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Influence on different sources of liming materials on nutrient concentration of maize leaf grown in acid soil of Odisha

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Abstract
A field experiment was conducted to study the "Influence of different sources of liming materials on nutrient concentration of maize leaf grown in acid soil of Odisha" in the village Bajpur of Khorda district during kharif, 2013. The application of different sources of liming materials increases the nutrient concentration (P, K, Ca, Mg & S) from the 1st stage (30 DAS) to the 3rd stage (90 DAS) except nitrogen because the nitrogen increase from 1st stage to 2nd stage then decreases thereafter from 2nd stage to 3rd stage. The total nutrient concentration in the maize leaf varies between 2.13-2.90 % N, 0.25-0.39 % P, 1.35-2.16 % K, 0.45-0.74 % Ca, 0.48-0.77 % Mg and 0.49-0.33 % S where lowest concentration of all the nutrients were seen in absolute control and highest concentration N was seen in ST @ 0.1 LR, P in PMS @ 0.1 LR+F, K in CS @ 0.2 LR, Ca in CS @ 0.2 LR+F and Mg & S in ST @ 0.2 LR+F. The increasing of nutrient concentration in the maize leaf follows the order N>K>Mg>Ca>P>S. The application of double dose of stromatolite @ 0.2 LR increases the P, Ca, Mg, S concentration & decreases the N, K concentration in all the stages but integration with FYM increases the N, K, Mg, S concentration and decreases the P, Ca concentration. Irrespective of the treatments the application of lone sources of liming materials increases all the nutrients in all the stages but mixed application of liming materials with FYM decreases the N, P, K concentration but increase the Ca, Mg & S concentration.

Keywords: acid soil, paper mill sludge, stromatolite, calcium silicate, maize leaf & nutrient concentration etc.

Introduction
Soil acidity affects nearly 50 percent of the world's potentially arable land, particularly in humid tropics (von Uexkull and Mutert 1995) [9]. In India, approximately one-third of the cultivated land is affected by soil acidity (Mandal 1997) [2]. Majority of these soils are concentrated in north-eastern region of India, with nearly 65% of its area being under extreme forms of soil acidity (pH below 5.5) (Sharma and Singh 2002) [8]. Crop productivity on such soils is mostly constrained by aluminium (Al) and iron (Fe) toxicity, phosphorus (P) deficiency, low base saturation, impaired biological activity and other acidity-induced soil fertility and plant nutritional problems (Patiram 1991; Manoj-Kumar *et al*. 2012) [7, 5]. The levels of soil acidity along with its associated impacts on soil fertility and crop productivity are expected to further intensify in a changing climate (Oh and Richter 2004; Manoj Kumar 2011a&b) [6, 3]. Soil acidity management and crop productivity improvement on such soils is therefore important for enhancing food security globally and regionally. Odisha is an agriculturally important state in India, with typically high levels of soil acidity and very high rainfall. Acidity–induced soil fertility problems coupled with traditionally minimal use of mineral fertilizers are often held responsible for low levels of crop productivity in the state. Lime application along with integrated nutrient management is often recommended to increase the phyto availability of essential nutrients and ameliorate the other acidity-induced fertility constraints on such soils (Haynes 1984; Patiram 1991; Manoj-Kumar *et al*. 2012) [1, 7, 5]. It is therefore imperative to ascertain the yield benefits of individual as well as combined application of lime, chemical fertilisers and organic manure in a particular edapho-climatic condition. We evaluated the same in a field experiment (with maize as a test crop) on an acid Alfisol of Odisha, India. Additionally, we also evaluated the effectiveness of the liming materials on nutrient concentration of the maize leaf.

Materials &b Methods

Three different types of liming materials were used in the experiment. These were Paper Mill Sludge (PMS), Stromatolite (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 laid out field with Radomised Block Design (RBD). The leaf samples were collected from all the treatments in three different stages i.e 30, 60 & 90 days after sowing. These samples were oven dried and digestion by the diacid digestion method. Then the N, P, K, Ca, Mg & S was analysed.

Result & Discussion

- **Concentration of the nitrogen (%) in maize leaf**

The influence of different sources of liming materials on concentration of the Nitrogen in maize leaf varies between 0.61% to 0.92% in the 1st stage (30 DAS), 0.79% to 1.16% in the 2nd stage (60 DAS) and 0.57% to 0.90% in the 3rd stage (90 DAS). The total concentration of the nitrogen in the maize leaf varies between 2.13% to 2.90%. Among three stages the concentration of the Nitrogen increases from the 1st stage to the 2nd stage but decreases from the 2nd stage to the 3rd stage. (Table-1).

Table 1: Concentration of the Nitrogen (%) in Maize leaf

Treatments	1st Stage (30 DAS)	2nd Stage (60 DAS)	3rd Stage (90 DAS)	Total Concentration
Absolute control	0.65	0.79	0.69	2.13
STD	0.76	0.92	0.74	2.42
STD + PMS @ 0.1 LR	0.82	0.93	0.79	2.54
STD+PMS @ 0.1 LR + FYM	0.61	0.88	0.87	2.36
STD +ST @ 0.1 LR	0.92	1.08	0.90	2.90
STD +ST @ 0.1 LR +FYM	0.81	1.05	0.83	2.69
STD + ST @ 0.2 LR	0.61	0.99	0.83	2.43
STD + ST @ 0.2 LR + FYM	0.84	0.98	0.88	2.70
STD + CS @ 0.2 LR	0.89	0.98	0.57	2.44
STD + CS @ 0.2 LR+FYM	0.80	1.16	0.82	2.78

The application of PMS @ 0.1 LR & ST @ 0.1 LR alone increases the nitrogen concentration in all the stages but the integrated application of PMS @ 0.1 LR & ST @ 0.1 LR with FYM decreases the nitrogen concentration in all the stages compare to the lone sources. The double dose of the stromatolite @ 0.2 LR alone gives the lower nitrogen concentration compare to the single dose but the integrated application of the stromatolite double dose with FYM gives the higher nitrogen concentration compare to the single dose in 1st (0.84%) and 3rd stage (0.88%) and lower nitrogen concentration in 2nd stage (0.98%) The application of CS @ 0.1LR alone increases the nitrogen concentration in all the stages but the integrated application of CS @ 0.1LR with FYM decreases the nitrogen concentration in the 1st stage (0.80%) & increases the nitrogen concentration in the 2nd (1.16%) & 3rd (0.82%) stage compare to the lone source. The highest nitrogen concentration in the 1st & 3rd stage was seen in ST @ 0.1 LR (0.92% & 0.90%) and 2nd stage was seen in CS @ 0.2 LR +FYM (1.16%). The lowest nitrogen concentration in the 1st stage was seen in PMS @ 0.1 LR + FYM (0.61%), 2nd stage was seen in absolute control (0.79%) & 3rd stage was seen in CS @ 0.2 LR (0.57)%. (Table-1).

- **Concentration of the phosphorous (%) in maize leaf**

The influence of different sources of liming materials on concentration of the Phosphorous in maize leaf varies between 0.41% to 0.78% in the 1st stage (30 DAS), 0.084% to 0.119% in the 2nd stage (60 DAS) and 0.130% to 0.196% in the 3rd stage (90 DAS). The total concentration of the phosphorous in the maize leaf varies between 0.25% to 0.39%. Among three stages the concentration of the Phosphorous increases from the 1st stage to the 3rd stage. (Table-2).

Table 2: Concentration of the Phosphorous (%) in Maize leaf

Treatments	1st Stage (30 DAS)	2nd Stage (60 DAS)	3rd Stage (90 DAS)	Total Concentration
Absolute control	0.038	0.084	0.130	0.25
STD	0.045	0.098	0.158	0.30
STD + PMS @ 0.1 LR	0.060	0.095	0.192	0.35
STD+PMS @ 0.1 LR + FYM	0.078	0.119	0.196	0.39
STD +ST @ 0.1 LR	0.068	0.094	0.139	0.30
STD +ST @ 0.1 LR +FYM	0.073	0.098	0.189	0.36
STD + ST @ 0.2 LR	0.077	0.112	0.183	0.37
STD + ST @ 0.2 LR + FYM	0.064	0.111	0.166	0.34
STD + CS @ 0.2 LR	0.062	0.112	0.157	0.33
STD + CS@ 0.2 LR+FYM	0.041	0.095	0.154	0.29

The application of PMS @ 0.1 LR and ST @ 0.1 LR mixed with FYM increases the phosphorous concentration compare to the application of lone sources in all the stages of maize leaf but the application of ST @ 0.2 LR and CS @ 0.2 LR mixed with FYM decreases the phosphorous concentration compare to the application of lone sources in all the stages of maize leaf. The application double dose of stromatolite @ 0.2 LR alone increases the phosphorous concentration compare to the single dose @ 0.1 LR in all the stages but the integrated application of double dose of stromatolite with FYM decreases the phosphorous concentration compare to the single dose in all the stages of maize leaf. Irrespective of the treatments application of PMS @ 0.1 LR with FYM gives the highest phosphorous concentration in all the stages but in

absolute control gives the lowest phosphorous concentration in all the stages. (Table-2)

- **Concentration of the Potassium (%) in Maize leaf**

The influence of different sources of liming materials on concentration of the potassium in maize leaf varies between 0.273% to 0.469% in the 1st stage (30 DAS), 0.308% to 0.479% in the 2nd stage (60 DAS) and 0.77% to 1.21% in the 3rd stage (90 DAS). The total concentration of the phosphorous in the maize leaf varies between 1.35% to 2.16%. Among three stages the concentration of the Phosphorous increases from the 1st stage to the 3rd stage. (Table-3).

Table 3: Concentration of the Potassium (%) in Maize leaf

Treatments	1st Stage (30 DAS)	2nd Stage (60 DAS)	3rd Stage (90 DAS)	Total Concentration
Absolute control	0.273	0.308	0.77	1.35
STD	0.410	0.472	0.87	1.75
STD + PMS @ 0.1 LR	0.390	0.410	0.94	1.74
STD+PMS @ 0.1 LR + FYM	0.435	0.479	1.03	1.94
STD +ST @ 0.1 LR	0.417	0.401	1.05	1.87
STD +ST @ 0.1 LR +FYM	0.408	0.349	1.01	1.77
STD + ST @ 0.2 LR	0.415	0.390	1.11	1.92
STD + ST @ 0.2 LR + FYM	0.439	0.423	1.19	2.05
STD + CS@ 0.2 LR	0.469	0.476	1.21	2.16
STD + CS@ 0.2 LR+FYM	0.436	0.409	1.13	1.98

The application of PMS @ 0.1 LR and ST @ 0.2 LR mixed with FYM increases the potassium concentration more compare to the lone sources of application in all the stages but the application of ST @ 0.1 LR and CS @ 0.2 LR mixed with FYM decreases the potassium concentration more compare to the lone sources of application in all the stages. The application of double dose of the stromatolite @ 0.2 LR alone decreases the potassium concentration in 1st & 2nd stage but increases in 3rd stage. The application of double dose of the stromatolite with FYM increases the potassium concentration in all the stages. Irrespective of the treatments the application of CS @ 0.2 LR gives the higher potassium concentration in all the stages but the absolute control gives the lower potassium concentration in all the stages. (Table-3).

- **Concentration of the Calcium (%) in Maize leaf**

The influence of different sources of liming materials on concentration of the calcium in maize leaf varies between 0.043% to 0.117% in the 1st stage (30 DAS), 0.097% to 0.158% in the 2nd stage (60 DAS) and 0.312% to 0.529% in the 3rd stage (90 DAS). The total concentration of the calcium in the maize leaf varies between 0.45% to 0.74%. Among three stages the concentration of the Phosphorous increases from the 1st stage to the 3rd stage. (Table-4).

Table 4: Concentration of the Calcium (%) in Maize leaf

Treatments	1st Stage (30 DAS)	2nd Stage (60 DAS)	3rd Stage (90 DAS)	Total Concentration
Absolute control	0.043	0.097	0.312	0.45
STD	0.065	0.118	0.451	0.63
STD + PMS @ 0.1 LR	0.111	0.135	0.392	0.64
STD+PMS @ 0.1 LR + FYM	0.117	0.148	0.418	0.68
STD +ST @ 0.1 LR	0.043	0.102	0.394	0.54
STD +ST @ 0.1 LR +FYM	0.117	0.158	0.418	0.69
STD + ST @ 0.2 LR	0.077	0.129	0.444	0.65
STD + ST @ 0.2 LR + FYM	0.084	0.146	0.494	0.72
STD + CS@ 0.2 LR	0.046	0.102	0.451	0.60
STD + CS@ 0.2 LR+FYM	0.058	0.154	0.529	0.74

The application of lone sources of liming materials increases the calcium concentration in all the stages of maize leaf but the application of liming materials with FYM increases the calcium concentration more compare to the lone sources of liming materials in all the stages of maize leaf. The double dose of stromatolite @ 0.2 LR increases the calcium concentration compare to the single dose @ 0.1 LR but mixed application of double dose of stromatolite with FYM decreases the calcium concentration compare to the single dose. Irrespective of the treatments the highest calcium concentration was seen by the application of PMS @ 0.1 LR + FYM in the 1st stage (0.117%), ST @ 0.1 LR + FYM in the 2nd stage (0.158%) and CS @ 0.2 LR + FYM in the 3rd stage (0.529%). The lowest calcium concentration was seen in the absolute control in all the stages of maize leaf.

- **Concentration of the Magnesium (%) in Maize leaf**

The influence of different sources of liming materials on concentration of the magnesium in maize leaf varies between 0.085% to 0.143% in the 1st stage (30 DAS), 0.104% to 0.185% in the 2nd stage (60 DAS) and 0.290% to 0.502% in the 3rd stage (90 DAS). The total concentration of the magnesium in the maize leaf varies between 0.48% to 0.77%. Among three stages the concentration of the magnesium increases from the 1st stage to the 3rd stage. (Table-5).

Table 5: Concentration of the Magnesium (%) in Maize leaf

Treatments	1st Stage (30 DAS)	2nd Stage (60 DAS)	3rd Stage (90 DAS)	Total Concentration
Absolute control	0.085	0.104	0.290	0.48
STD	0.131	0.148	0.447	0.73
STD + PMS @ 0.1 LR	0.119	0.121	0.372	0.61
STD+PMS @ 0.1 LR + FYM	0.125	0.136	0.375	0.64
STD +ST @ 0.1 LR	0.090	0.104	0.345	0.54
STD +ST @ 0.1 LR +FYM	0.105	0.127	0.404	0.64
STD + ST @ 0.2 LR	0.109	0.129	0.470	0.71
STD + ST @ 0.2 LR + FYM	0.119	0.150	0.502	0.77
STD + CS @ 0.2 LR	0.123	0.143	0.365	0.63
STD + CS @ 0.2 LR+FYM	0.143	0.185	0.415	0.74

The application of lone sources of liming materials increases the magnesium concentration in all the stages of maize leaf but the mixed application of liming materials with FYM increases the magnesium concentration more compare to the lone sources in all the stages of maize leaf. The application of double dose of stromatolite @ 0.2 LR alone increases the magnesium concentration compare to the single dose @ 0.1 LR and integrated application of double dose of stromatolite with FYM also increases the magnesium concentration compare to the single dose in all the stages of maize leaf. Irrespective of the treatments the highest magnesium concentration was seen by the application of CS @ 0.2 LR + FYM in the 1st stage (0.143%) & 2nd stage (0.185%) and ST @ 0.2 LR + FYM in the 3rd stage (0.502%). The lowest magnesium concentration was seen in the absolute control in all the stages of the maize leaf.

- **Concentration of the Sulphur (%) in Maize leaf**

The influence of different sources of liming materials on concentration of the sulphur in maize leaf varies between 0.035% to 0.049% in the 1st stage (30 DAS), 0.044% to 0.059% in the 2nd stage (60 DAS) and 0.109% to 0.222% in the 3rd stage (90 DAS). The total concentration of the sulphur in the maize leaf varies between 0.19% to 0.33%. Among three stages the concentration of the sulphur increases from the 1st stage to the 3rd stage. (Table-6).

Table 6: Concentration of the Sulphur (%) in Maize leaf

Treatments	1st Stage (30 DAS)	2nd Stage (60 DAS)	3rd Stage (90 DAS)	Total Concentration
Absolute control	0.035	0.044	0.109	0.19
STD	0.045	0.050	0.138	0.23
STD + PMS @ 0.1 LR	0.041	0.039	0.155	0.24
STD+PMS @ 0.1 LR + FYM	0.044	0.052	0.191	0.29
STD +ST @ 0.1 LR	0.043	0.049	0.153	0.25
STD +ST @ 0.1 LR +FYM	0.047	0.056	0.200	0.30
STD + ST @ 0.2 LR	0.039	0.054	0.163	0.26
STD + ST @ 0.2 LR + FYM	0.049	0.059	0.222	0.33
STD + Ca-Si @ 0.2 LR	0.042	0.049	0.116	0.21
STD + Ca-Si@ 0.2 LR+FYM	0.048	0.059	0.129	0.24

The application of lone sources of liming materials increases the sulphur concentration in all the stages of maize leaf but the mixed application of liming materials with FYM increases the sulphur concentration more compare to the lone sources in all the stages of maize leaf. The application of double dose of stromatolite @ 0.2 LR alone increases the sulphur concentration compare to the single dose @ 0.1 LR and integrated application of double dose of stromatolite with FYM also increases the sulphur concentration compare to the single dose in all the stages of maize leaf. Irrespective of the treatments the highest sulphur concentration was seen by the application of ST @ 0.2 LR + FYM in all the stages of maize leaf but the lowest sulphur concentration was seen in the absolute control.

Conclusion

The application of different sources of liming materials increases the nutrient concentration (P, K, Ca, Mg & S) from the 1st stage (30 DAS) to the 3rd stage (90 DAS) except nitrogen because the nitrogen increase from 1st stage to 2nd stage then decreases thereafter from 2nd stage to 3rd stage. The total nutrient concentration in the maize leaf varies between 2.13-2.90% N, 0.25-0.39% P, 1.35-2.16% K, 0.45-0.74% Ca, 0.48-0.77% Mg and 0.49-0.33% S where lowest concentration of all the nutrients were seen in absolute control and highest concentration N was seen in ST @ 0.1 LR, P in PMS @ 0.1 LR+F, K in CS @ 0.2 LR, Ca in CS @ 0.2 LR+F and Mg & S in ST @ 0.2 LR+F. The increasing of nutrient concentration in the maize leaf follows the order N>K>Mg>Ca>P>S. The application of double dose of stromatolite @ 0.2 LR increases the P, Ca, Mg, S concentration & decreases the N, K concentration in all the stages but integration with FYM increases the N, K, Mg, S concentration and decreases the P, Ca concentration. Irrespective of the treatments the application of lone sources of liming materials increases all the nutrients in all the stages but mixed application of liming materials with FYM decreases the N, P, K concentration but increase the Ca, Mg & S concentration.

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