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Scientific influence of different sources of liming materials with and without FYM on concentration, uptake and recovery of the nutrients for maize crop grown in acid soil of Khurda Dist. of Odisha

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Abstract
A field experiment was conducted to study the "Scientific Influence of different sources of Liming materials with and without FYM on Concentration, Uptake & Recovery of the nutrients for Maize crop grown in Acid Soil " in the village Bajpur in khorda district of Odisha during *Kharif*, 2013. The soil was ameliorated with three different source sof 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. The maximum concentration of the major nutrients follows the order as N>K>P>Mg>Ca>S. The maximum uptake of the 'N' (74.8 kg/ha) was observed in Paper mill sludge source applied @ 0.2 LR with STD & FYM but the maximum uptake of the 'K' (32.2 kg/ha) & 'S' (7.1 kg/ha) was observed in Calcium Silicate source applied @ 0.2 LR integrated with STD & FYM and the maximum uptake of the 'P' (13.4 kg/ha), 'Ca' (15.5 kg/ha) & 'Mg' (6.7 kg/ha) was observed in Stromatolyte source applied @ 0.2 LR with STD & FYM. Among the major nutrients, the recovery of 'P' was maximum ranging from 26-66 %, followed by 'K' from 22 to 55 per cent, 'N' from 17 to 36 per cent and S from 6.2 to 28.7 per cent.The maximum recoveries of major nutrients were recorded with Stromatolyte source applied @ 0.2 LR integrated with STD and FYM.

Keywords: Acid soil, Paper mill sludge, Stromatolyte, Calcium Silicate, Concentration, Uptake & Recovery etc

Introduction
Soil acidity is a major yield limiting factor for crop production worldwide. Land area affected by acidity is estimated at 4 billion hectares, representing approximately 30% of the total ice-free land area of the world (Sumner and Noble, 2003) [1]. In the tropics, substantial weathering of soils over millennia has resulted in the leaching of crop nutrient bases (mainly K, Mg and Ca) followed by their replacement by H, Al, Mn cations which have contributed to acid related stresses on crop production (Okalebo *et al*., 2009) [2]. Acid infertility factors limit crop growth and yield as well as soil productivity in highly weathered soils of humid and sub-humid regions of the world due to deficiency of essential nutrient elements (Akinrinade *et al*., 2006) [3]. Crop production is low and declining on such acid soils and particularly where acid forming fertilizers, such as di-ammonium phosphate (DAP) and other ammonia fertilizers have been applied continuously to already acidified soils over years (Nekesa, 2007) [4]. As these soils suffer in multi-nutrient deficiencies, application of mineral fertilizers has become mandatory to increase crop yields. However, mineral fertilizers are commonly scarce, costly; having imbalanced nutrition and their use could exacerbate the problem of soil acidity (Oguike *et al*., 2006; Nottidge *et al*., 2006) [5, 6]. The practice of liming acid soils is not common in Sub-Saharan Africa (SSA), probably because of limited knowledge online usage and its effectiveness, availability and high hauling costs of liming materials (Okalebo *et al*., 2009) [2]. Continuous cropping using incorrect fertilizer types has intensified soil chemical degradation of arable lands resulting in reduced capacity of soils to produce crops sustainably (Nandwa, 2003; Ayuke *et al*., 2007; Mugendi *et al*., 2007) [7, 8, 9]. According to Kisinyo *et al*. (2005) [10], continuous cropping has led to development of soil acidity which is a major constraint to maize production on tropical soils due to toxic levels of aluminium (Al) and the concomitant phosphorus (P) deficiency that hinder plant growth. The main objective of this work was to determine the influence of different sources of liming materials with or without FYM for concentration, uptake and recovery of the nutrients of Maize crop grown in Acid Soil.

Materials and Methods

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. The different plant parts like leaf,shoot,cob,grain and roots were kept in separate envelops, washed, labeled properly and dried in hot air oven till a constant weight was recorded. Each sample was grinded separately and was used for analysis of different elements. Nitrogen in the processed sample was determined by Kjeldahl digestion method as described in AOAC (1960). The samples were digested in diacid mixure [HNO_3: $HClO_4$ (3:2)]. The P and S were estimated spectrophotometrically, K, flame photometrically, Ca & Mg by EDTA titration method. (Jackson, 1973) [11].

Nutrient uptake (kg ha^{-1}) = Dry matter (q/ha) x nutrient concentration (%)

$$\text{Apparent Recovery of Nutrient (\%)} = \frac{\text{Uptake of nutrient in desired treatment} - \text{Uptake in absolute control}}{\text{Amount of nutrient added}} \times 100$$

Results and Discussion

Concentration, uptake and recovery of the Nitrogen as influenced by addition of different liming materials

The concentration N in different maize plant parts and uptake through these parts have been presented in Table-1. Its concentration of N in grain was more (ranging from 1.30 to 1.55 %) than through stover (ranging from 0.31 to 0.44 %) and than through roots (ranging from 0.58 to 1.23 %). So also the N uptake through grain was more (ranging from 15.7 to 54.9 $kgha^{-1}$) than stover (ranging from 5.1 to 20.1 $kgha^{-1}$) than through roots (ranging from 0.06 to 1.97 $kgha^{-1}$). The total uptake under different treatments varied significantly between 20.9 and 74.8 $kgha^{-1}$, lowest with control and highest with STD + PMS @ 0.1 LR + FYM.

Table 1: Concentration, Uptake and Recovery of the Nitrogen as influenced by application of different liming materials.

Treatments	Concentration (%)			Uptake(kg/ha)				ANR
	Grain	Stover	Root	Grain	Stover	Root	Total	(%)
Absolute control	1.41	0.34	0.58	15.7	5.1	0.06	20.9	----
STD	1.55	0.38	0.85	34.2	11.4	0.43	45.9	17
STD + PMS @ 0.1 LR	1.33	0.44	0.97	35.9	16.6	0.77	53.3	22
STD+PMS @ 0.1 LR + FYM	1.42	0.45	1.05	52.8	20.1	1.82	74.8	36
STD +ST @ 0.1 LR	1.43	0.32	1.01	38.2	10.0	1.13	49.4	19
STD +ST @ 0.1 LR +FYM	1.38	0.38	1.02	44.3	14.5	1.23	59.9	26
STD + ST @ 0.2 LR	1.40	0.38	1.06	44.5	14.9	1.16	60.7	27
STD + ST @ 0.2 LR + FYM	1.30	0.40	1.23	51.4	18.9	1.77	71.9	34
STD + Ca-Si @ 0.2 LR	1.32	0.31	1.21	40.0	11.6	1.49	53.1	22
STD + Ca-Si@ 0.2 LR+FYM	1.48	0.34	1.23	54.9	15.1	1.97	71.9	34
CD(P=0.05)	0.16	6.63		8.58	3.38	0.28	9.66	

Application of STD based inorganic nutrients significantly increased N uptake by the crop. Combined application of liming materials with STD though increased N uptake but not significantly higher than STD alone, except for ST @ 0.2 LR. However, integrating FYM application with STD and lime sources significantly increased N uptake even compared to N uptake due to STD + lime sources, indicating the importance of organic integration in improving efficiency of liming materials. The similar results were also reported by Doddamani (1975) [12] and Patil and Ananthanaryana (1989) [13] when acid soils were limed.

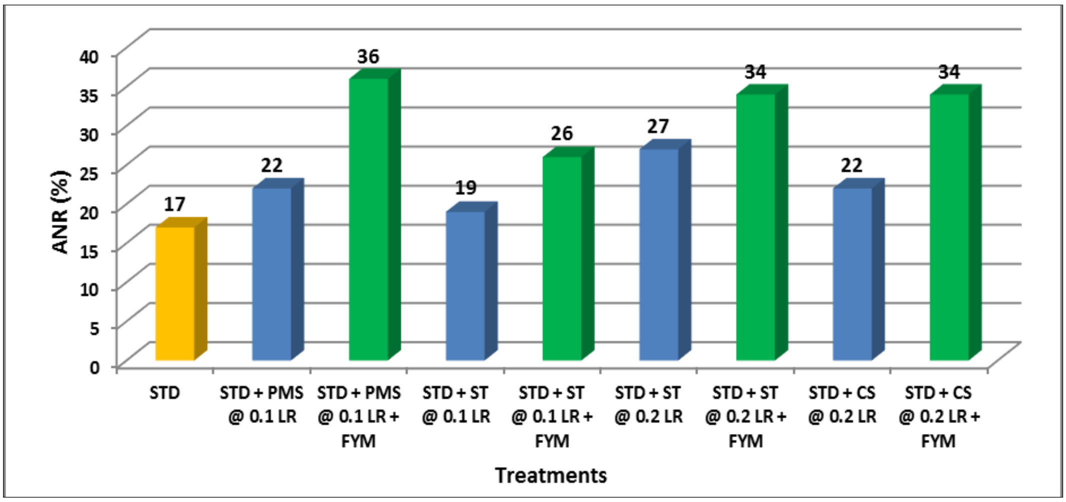

Fig-1: Apparent Nitrogen Recovery by Maize crop as influenced by application of different liming materials

The recovery added by maize crop increased from the level of 17 to 36 per cent (Fig-1). Liming of acid soil improved the recovery of N ranging from 5 to 10 per cent over the recovery due to STD (17 %). The lime sources followed the order: ST @ 0.2 LR > CS @ 0.2 LR = PMS @ 0.1 LR > ST @ 0.1 LR. Integrating FYM application with liming materials further increased the recovery of N ranging from 7 to 11 per cent. The combinations followed the order: PMS @ 0.1 LR = CS @ 0.2 LR > ST @ 0.2 LR = ST @ 0.1 LR

Concentration, uptake and recovery of the Phosphorus as influenced by addition of different liming materials

The data relating to the concentration of P and its uptake through maize crop have been presented in Table -2.The concentration of P in maize grain was more (from 0.25 to 0.31 %) than its root (from 0.05 to 0.13 %) than the stover (from 0.03 to 0.06 per cent). The uptake through grain was more (from 3.3 to 10.7 $kgha^{-1}$) than stover (from 0.9 to 2.6 $kgha^{-1}$) than the roots (from0.01 to 0.21 $kgha^{-1}$). The total uptake varied significantly between 4.2 and 13.4 $kgha^{-1}$, lowest with control and highest with STD + ST @ 0.2 LR.

Table 2: Concentration, Uptake and Recovery of the Phousphorus as influenced by application of different liming materials

Treatments	Concentration (%)			Uptake(kg/ha)				APR
	Grain	Stover	Root	Grain	Stover	Root	Total	(%)
Absolute control	0.29	0.03	0.06	3.3	0.9	0.01	4.2	----
STD	0.31	0.05	0.08	6.7	1.3	0.04	8.1	26
STD + PMS @ 0.1 LR	0.26	0.05	0.08	7.1	2.0	0.07	9.2	34
STD+PMS @ 0.1 LR + FYM	0.25	0.06	0.09	9.4	2.5	0.16	12.1	57
STD +ST @ 0.1 LR	0.28	0.04	0.05	7.3	1.4	0.06	8.8	31
STD +ST @ 0.1 LR +FYM	0.27	0.05	0.08	8.5	1.7	0.09	10.2	42
STD + ST @ 0.2 LR	0.28	0.05	0.06	8.9	1.9	0.07	10.9	47
STD + ST @ 0.2 LR + FYM	0.27	0.06	0.09	10.7	2.6	0.13	13.4	66
STD + Ca-Si @ 0.2 LR	0.26	0.05	0.09	8.0	2.0	0.11	10.1	41
STD + Ca-Si@ 0.2 LR+FYM	0.28	0.06	0.13	10.5	2.4	0.21	13.1	64
CD(P=0.05)	4.58	1.07		1.52	0.42	1.63	1.48	

With the application of soil test based inorganic fertilizers there was significant influence on P uptake, but with the application of liming materials with STD, the P uptake increased significantly with ST @ 0.2 LR and CS @ 0.2 LR not with PMS 0.1 LR or ST @ 0.1 LR. However combined application of FYM with the sources significantly increased P uptake except with ST @ 0.1 LR. The results corroborate with the findings of Mohammadi *et al* (2010) [16]. He found that application of Paper mill sludge increased the P uptake by $L_{0.5}$ and L_1 treatments of lime in sorghum.

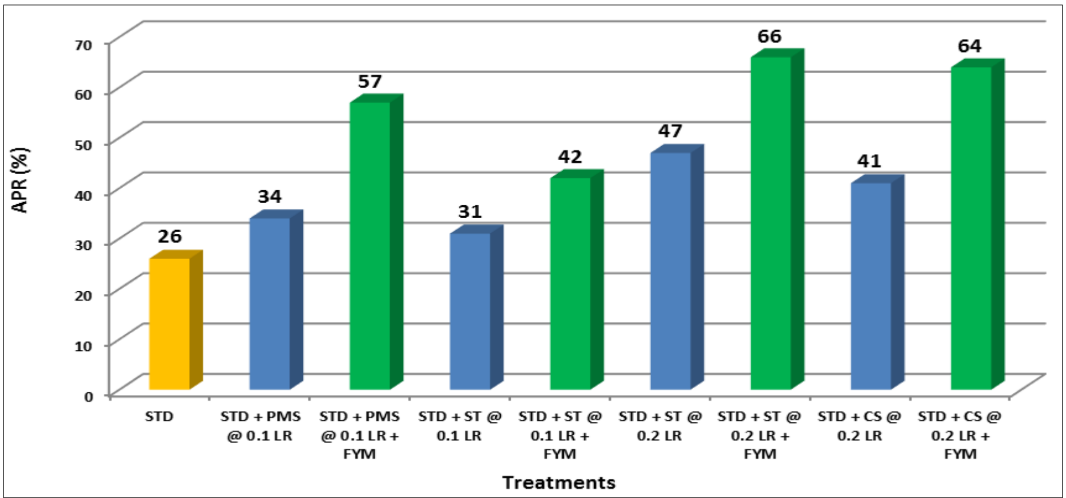

Fig-2: Apparent Phosphorus Recovery by Maize crop as influenced by application of different liming materials

The recovery of P by maize crop increased from a level of 26 to 66 per cent. (Fig-2) Integrating application of ST @ 0.1 LR with STD increased P recovery by 5 per cent, PMS @ 0.1 LR with STD by 8 per cent, CS @ 0.2 LR with STD by 15 per cent and ST @ 0.2 LR with STD by 21 per cent compared to that of STD alone. Integrating FYM application with lime sources increased the recovery further (ST @ 0.1 LR by 11 %, ST @ 0.2 LR by 19 % both PMS @ 0.1 LR and CS @ 0.2 LR by 23 %).

Concentration, uptake and recovery of the Potassium as influenced by addition of different liming materials

The data related to potassium concentration and uptake by Maize crop have been presented in Table- 3. The concentration of K in maize root was more (ranging from 0.31-0.60%) than its stover (ranging from 0.32-0.44%) than its grain (ranging from 0.32 to 0.37%. But its uptake through stover was more (ranging from 6.0-19.4 Kg/ha) than its grain (ranging from 4.1- 12.8 Kg/ha) and roots (ranging from 0.03-0.96%). The total uptake varied significantly between 10.1 and 32.2 kg/ha. The uptake of K was significantly influenced by the application of STD compared to control. The results corroborate with the findings of Mohammadi *et al* (2010) [16]. He found that application of Paper mill sludge increased the K uptake in L_1 and L_2 treatments of lime in sorghum.

Table 3: Concentration, Uptake and Recovery of the Potassium as influenced by application of different liming materials.

Treatments	Concentration (%)			Uptake (kg/ha)				AKR
	Grain	Stover	Root	Grain	Stover	Root	Total	(%)
Absolute control	0.36	0.39	0.31	4.1	6.0	0.03	10.1	----
STD	0.37	0.35	0.40	8.1	10.5	0.20	18.8	22
STD + PMS @ 0.1 LR	0.33	0.38	0.41	8.9	14.5	0.33	23.6	34
STD+PMS @ 0.1 LR +FYM	0.32	0.43	0.45	11.8	19.6	0.77	32.2	55
STD +ST @ 0.1 LR	0.33	0.32	0.44	8.8	10.4	0.49	19.7	24
STD +ST @ 0.1 LR +FYM	0.32	0.42	0.52	10.2	16.0	0.62	26.9	42
STD + ST @ 0.2 LR	0.36	0.38	0.44	11.3	15.3	0.49	27.0	42
STD + ST @ 0.2 LR + FYM	0.32	0.39	0.52	12.8	18.1	0.75	31.5	54
STD + Ca-Si @ 0.2 LR	0.34	0.40	0.43	10.2	14.8	0.53	25.5	39
STD + Ca-Si@ 0.2 LR+FYM	0.32	0.44	0.60	11.9	19.4	0.96	32.2	55
CD(P=0.05)	0.08	0.12	---	1.58	4.66	7.93	4.70	----

Integrating use of ST @ 0.2 LR and CS @ 0.2 LR with STD significantly increased the K uptake but not the PMS or ST @0.1 LR. However, combining FYM application with STD and lime sources significantly increased K uptake by maize crop compared to FYM.

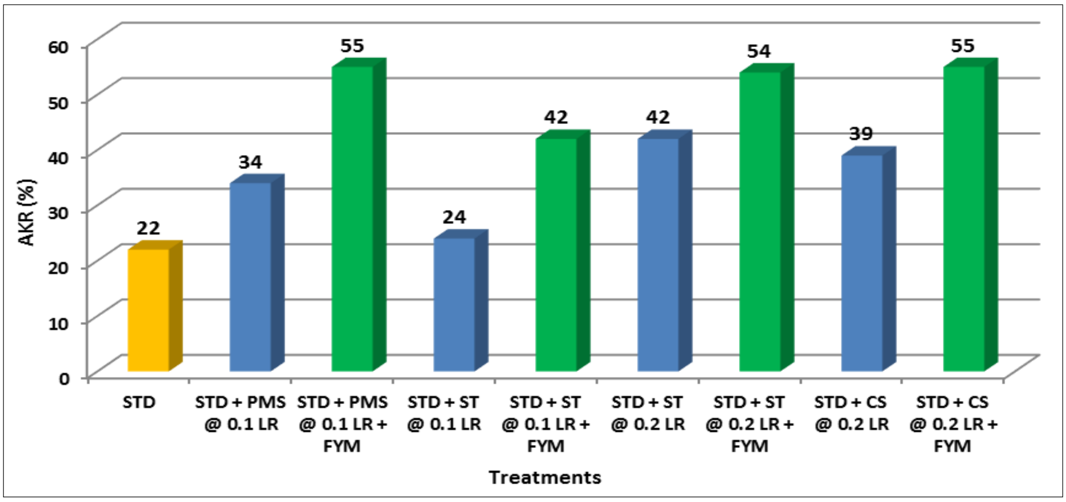

Fig-3: Apparent Potassium Recovery by Maize crop as influenced by application of different liming materials

The recovery of K by maize crop increased from a level of 22 per cent with STD only to a level of 55 per cent STD + PMS @ 0.1 LR / CS @ 0.2 LR + FYM (Fig-3). The recovery of K with integrated use of ST @ 0.1 LR with STD increased only by 2 per cent, 12 per cent with PMS, 17 per cent with CS @ 0.2 LR and 20 per cent by ST @ 0.2 LR. Due to FYM integration with STD+Lime sources, the recovery per cent further increased by 12 per cent with ST @ 0.2 LR, 16 per cent with PMS@ 0.1 LR.

Concentration, uptake and recovery of the Sulphur as influenced by addition of different liming materials

The data related to sulphur nutrition of maize have been presented in Table-4. There are not much difference in the distribution of S in maize grain, stover and roots. In the grain it was 0.05-0.08, in stover from 0.055-0.088 and in root from 0.03-0.1 per cent. The removal through stover was more (ranging from 0.9-3.9 Kg/ha.) than grain (ranging from 0.6-3.0 Kg/ha) and roots (ranging from 0.01-0.16 Kg/ha).

Table 4: Concentration, Uptake and Recovery of the Sulphur as influenced by application of different liming materials

Treatments	Concentration (%)			Uptake (kg/ha)				ASR
	Grain	Stover	Root	Grain	Stover	Root	Total	(%)
Absolute control	0.06	0.058	0.03	0.6	0.9	0.01	1.5	----
STD	0.05	0.055	0.07	1.0	1.6	0.04	2.7	6.2
STD + PMS @ 0.1 LR	0.05	0.054	0.06	1.4	2.0	0.05	3.5	10.3
STD+PMS @ 0.1 LR + FYM	0.06	0.06	0.07	2.2	2.8	0.12	5.1	18.4
STD +ST @ 0.1 LR	0.07	0.068	0.05	1.8	2.2	0.06	4.1	13.3
STD +ST @ 0.1 LR +FYM	0.08	0.075	0.06	2.5	2.8	0.08	5.4	19.9
STD + ST @ 0.2 LR	0.06	0.07	0.07	2.1	2.7	0.07	4.8	16.9
STD + ST @ 0.2 LR + FYM	0.07	0.082	0.09	2.7	3.6	0.12	6.4	25.1
STD + Ca-Si @ 0.2 LR	0.07	0.075	0.07	2.1	2.7	0.08	4.9	17.4
STD + Ca-Si@ 0.2 LR+FYM	0.08	0.088	0.10	3.0	3.9	0.16	7.1	28.7
CD(P=0.05)	0.005	0.006	0.006	0.39	0.42	0.05	0.41	

The total uptake varied significantly between 1.5 and 7.1 Kg/ha. Application of STD of fertilizers either alone or or with liming materials or more specifically with FYM significantally influenced S uptake by the crop. The similar results of S uptake was found by the Adetunji and Bamiro in 1994.

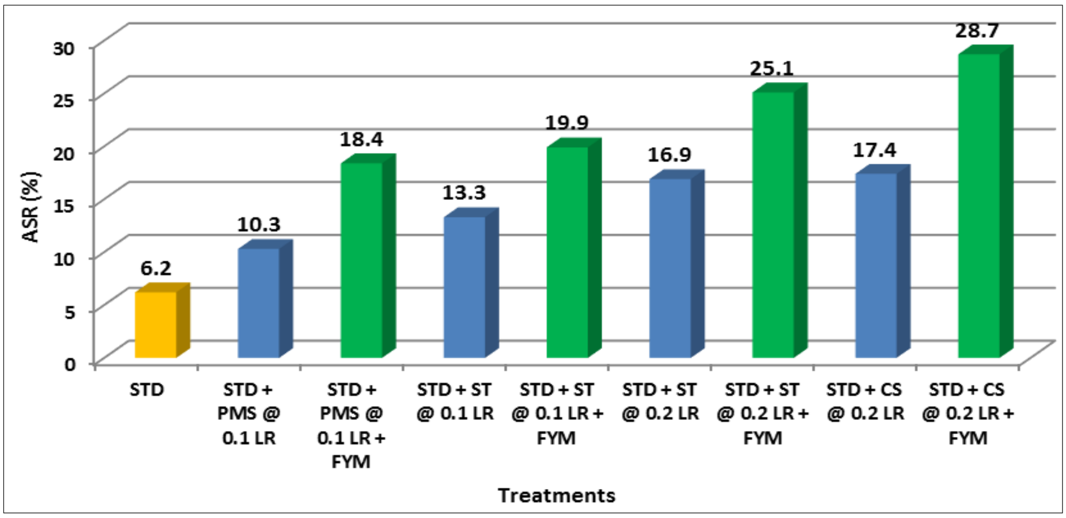

Fig 4: Apparent Sulphur Recovery by Maize crop as influenced by application of different liming materials

The apparent recovery of applied S by maize crop increased from a level of 2.2 to 8.8 per cent. Integrated use of fertilizers, Lime sources and FYM acted positively for recovery (Fig-4).

Concentration and uptake of the Calcium as influenced by addition of different liming materials

In maize crop more of Ca was analysed from its stover (ranging from 0.12 to 0.19%) than from grain (ranging from 0.10-0.17%) and least in roots (ranging from 0.08-0.10%) (Table-5). Its uptake through stover was more (ranging from 1.9-9.0Kg/ha.) than grain (ranging from 1.1-6.4 Kg/ha) and root (ranging from 0.01-0.16 kg/ha).

Table 5: Concentration and Uptake of Calcium as influenced by application of different liming materials

Treatments	Concentration (%)			Uptake(kg/ha)			
	Grain	Stover	Root	Grain	Stover	Root	Total
Absolute control	0.10	0.12	0.08	1.1	1.9	0.01	3.1
STD	0.11	0.16	0.09	2.4	4.7	0.05	7.1
STD + PMS @ 0.1 LR	0.09	0.17	0.07	2.6	6.6	0.06	9.3
STD+PMS @ 0.1 LR + FYM	0.10	0.17	0.08	4.1	8.0	0.14	12.2
STD +ST @ 0.1 LR	0.17	0.18	0.08	3.1	5.6	0.09	8.8
STD +ST @ 0.1 LR +FYM	0.12	0.19	0.09	3.9	7.3	0.12	11.4
STD + ST @ 0.2 LR	0.14	0.18	0.07	4.3	6.9	0.08	11.3
STD + ST @ 0.2 LR + FYM	0.16	0.19	0.10	6.4	9.0	0.14	15.5
STD + Ca-Si @ 0.2 LR	0.13	0.16	0.08	3.9	6.3	0.07	10.3
STD + Ca-Si@ 0.2 LR+FYM	0.14	0.17	0.09	5.0	7.6	0.16	12.8

The total uptake variedbetween 3.1 and 12.8 kg/ha. Fertilizering crop increased Ca uptake by the crop compared to control. Even its uptake increased by combining both liming materials and FYM (Table-5). The similar results uptake of Ca was observed in groundnut due to liming by Bheemaiah and Ananthanrayana (1984) [14], Prasad *et al.* (1983) [15].

Concentration and uptake of the Magnesium as influenced by addition of different liming materials

More Mg was analysed from maize roots (ranging erom 0.16-0.29 %) than grain (ranging from 0.07-0.10 %) and stover (ranging from 0.05-0.09%). The Mg in maize root was even more than the Ca in the root (Table-6). The uptake of Mg through stover was more (ranging from 0.8-3.8 kg/ha) than grain (ranging from 0.8-3.9 kg/ha) and root (ranging from 0.02-0.51 kg/ha).

Table 6: Concentration and Uptake of Magnesium as influenced by application of different liming materials.

Treatments	Concentration (%)			Uptake(kg/ha)			
	Grain	Stover	Root	Grain	Stover	Root	Total
Absolute control	0.07	0.05	0.16	0.8	0.8	0.02	1.7
STD	0.08	0.06	0.17	1.7	1.6	0.09	3.4
STD + PMS @ 0.1 LR	0.08	0.07	0.19	2.2	2.9	0.15	5.3
STD+PMS @ 0.1 LR + FYM	0.09	0.08	0.29	3.2	3.8	0.51	7.5
STD +ST @ 0.1 LR	0.09	0.06	0.17	2.5	1.9	0.19	4.6
STD +ST @ 0.1 LR +FYM	0.10	0.09	0.18	3.9	3.6	0.21	7.6
STD + ST @ 0.2 LR	0.07	0.06	0.25	2.3	2.3	0.27	4.9
STD + ST @ 0.2 LR + FYM	0.08	0.08	0.28	2.9	3.4	0.40	6.7
STD + Ca-Si @ 0.2 LR	0.07	0.07	0.27	2.2	2.8	0.33	5.3
STD + Ca-Si@ 0.2 LR+FYM	0.08	0.08	0.28	3.0	3.1	0.45	6.6

The total Mg uptake varied between 1.7 and 7.5 kg/ha. The use of soil test based fertilizers either alone or its integration with liming materials and particularly FYM increased Mg uptake by the crop (Table-6).

Conclusion

The maximum concentration of the major nutrients follows the order as N>K>P>Mg>Ca>S.The maximum uptake of the 'N' (74.8 kg/ha) was observed in Paper mill sludge source applied @ 0.2 LR with STD & FYM but the maximum uptake of the 'K' (32.2 kg/ha) & 'S' (7.1 kg/ha) was observed in Calcium Silicate source applied @ 0.2 LR integrated with STD & FYM and the maximum uptake of the 'P' (13.4 kg/ha), 'Ca' (15.5 kg/ha) & 'Mg' (6.7 kg/ha) was observed in Stromatolyte source applied @ 0.2 LR with STD & FYM.Among the major nutrients, the recovery of 'P' was maximum ranging from 26-66 %, followed by 'K' from 22 to 55 per cent, 'N' from 17 to 36 per cent and S from 6.2 to 28.7 per cent.The maximum recoveries of major nutrients were recorded with Stromatolyte source applied @ 0.2 LR integrated with STD and FYM.

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