International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 678-682
© 2017 JEZS
Received: 03-05-2017
Accepted: 04-06-2017

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Effect of integrated nutrient management practices on acidity and nutrient availability in acid soil

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Abstract
A pot experiment was conducted to assess "Effect of Integrated nutrient management practice on acidity and nutrient availability in acid soil" in The Dept. of Soil Science & Agricultural Chemistry, C.A. BBSR in *Kharif* (2016). The pot experiment was conducted in an acid sandy loam soil with Maize as the test crop (Hybrid). The experimental site experiences a warm and moist with hot and humid summer and mild winter. In each pot 5 kg of collected soil were filled up. Then 3 seeds were sown per pot. The treatments were given to Control (T_1), Soil test based recommended dose (STD) (T_2), Vermicompost (T_3), Lime (T_4), Lime + vermicompost (T_5), STD + VC@ 2.5 t ha^{-1} (T_6), STD + Lime (T_7), STD + VC @ 2.5 t ha^{-1}+ Lime (T_8). The results of the present experiment indicated that combined aplication of STD + VC @ 2.5 t ha^{-1}+ Lime was reduced the acidity and increase the nutrient availability in acid soil.

Keywords: Acid soil, Pot culture, Lime, Vermicompost, Integrated nutrient management

Introduction
In India, the acid soils occupy 90 million ha covering 25 per cent of the total geographical area. About 80 per-cent of Odisha soils are acidic. Low water holding capacity, high bulk density, and soil crusting along with chemical constraints like low pH, low CEC, low base saturation (16 to67 per-cent), high Al, Fe and Mn saturation, and high P fixing capacity (80 to 91 per-cent) are major reasons for low crop productivity in such soils (Misra *et al*., 1989) [6]. Acid soils are generally deficient in Ca, Mg, P, Mo, B, and Si. The availability of Fe, Mn, Cu and Zn is high, sometimes reaching toxic levels. These problems can be managed by inorganic and organic ameliorants. Lime application (inorganic) elevates pH, base saturation, and cation exchange capacity and reduces Al, Fe, and Mn availability, acidity andP fixation (Misra *et al*., 1989; Mishra and Pattanayak, 2002) [6, 7]. Organic ameliorants (FYM/compost) reduce exchangeable Al in soil through precipitation with hydroxyl ions. The organic acids released from organic ameliorants complex with Al and Fe, reducing their availability and harmful effects. Combined use of organic and inorganic ameliorants simultaneously controls soil acidity, reduces Aland Fe toxicity, and increases nutrient availability leading to better crop growing conditions in these soils. So a pot culture and an incubation study will conduct by using industrial byproduct and organic residues, which are potential lime sources. Hence, the purpose of the present investigation is to evaluate the "Effect of INM practice on acidity and nutrient availability in acid soil"

Materials and methods
A pot experiment was conducted in The Dept. of Soil Science & Agricultural Chemistry, C.A. BBSR in. The experimental site experiences a warm and moist with hot and humid summer and mild winter. The mean minimum and maximum temperature were 22.1^0c and 31.9^0 c respectively. Soil sample was collected from Central Horticultural Research Station, OUAT. Then the samples were processed by removing grasses, stones and other waste materials. In each pot 5 kg of collected soil were filled up. Before sowing calculated amount of calcium silicate, fertilizers and VC mixed properly in experimental soil. Then 3 seeds were sown per pot. The treatments were given to Control (T_1), Soil test based recommended dose (STD) (T_2), Vermicompost (T_3), Lime (T_4), Lime + vermicompost (T_5), STD + VC@ 2.5 t ha^{-1} (T_6), STD + Lime (T_7), STD + VC @ 2.5 t ha^{-1}+ Lime (T_8).

Collection and Processing of Soil

Representative composite soil samples were collected at 7 days interval from all the treatments during crop growth period. The initial and post harvest soils were also collected. The samples 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 soil samples were analysed for different parameters following standard methods were followed. The sand, silt and clay content of the soil samples were determined by Bouyoucos Hydrometer method as described by Piper (1966) [12]. The bulk density of experimental soil was determined by core method as described by. Soil pH was determined in 1:2.5 soil: water ratio by pH meter as described by Jackson (1973) [4]. The exchange H^+ and Al^{+3} were determined by following the method as described by Page *et al*., (1982) [11]. The lime requirement of the acid soil was determined by Woodruff Buffer method. 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. Available phosphorous in the soil was determined by Bray's 1 method (Bray and Kurtz, 1945) [2] 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.

Results and discussion

Characteristic of experimental soil

The soil of the experimental site (Table – 1) was sandy loam in texture with Sand- 74%, silt- 17.25%, Clay- 8.75% with 1.54 Mg m^{-3} of bulk density and particle density 2.32 Mg m^{-3}. The soil was moderately acidic in reaction (pH_w 5.41). The organic carbon status was medium, i.e. 4.3 gkg^{-1} with lime requirement of 2.5 t $CaCO_3ha^{-1}$. The exchange acidity, acidity due to Al^{3+} and H^+ of the experimental soil were 0.23, 0.188 and 0.021 $cmol(p^+)kg^{-1}$ soil respectively. The available nitrogen, phosphorous, potassium in soil were 152 (low), 14.43 (low) and 132 (medium) respectively.

Effect of INM practice on soil reaction during crop growth period

The pH of initial soil was 5.41 and the soil was strongly acidic in reaction. During crop growth period in control treatment the soil pH was gradually (Table-2).

The addition of inorganic fertilizers alone (STD), the soil pH increased to a level of 5.60 at 30 DAS, there after decreased continuously and attended the pH level of 5.54. The organic addition through VC helped to increase the level of pH was 5.64 at 30th DAS and lowest level of 5.58 at 75 DAS. The Soil amelioration measure with the addition addition of Calcium silicate (CS) raised the pH up to 6.10 at 30th DAS, there after slightly decrease. The combined application of VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR and STD + VC @ 2.5 t ha^{-1} raised the pH up to 6.36 at 30th DAS, there after slightly decrease. Soil amelioration measure with the addition of Calcium silicate (CS) when used with STD and STD + VC @ 2.5 t ha^{-1} was raised the pH up to 6.37 and 6.21 respectively at 30th DAS, there after slightly decrease.

Soil amelioration measure with the addition of STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR was raised the pH was higher as compared to other treatments, pH was 6.47 at 30th DAS, there after slightly decrease. Similar results were also observed by Misra *et al* (1989) [6], Mishra, M. and S.K. Pattanayak, (2002) [7], Misra, U. K. and N Das, (2009) [8].

Effect of INM on soil exchange acidity

The initial exchange acidity in soil was 0.234 cmol (P^+) kg^{-1} there after increased and attended a level of 0.241 $cmol(P^+)kg^{-1}$ soil by 45 DAS in absolute control (Table-3). In STD treatment, due to addition of external sources of nutrients; namely Urea, DAP and MOP temporarily decreased the acidity level of 0.227 cmol (P^+) kg^{-1} during 15 to 30 DAS, there after increased and attended a level of 0.231 cmol (P^+) kg^{-1} soil by 75 DAS. The organic addition through VC helped alleviating the soil acidity condition through its buffering action, brought down exchange acidity to 0.21 $cmol(P^+)kg^{-1}$ soil level by 15th DAS and lowest level of 0.18 $cmol(P^+)kg^{-1}$ soil by 30st DAS, increased there after gradually and attended a maximum of 0.219 cmol (P^+) kg^{-1}. The Soil amelioration measure with the addition addition of Calcium silicate (CS) neutralized the acidity (both H^+ and Al^{3+} ions), raised the pH, neutralized acidity to a level of 0.187 $cmol(P^+)kg^{-1}$ soil at 30th DAS, there after slightly increase.

The combined application of VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR neutralized the acidity (both H^+ and Al^{3+} ions), raised the pH, neutralized acidity to a level of 0.100 cmol (P^+) kg^{-1} at 30th DAS, there after slightly increase. Soil amelioration measure with the addition of Calcium silicate (CS) when used with STD and STD + VC @ 2.5 t ha^{-1} was neutralized the acidity (both H^+ and Al^{3+} ions), raised the pH, neutralized acidity to a level of 0.090 cmol $(P^+)kg^{-1}$ and 0.128 cmol $(P^+)kg^{-1}$ respectively by 30th DAS, there after slightly increase.

Soil amelioration measure with the addition of STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR was neutralized the acidity (both H^+ and Al^{3+} ions) and raised the pH value was higher as compared to other treatments, neutralized acidity to a level of 0.038 cmol $(P^+)kg^{-1}$ by 30th DAS, there after slightly increase. Similar results were also observed by Misra *et al* (1989) [6], Mishra, M. and S.K. Pattanayak, (2002) [7] and Misra, U. K. and N Das, (2009) [8].

Effect of INM on exchangeable Al^{3+} and H^+

The initial exchangeable Al^{3+} ion in soil was 0.188 cmol (P^+) kg^{-1}. The exchangeable Al^{3+} ion was decreased upto a level of 0.179 $cmol(P^+)kg^{-1}$ soil by 30 DAS in absolute control (Table-3). In STD treatment due to addition of external sources of nutrients; Urea, DAP and MOP temporarily decreased the exchangeable Al^{3+} ion was 0.154 cmol (P^+) kg^{-1} up to 30 DAS, there after increased slightly.

The organic addition through vermicompost were observed temporarily decreased the exchangeable Al^{3+} ion was 0.110 $cmol(P^+)kg^{-1}$ up to 30th DAS, there after gradually increased and attended a maximum of 0.122 cmol (P^+) kg^{-1}. The Soil amelioration measure with the addition addition of Calcium silicate (CS) were observed decreased the exchangeable Al^{3+} ion was 0.099 cmol (P^+) kg^{-1} at 30th DAS, there after slightly increase. The combined application of VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR and STD + VC @ 2.5 t ha^{-1} were observed decreased the exchangeable Al^{3+} ion was 0.089 cmol (P^+) kg^{-1} and 0.095 cmol (P^+) kg^{-1} respectively at 30th DAS, there after slightly increase. Soil amelioration measure with the addition of Calcium silicate (CS) when used with STD and STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR were observed that don't have any exchangeable Al^{3+} Ion. Similar results were also observed by Misra *et al* (1989) [6], Mishra, M. and S.K. Pattanayak, (2002) [7] and Misra, U. K. and N Das, (2009) [8].

The initial exchangeable H^+ ion in soil was 0.021 cmol (P^+) kg^{-1}. The exchangeable H^+ ion was increased gradually up to

0.040 cmol(P^+)kg^{-1} at 75 DAS in absolute control (Table-5). In STD treatment due to addition of external sources of nutrients; Urea, DAP and MOP temporarily decreased the exchangeable H^+ ion was 0.018 cmol (P^+) kg^{-1} up to 30 DAS, there after increased slightly.

The organic addition through vermicompost temporarily decreased the exchangeable H^+ ion was 0.016 cmol (P^+) kg^{-1} up to 30th DAS, there after gradually increased and attended a maximum of 0.018 cmol (P^+) kg^{-1}. The Soil amelioration measure with the addition addition of Calcium silicate (CS) decreased the exchangeable H^+ ion was 0.011 cmol (P^+) kg^{-1} at 30th DAS, there after slightly increase.The combined application of VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR and STD + VC @ 2.5 t ha^{-1} were observed that decreased the exchangeable H^+ ion was 0.009 cmol (P^+) kg^{-1} and 0.013 cmol (P^+) kg^{-1} respectively at 30th DAS, there after slightly increase.

Soil amelioration measure with the addition of Calcium silicate (CS) when used with STD and STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR were observed that exchangeable H^+ ion was 0.011 cmol (P^+) kg^{-1} and 0.005 cmol (P^+) kg^{-1} respectively at 30 DAS. Similar results were also observed by Misra *et al* (1989) [6], Mishra, M. and S.K. Pattanayak, (2002) [7] and Misra, U. K. and N Das, (2009) [8].

Effect of INM on available N (Kg ha^{-1}) in acid soil

The results of the present experiment reveals that initially available nitrogen was low (152 kg ha^{-1}) and gradually decrease along with crop growing period increase. The available nitrogen was gradually increase up to 30th DAS after that slightly decrease with a given treatments. The treated with lime its gives to increase the availability of nitrogen as compared to without liming. The available nitrogen was higher with the combined application of STD + VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR was 334 Kg ha^{-1} as compared to other treatment (Table-6). Similar results were also observed by Mishra, M. and S.K. Pattanayak, (2002) [7] and Misra, U. K. and N Das, (2009) [8].

Effect of INM on available P (Kg ha^{-1}) in acid soil

The results of the present experiment reveals that initially available phosphorus was low (14.43 kg ha^{-1}) and gradually decrease along with crop growing period increase. The available phosphorus was gradually increase up to 30th DAS after that slightly decrease with a given treatments. The treated with lime its gives to increase the availability of phosphorus as compared to without liming. The available phosphorus was higher with the combined application of STD + VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR was 33.27 Kg ha^{-1} as compared to other treatment (Table-7). Similar results were also observed by Mishra, M. and S.K. Pattanayak, (2002) [7] and Misra, U. K. and N Das, (2009) [8].

Effect of INM on available K (Kg ha^{-1}) in acid soil

The present invistigation shows that initially available potassium was low (132 kg ha^{-1}) and gradually decrease along with crop growing period increase. The available potassium was gradually increase up to 30th DAS after that slightly decrease with a given treatments. The treated with lime its gives to increase the availability of potassium as compared to without liming. The available potassium was higher with given treatment STD + VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR was 332 Kg ha^{-1}as compared to other treatment (Table-8). Similar results were also observed by Mishra, M. and S.K. Pattanayak, (2002) [7] and Misra, U. K. and N Das, (2009) [8].

Table 1: Initial properties of soil

Texture (Bouyoucos Hydrometer method)	**Sandy loam [Sand- 74%, silt- 17.25%, Clay- 8.75%]**
Bulk Density (g/cm^3)	1.54
Particle Density (g/cm^3)	2.32
Porosity (%)	33.6
Lime Requirement- ($CaCO_3$ kg ha^{-1}) 1.Modified woodruffs buffer method 2.Simplefied CaCl2 & Ca(OH)2 equilibration method	2567 1843
Ph	5.41
Exchange acidity [cmol(p+) kg-1]	0.234
Exchange Al3+ [cmol(p+) kg-1] Exchange H+ [cmol(p+) kg-1]	0.188 0.021
Organic carbon [%]	0.43
Available N [kg ha-1]	152
Available P [kg ha-1]	14.43
Available K [kg ha-1]	132

Table 2: Effect of INM practice soil reaction during crop growth period

			Days After Sowing				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	5.41	5.35	5.38	5.32	5.34	5.40
T2	Soil test based recommended dose (STD)	5.41	5.58	5.60	5.59	5.57	5.54
T3	Vermiculite @ 2.5 t ha^{-1}	5.41	5.61	5.64	5.62	5.60	5.58
T4	Ca-Silicate @ 0.2 LR	5.41	6.04	6.10	5.95	5.91	5.88
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	5.41	6.32	6.36	6.28	6.26	6.25
T6	STD + VC @ 2.5 t ha^{-1}	5.41	6.19	6.21	6.17	6.15	6.15
T7	STD + Lime	5.41	6.34	6.37	6.35	6.33	6.30
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	5.41	6.44	6.46	6.42	6.4	6.38

Table 3: Effect of INM on soil exchange acidity (cmol(P^+)kg^{-1} soil)

			Days After Sowing				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	0.234	0.234	0.236	0.240	0.241	0.241
T2	Soil test based recommended dose (STD)	0.234	0.229	0.227	0.228	0.230	0.231
T3	Vermiculite @ 2.5 t ha^{-1}	0.234	0.210	0.180	0.211	0.217	0.219
T4	Ca-Silicate @ 0.2 LR	0.234	0.197	0.187	0.191	0.198	0.199
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	0.234	0.122	0.100	0.124	0.129	0.130
T6	STD + VC @ 2.5 t ha^{-1}	0.234	0.144	0.128	0.129	0.137	0.140
T7	STD + Lime	0.234	0.100	0.090	0.098	0.105	0.106
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	0.234	0.042	0.038	0.040	0.042	0.044

Table 4: Effect of INM on exchange able Al^{3+}(cmol(P^+)kg^{-1} soil)

			Days After Sowing				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	0.188	0.180	0.176	0.179	0.181	0.189
T2	Soil test based recommended dose (STD)	0.188	0.164	0.154	0.161	0.166	0.179
T3	Vermiculite @ 2.5 t ha^{-1}	0.188	0.122	0.110	0.119	0.121	0.122
T4	Ca-Silicate @ 0.2 LR	0.188	0.100	0.099	0.099	0.101	0.102
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	0.188	0.096	0.089	0.091	0.095	0.095
T6	STD + VC @ 2.5 t ha^{-1}	0.188	0.098	0.095	0.097	0.0.97	0.097
T7	STD + Lime	0.188	0.000	0.000	0.001	0.009	0.010
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	0.188	0.000	0.000	0.000	0.000	0.001

Table 5: Effect of INM on exchangeable H^+ (cmol(P^+)kg^{-1} soil)

			Days After Sowing				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	0.021	0.026	0.029	0.033	0.037	0.040
T2	Soil test based recommended dose (STD)	0.021	0.019	0.018	0.019	0.021	0.021
T3	Vermiculite @ 2.5 t ha^{-1}	0.021	0.018	0.016	0.017	0.017	0.018
T4	Ca-Silicate @ 0.2 LR	0.021	0.013	0.011	0.012	0.014	0.015
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	0.021	0.011	0.009	0.011	0.014	0.014
T6	STD + VC @ 2.5 t ha^{-1}	0.021	0.014	0.013	0.015	0.016	0.018
T7	STD + Lime	0.021	0.012	0.011	0.013	0.015	0.015
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	0.021	0.006	0.005	0.009	0.011	0.014

Table 6: Effect of INM on available N (Kg ha^{-1}) in acid soil

			Days After Sowing				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	152	148	145	140	138	135
T2	Soil test based recommended dose (STD)	152	`188	209	200	196	190
T3	Vermiculite @ 2.5 t ha^{-1}	152	218	237	221	213	211
T4	Ca-Silicate @ 0.2 LR	152	233	241	239	235	231
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	152	277	284	270	268	265
T6	STD + VC @ 2.5 t ha^{-1}	152	266	270	268	263	260
T7	STD + Lime	152	293	311	302	299	295
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	152	322	334	329	325	320

Table 7: Effect of INM on available P (Kg ha^{-1}) in acid soil

			DAS				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	14.43	14.00	13.23	13.01	12.33	11.43
T2	Soil test based recommended dose (STD)	14.43	16.22	17.87	17.19	16.62	16.22
T3	Vermiculite @ 2.5 t ha^{-1}	14.43	17.41	18.65	18.03	17.82	17.63
T4	Ca-Silicate @ 0.2 LR	14.43	19.98	21.88	20.43	20.01	19.12
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	14.43	22.10	24.36	23.27	22.98	22.23
T6	STD + VC @ 2.5 t ha^{-1}	14.43	21.23	22.90	22.11	21.76	21.27
T7	STD + Lime	14.43	25.87	27.32	27.11	26.98	26.56
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	14.43	30.43	33.27	33.10	32.89	32.76

Table 8: Effect of INM on available K (Kg ha^{-1}) in acid soil

			Days After Sowing				
	Treatments	**Initial**	**15**	**30**	**45**	**60**	**75**
T1	Absolute control	132	130	128	126	125	125
T2	Soil test based recommended dose (STD)	132	139	142	140	138	137
T3	Vermiculite @ 2.5 t ha^{-1}	132	145	150	148	146	144
T4	Ca-Silicate @ 0.2 LR	132	160	171	166	163	161
T5	VC @ 2.5t ha^{-1}+ Ca-Silicate @ 0.2 LR	132	173	181	180	176	171
T6	STD + VC @ 2.5 t ha^{-1}	132	153	161	159	155	152
T7	STD + Lime	132	190	201	1195	193	191
T8	STD + VC @ 2.5 t ha^{-1}+ Ca-Silicate @ 0.2 LR	132	226	232	228	226	221

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