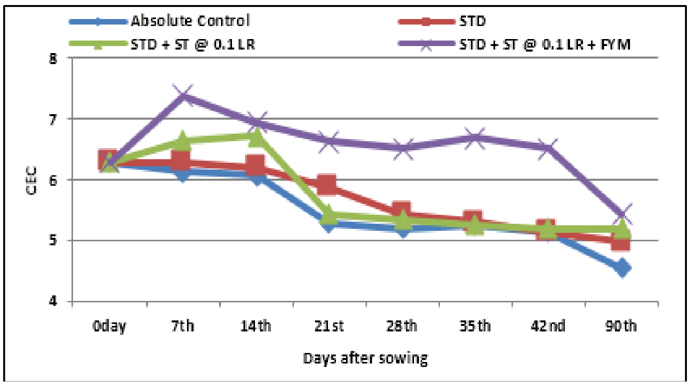
Table 2: Change in acidity due to Hydrogen in soil

Treatments	Days after sowing (DAS)										
	0th	7th	14th	21th	28th	35th	42th	49th	56th	63th	90th
Absolute Control	0.44	0.35	0.41	0.49	0.34	0.25	0.17	0.18	0.14	0.2	0.39
STD	0.44	0.17	0.22	0.4	0.42	0.37	0.39	0.55	0.41	0.33	0.31
STD + PMS @ 0.1 LR	0.44	0.15	0.12	0.06	0.35	0.37	0.39	0.4	0.41	0.33	0.31
STD + PMS @ 0.1 LR + FYM	0.44	0.26	0.32	0.11	0.45	0.38	0.48	0.54	0.43	0.52	0.22
STD + ST @ 0.1 LR	0.44	0.2	0.22	0.04	0.29	0.32	0.08	0.06	0.13	0.23	0.29
STD + ST @ 0.1 LR + FYM	0.44	0.14	0.22	0.08	0.18	0.28	0.35	0.18	0.16	0.22	0.09
STD + ST @ 0.2 LR	0.44	0.17	0.13	0.04	0.22	0.21	0.1	0.17	0.27	0.28	0.54
STD + ST @ 0.2 LR + FYM	0.44	0.16	0.13	0.03	0.18	0.22	0.18	0.14	0.12	0.31	0.37
STD + CS @ 0.2 LR	0.44	0.45	0.41	0.35	0.35	0.3	0.12	0.12	0.14	0.15	0.32
STD + CS @ 0.2 LR + FYM	0.44	0.04	0.06	0.07	0.21	0.22	0.23	0.18	0.14	0.31	0.38

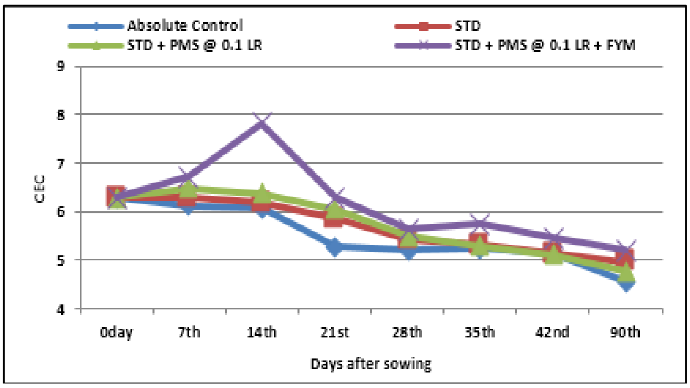
In general it was observed that use of liming materials were very much effective in neutralising the acidity due to H+ and brought down to lower manageable level well below the initial level for entire crop growth period. At the same time the acidity due to Al3+ ions were brought down below initial level up to 28th DAS by PMS @ 0.1 LR, 35th DAS by ST @ 0.1 LR, 42nd DAS by ST @ 0.2 LR, 35th DAS by CS @ 0.2 LR Combining FYM application increased the effectiveness of liming materials further, by maintaining H+ ions concentration well below the initial level of 0.44 cmol (P+) kg-1 soil throughout the growing period and at the same time Al3+ ion acidity up to 63rd DAS by PMS, 56th DAS by ST @ 0.1 LR, 90th DAS by ST @ 0.2 LR and 42nd DAS by CS @ 0.2 LR.

(d) Cation Exchange Capacity (CEC) of soil under the influence of lime, fertilizer and manure application

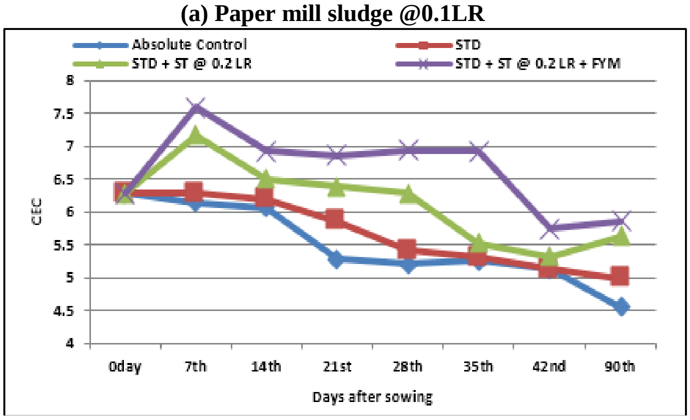
Initial CEC in soil was 6.29 cmol (p+)kg-1 soil. It had increased in limed and FYM amended treatments (ranging from 6.64 to 8.03), remained same in STD but decreased in absolute control treatment after 7 DAS, there after decreased gradually till the harvest of the crop. Up to 35th DAS the limed treatments maintained higher CEC than unlimed one. Further manure treatments maintained higher CEC compared to unmanured ones, all along the crop growth period. The lime source PMS @ 0.1 LR maintained higher CEC 6.39 cmol(p+)kg-1 of soil up to 14th DAS and highest of 6.49 cmol(p+)kg-1 soil by 7th DAS. The ST @ 0.1LR recorded highest CEC of 6.72 cmol (p+) kg-1 by 14 DAS decreased there after. It’s double dose recorded highest CEC of 7.16 cmol (p+)kg-1 soil at 7 DAS and maintained higher CEC compared to initial status by 21st DAS, decreased thereafter. The CS @ 0.2 LR recorded highest CEC of 7.37 cmol(p+)kg-1 at 7th DAS, maintained higher CEC compared to initial status by 28th DAS. Combined use of FYM with PMS maintained higher CEC up to 21st DAS (7 days more compared to PMS alone)(Fig-3.a), ST @ 0.1 LR with FYM, achieved highest CEC of 7.38 by 7th DAS and higher CEC compared to initial up to 42nd DAS (Fig-3.b). When double dose of Stromatolyte was used with FYM, highest CEC of 7.59 cmol (p+)kg-1 soil was achieved by 7th DAS and higher CEC continued up to 35th DAS, decreased there after(Fig-3.c). The CS @ 0.2 LR with FYM, recorded highest CEC of 8.03 cmol (p+)kg-1 soil by 7th DAS, all time higher CEC values compared to other sources up to 28th DAS, decreased there after (Fig-3.d).



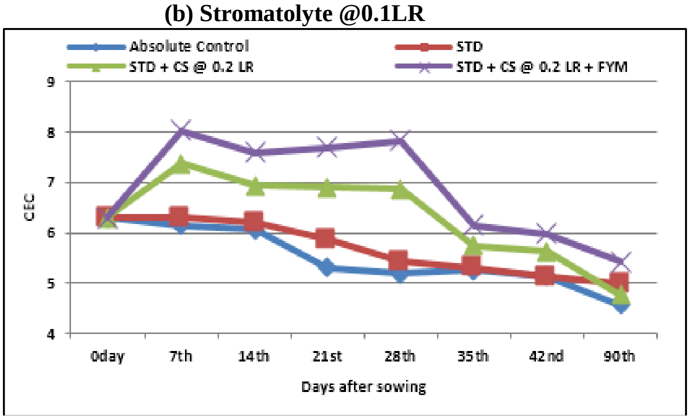
(a) Paper mill sludge @0.1LR



(b) Stromatolyte @0.1LR



(c) Stromatolyte @0.2LR



(d) Calcium Slicate @0.2LR

Fig 3: Change in CEC due to the application of liming materials with or without FYM

(e) Exchangeable Calcium in soil under the influence of application of agro-inputs

The exchangeable Ca status in soil under the influence of liming, manuring and fertilization practice have been presented in Table-3. Before experimentation the exchangeable Ca in soil was 3.4 cmol $(p^{+})kg^{-1}$soil.The exchangeable calcium under controlled condition, decreased its status at the beginning with a small increase at mid stages of crop growth and decreased to words at the harvest stage (Table-3). Similar trend of exchangeable Ca status was observed with the application of STD, where its status decreased maintained below the level in absolute control under each treatment (Table-3). On the other hand application of PMS @ 0.1 LR, ST @ 0.1/0.2 LR and CS @ 0.2 LR continued to supply Ca and maintain higher exchangeable Ca status till the harvest of crop compared to the status without their application (Table-3).Combining FYM application with lime sources maintained still higher status of Ca in the exchange complex compared to their lone sources throughout the growing period of the crop (Table-3).

Table 3: Change in Exchangeable Calcium of soil

Treatments	Days after sowing (DAS)							
	0day	7th	14th	21st	28th	35th	42nd	90th
Absolute Control	3.4	2.8	3.2	3.2	4.4	4.8	4.2	3.2
STD	3.4	3.6	3.2	2.8	3.6	4.1	4	3
STD + PMS @ 0.1 LR	3.4	3.6	3.8	3.9	4.8	4.9	4.3	3.5
STD + PMS @ 0.1 LR + FYM	3.4	4.0	4.2	5.5	5.4	4.6	4.5	3.8
STD + ST @ 0.1 LR	3.4	4.0	4.4	4.2	4.3	4.5	4.8	3.6
STD + ST @ 0.1 LR + FYM	3.4	4.4	4.8	5.2	5.2	5.3	4.9	3.9
STD + ST @ 0.2 LR	3.4	3.6	4.6	5.2	4.8	3.8	3.9	3.8
STD + ST @ 0.2 LR + FYM	3.4	5.6	5.8	6.0	5.0	4.2	4.1	3.5
STD + CS @ 0.2 LR	3.4	4.4	4.4	4.8	4.4	4.7	4.3	3.7
STD + CS @ 0.2 LR + FYM	3.4	4.8	4.8	5.6	4.8	4.9	4.5	4

(f) Exchangeable Mg in soil

The informations on dynamics of Mg in the soil exchange complex have been presented in Table-4.

Its status in initial stage was almost half (53 %) of the exchangeable Ca. The Mg in the soil exchange complex continued to decrease till the harvest of the maize crop in absolute control as well as in STD treatments (Table-4). Supplimentation of Mg through liming sources helped maintaining high exchangeable Mg status in the soil covering majority of times of the growing of maize, however decreased towards the crop harvest. Combined use of FYM with liming materials prevented quick loss of Mg from exchange complex and helped maintaining higher status till the harvest of the crop, inspite of crop removal (Table-4).

Table 4: Change in Exchangeable Magnesium of soil

Treatments	Days after sowing (DAS)							
	0day	7th	14th	21st	28th	35th	42nd	90th
Absolute Control	1.8	1.6	1.2	1.2	2	1.8	1.6	1.6
STD	1.8	1.2	1.2	1.6	2.2	2	1.8	1.4
STD + PMS @ 0.1 LR	1.8	2	2.2	2.4	2.6	2.6	1.7	1.6
STD + PMS @ 0.1 LR + FYM	1.8	2.1	2.4	4.4	2.8	3.2	3.1	2
STD + ST @ 0.1 LR	1.8	2.4	2	2	2	2.2	2	2
STD + ST @ 0.1 LR + FYM	1.8	2.5	2.8	3.6	2.4	2.6	2.3	1.6
STD + ST @ 0.2 LR	1.8	3.6	2.4	3.5	2.8	3.1	2.8	2
STD + ST @ 0.2 LR + FYM	1.8	4	3.2	3.6	3.4	3.3	2.6	1.6
STD + CS @ 0.2 LR	1.8	1.5	1.6	1.2	2.4	2.5	2.2	2
STD + CS @ 0.2 LR + FYM	1.8	2	2.4	3.6	2.8	3	2.7	1.6

(g) Exchangeable K in soil

The exchangeable K status in soil under the influence of different liming materials have been presented in Table-5.Initially it was 0.19 cmol(p^+)kg^{-1} soil, decreased continuously till the harvest of the crop in control treatment. Its addition through fertilizer continued to maintain higher status up to 28th DAS, decreased there after. Under soil ameliorated condition particularly lime sources with FYM maintained higher status of exchangeable K in soil 21 DAS, gradually decreased there after. Among the exchangeable cations, K was next in abundance to Ca and Mg.

Table 5: Change in Exchangeable Potassium of soil

Treatments	0day	7th	14th	21st	28th	35th	42nd	90th
Absolute Control	0.19	0.13	0.12	0.11	0.1	0.09	0.08	0.05
STD	0.19	0.25	0.24	0.23	0.21	0.18	0.16	0.1
STD + PMS @ 0.1 LR	0.19	0.21	0.2	0.18	0.16	0.16	0.15	0.11
STD + PMS @ 0.1 LR + FYM	0.19	0.28	0.42	0.28	0.26	0.19	0.18	0.13
STD + ST @ 0.1 LR	0.19	0.28	0.4	0.3	0.23	0.21	0.2	0.1
STD + ST @ 0.1 LR + FYM	0.19	0.47	0.42	0.31	0.24	0.22	0.21	0.11
STD + ST @ 0.2 LR	0.19	0.29	0.25	0.24	0.22	0.24	0.21	0.09
STD + ST @ 0.2 LR + FYM	0.19	0.31	0.29	0.31	0.27	0.26	0.23	0.05
STD + CS @ 0.2 LR	0.19	0.26	0.29	0.28	0.27	0.24	0.24	0.03
STD + CS @ 0.2 LR + FYM	0.19	0.28	0.32	0.31	0.29	0.25	0.26	0.14

Conclusion

The liming materials neutralised the activity due to H^+ and Al^{3+} and the exchange acidity to lower manageable level and raised the pH differently depending upon the neutralising value of the sources. The PMS applied @ 0.1 LR maintained higher pH up to 14 days after sowing. The Stromatolyte applied @ 0.1 and @ 0.2 LR doses maintained higher pH up to 28 and 35 days after sowing respectively. The calcium silicate source maintained higher pH up to 21 days after sowing. The effectiveness of the lime sources increased with their combined application with FYM, for PMS it was 21 days, ST @ 0.1 LR - 35 days, ST @ 0.2 LR -49 days and CS @ 0.2 LR - 28 days after sowing. The acid neutralizing efficiency of liming materials followed the order: ST @0. 2LR>CS@0.2LR>PMS@0.1LR>ST@0.1LR. Appliaction of lone sources of liming materials alone increased the CEC from 6.39 to 7.37 cmol(p^+)kg^{-1}but the combine application of liming materials with FYM increased the CEC from 7.38 to 8.03 cmol(p^+)kg^{-1}.

References

1. Alves MC, Paz Gonzalez A, Colorado G, Perecin Junior H, Vidal V. Influence ofbiosolids rate on chemical properties of an Oxisol in Sao Paulo, Brazil. Communicationin Soil Science and Plant Analysis. 2006; 37(15/20):2481-2493.
2. Chesnin L, Yein CH. Soil Science Soc. of Amer Proc. 1951; 15:149-151.
3. Curnoe WE, Irving DC, Dow CB, Velema G, Unc A. Effect of spring application ofa paper mill soil conditioner on corn yield. Agronomy J. 2006; 98(3):423-429.
4. Edward JH, Horton BD, White AW, Bennett OL. Fluidized bed combustion residue asan alternative liming material and Ca source. Communication In Soil Science Plant Analysis. 1985; 16(6):621-637.
5. Haby VA, Loeppert RH, Villavicecio R, Leonard AT, Davic JV. Limestone efficiency and boron effects on forage yield and soilproperties. Plant-Soil Interactions at Low pH: Principle and Management. 1995, 505-510.
6. Hea J, Langea CR, Dougherty M. Laboratory study using paper mill lime mud for agronomic benefit. Process Safety and Environmental Protection. 2009; 87:401-405.
7. Jackson ML. *Soil Chemical Analysis*, Madison, Wisconsin, 1973.
8. Mishra M, Pattanayak SK. Response of crops to graded doses of lime amended with or without FYM in different crops grown in acid soil. Professor IFFCO chairreport, OUAT, Bhubaneswar, 2002.
9. Misra UK. Acid Soil and its Management. Journal of the Indian Society of Soil Science. 2004; 52(4):332-343.
10. Mohammadi Torkashv A. Improvements on compost quality byaddition of some amendments. Australian Journal of Crop Science. In press, 2010.
11. Page AL, Miller RH, Keny DR. Methods of soil and plant analysis, part-2, 2nd Edn. No (9) Part in the series, American Society of Agronomy, Inc. Soil Science Society of American Journal. Madison, Wisconsin, U.S.A, 1982.
12. Panda N, Koshy MM. In: Review of soil research in India, Pt-1, XII International Congress of Soil Science, 8-16th Feb., New Delhi, 1982.
13. Pattanayak SK. Paper mill sludge as an Acid soil ameliorant. In Acid soils Their chemistry and management. Edited by A.K. Sarkar New India Publishing Agency New Delhi-110034, 2013.
14. Oguntoinbo FI, Aduay EA, Sobulo RA. Effectiveness of some local liming materialsin Nigeria as ameliorants of soil acidity. J Plant Nutrition. 1996; 19(7):999-1016.
15. Quoggio JA, Gallo PB, Mascarenhas HA. Agronomic efficiency of limestone with different acid-neutralizing capacity, under field condition. Plant-Soil Interactions atLow pH: Principle and Management. 1995, 491-496.
16. Sahu GC, Patnaik S. Influence of lime or organic matter on pH and ion exchange phenomenon of some *Alfisols*. Journal of the Indian Society of Soil Science. 1990; 38:154-157.
17. Stuczynski TI, McCarty GW, Wright RJ. Impact of coal combustion productamendments on soil quality: 1. Mobilization of soil organic nitrogen. Soil Sci. Soc. Am. J. 1998; 163(12):952-959.
18. Ulrich BA. concept of ecosystem stability and of acid deposition as driving force for destabilization.
19. Vityakon P, Seripong S, Date RA, Grundon NJ, Rayment GE, Probert ME. Evaluation of paper mill lime sludge as an acid soilamendment in northeast Thailand. Plant-SoilInteractions at Low pH: Principle and Management. 1995, 595-599.