Journal of the Andaman Science Association Vol. 18(2):135-141 (2013)
ISSN 0970-4183, Printed in India
© Andaman Science Association, Port Blair (A & N Islands), India
www.asapb.org

MANAGEMENT OF ACID SOILS OF ANDAMAN FOR MAIZE PRODUCTION USING LOCALLY AVAILABLE ORGANICS

T. P. Swarnam* and A. Velmurugan
Division of Natural Resource Management, Central Agricultural Research Institute, Port Blair-744 101, India
* *Corresponding author:* swarna_8@yahoo.com

ABSTRACT

Soil acidity is a major problem in many of the tropical Islands where limestone is used as amendment however an attempt has been made to use organic materials for ameliorating soil acidity. A field experiment was conducted during 2011-12 to study the effect of poultry manure, vermicompost, coconut husk compost and *gliricidia* applied @ 20 t ha^{-1} on maize and compared with lime. Application of organics significantly increased plant height, no. of grain rows per cob, grain weight per cob and 100 grain weight of maize. The increase was in the order of coconut husk compost > gliricidia > vermicompost > poultry manure mainly because of improved availability of plant nutrients besides increase in soil pH. The poultry manure (3.79 t ha^{-1}) and vermicompost (3.73t ha^{-1}) application recorded significantly higher grain yield. Though no significant differences were observed in root length, significant increase was recorded in root volume. The soil parameters like pH, exchangeable Al^{3+}, DTPA extractable Fe^{2+} and Mn^{2+} significantly reduced, while P_{Bray} significantly increased in organic treatments.

Key words: Alternative liming materials, coconut husk compost, soil acidity, micronutrient

INTRODUCTION

Soil acidity is one of the most prevalent problems for crop production throughout the world because at least 40% of the world's arable land is affected by acidity of varying degrees (Rengel 2003). The productivity of acid soils is limited by the presence of toxic levels of aluminium (Al) and manganese (Mn) and deficiency of nutrients such as phosphorus, calcium, magnesium and molybdenum. Aluminium toxicity due to high exchangeable Al, reduced P uptake and a high soil P fixing capacity are the main factors affecting maize growth and yield on acid soils (Gaume et al. 2001). Liming not only raises the soil pH, but it also affects the solubility and availability of most plant nutrients, by reducing toxic concentrations of aluminum and manganese (Biswas and Mukherjee 1994). There are different materials of conventional and non conventional sources to correct soil acidity. The general practice for correcting soil acidity is the application of lime. However the key to sustainable food production in low input agricultural system is the use of locally available non conventional liming materials to reduce soil acidity. The organic materials such as wood ash (Clapham and Zibilske 1992, Materechera 2012), poultry manure (Chandrashekara *et al*. 2000, Haynes and Mokolobate 2001), green and animal manures (Berek *et al*. 1995) were reported to increase the pH of acid soils and improve soil fertility by supplying essential plant nutrients especially phosphorus.

In Andaman Islands soil acidity is a major constraint for crop production, as majority of the area is affected by acidity of varying degrees due to the existing hot and humid tropical climate. Plantations of coconut and arecanut occupy about 48.1 % of total cropped area and the plantation residues available in plenty are dumped as a waste. Besides, cattle and poultry manure are available in sizable quantities among the farmers as mixed farming is predominantly found in these Islands. However, they are not properly used for either ameliorating soil acidity or as a nutrient source. The average farm holding is only 1.84 ha and application of conventional limestone is not a sustainable option due to its local unavailability and existing low input agricultural system. Moreover, the organic wastes available within each farm can be a potential source of soil amendment as well as nutrient source if properly recycled and used. Hence, an experiment was conducted with the objective to evaluate the effect of these locally available organic materials on maize growth and yield in acid soil besides studying their effect on soil acidity and nutrient availability as compared to conventional lime application.

MATERIALS AND METHODS

The field experiment was conducted at Horticultural Research Farm of Central Agricultural Research Institute, Port Blair during dry periods of 2010-11 and 2011-12. The soil of experimental site was sandy loam (sand: 74.0 %, silt: 8.0 % & clay: 18.0 %), strongly acidic (pH_{CaCl2} 4.19), non saline (ECw 0.36 dSm^{-1}). The soil recorded 6.5 g organic C, 124.3 mg of alkaline $KMnO_4$ hydrolysable N, 5.6 mg Bray P and 73 mg ammonium acetate extractable K kg^{-1} soil. The cation exchange capacity was 8.51 $cmol_c$ kg^{-1} soil with exchangeable Ca 3.01 $cmol_c$ kg^{-1} soil. The exchange acidity was 2.65 $cmol_c$ kg^{-1} soil with 0.84 $cmol_c$ kg^{-1} soil of exchangeable Al^{3+}. The DTPA extractable Fe^{2+} and Mn^{2+} are high with values of 11.94 and 13.79 ppm respectively.

The experiment was laid out in randomized block design with three replications and seven treatments viz., control (T1), poultry manure (T2), vermicompost (T3), *gliricidia* (T4), coconut husk compost (T5), coconut husk compost + lime (T6) and lime (T7) in plots of 3x3 m. The organic amendments were applied at the rate of 20 t ha^{-1} and lime @ 4 t ha^{-1} and incorporated well into the soil 10 days before sowing of the maize seeds. Two maize seeds (*Zea mays L.*, variety NK6240) were dibbled at a spacing of 60 x 25 cm and later thinned to one per stand after two weeks of sowing. Standard package of practices were followed for other intercultural operations. The above ground biomass was removed from each plot after harvesting of the cobs. The organic wastes used in the experiment viz**.,** poultry manure, coconut husk compost, vermicompost and gliricidia were collected from the Institute Farm itself. Random samples were collected from the amendments used for soil application and were analysed for total nutrient content especially total N, P and K by wet digestion and subsequent analysis of the above elements by standard procedure. The nutrient composition of organics used in the study is presented in Table1. Surface soil samples (0-15cm) were collected before initiating the experiment and after harvest of the maize crop in 2012. The soil sample was air dried and passed through 2mm sieve prior to analysis. The soil pH was measured in 2mM $CaCl_2$ in a soil to solution ratio of 1:2. The available P (Bray & Kurtiz 1945) and DTPA extractable Fe^{2+}, Mn^{2+} and Zn^{2+} (Lindsay and Norvell 1978) were analysed for each soil sample. Growth parameters such as plant height (cm), root length (cm) and root volume (mm^3) were recorded for plant samples collected from each plot at the time of harvest. The yield parameters such as cob length (cm), 100 grain weight (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}) were recorded for each plot in triplicates for both the years. The grain weight and grain yield are expressed at 12% moisture content. The data recorded were subjected to analysis of variance (ANOVA) for a randomized block design with three replications using the AGRES software package. The comparison of means was performed by Fisher's Least Significant difference (LSD) at 95% level of probability and correlation analysis was done to determine relationship between different soil parameters.

RESULTS AND DISCUSSION

Maize growth and yield

This study demonstrated that growth and yield parameters of maize crop were significantly ($p<0.05$) affected by application of lime and organic amendments as compared to control (Figure 1). The plant height increased from 135.3 cm in control to 210.0 cm in poultry manure amended soils. The organics such as poultry manure, vermicompost, *gliricidia* and coconut husk compost application recorded on par results followed by lime and coconut husk compost + lime application. The increase in plant height with application of organics was mainly due to the increased availability of nutrients especially N. The results are in accordance with the findings of Mitchell and Tu (2005) and Warren et al. (2006).

Table 1. Selected properties of organic manures/composts used in the study

Parameter	Unit	Concentration (mean of three replicates)*			
		PM	VC	GL	CHC
pH (2mM CaCl2)	-	8.9	7.6	5.1	6.5
Total N	g kg^{-1}	27.1	17.3	22.6	8.7
Total P	g kg^{-1}	14.3	9.1	1.7	1.2
Total K	g kg^{-1}	18.2	5.8	11.9	14.2
Total Ca	g kg^{-1}	24.9	13.1	12.7	14.3
Total Mg	g kg^{-1}	10.1	6.6	3.7	6.3

* PM-poultry manure VC- Vermicompost GL-*Gliricidia* CH – Coconut husk compost

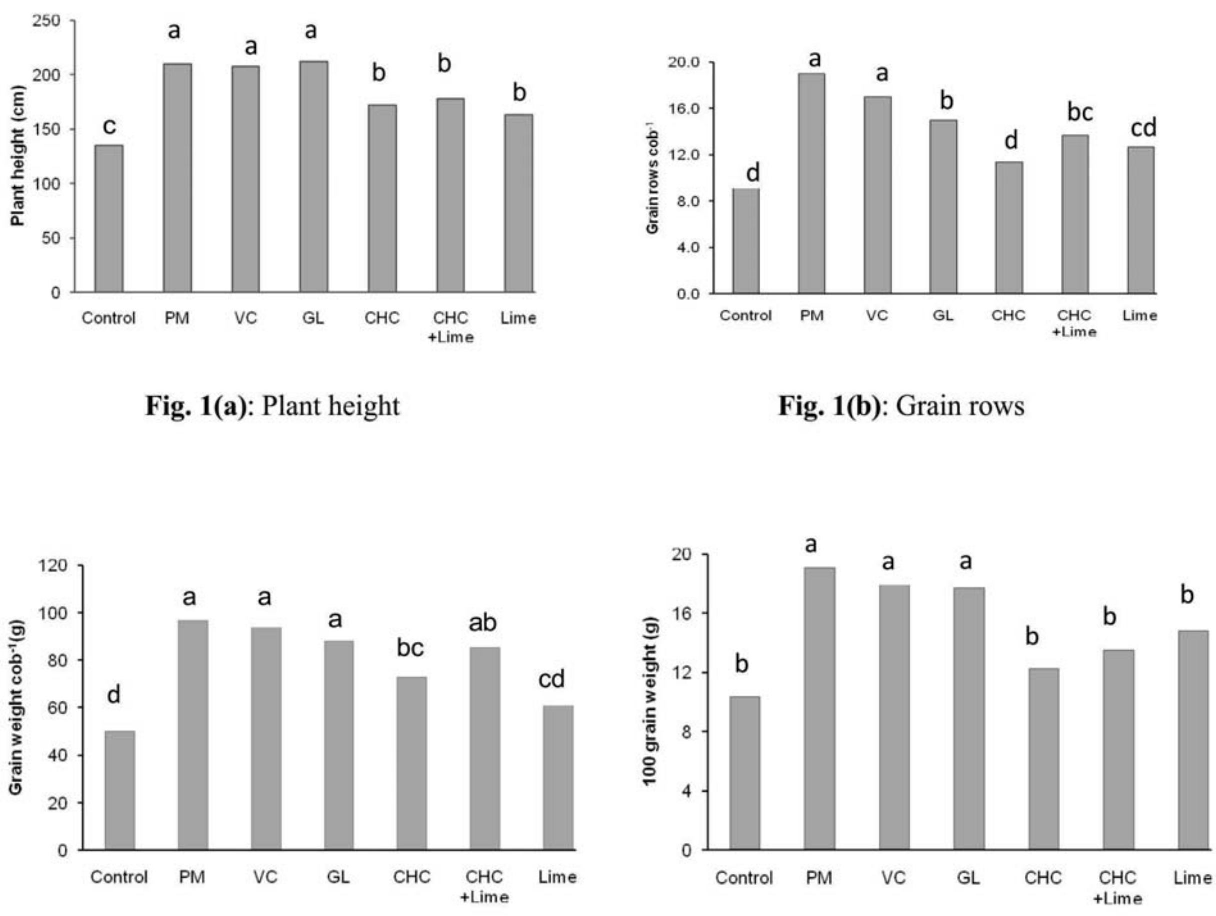

Fig. 1(a): Plant height **Fig. 1(b)**: Grain rows

Fig. 1(c): Grain weight per cob **Fig. 1(d)**: 100 grain weight

Fig. 1: Effect of lime and organic amendments on plant height and yield parameters of maize (pooled mean)

The number of grain rows per cob is an important yield determining factor in maize, which affects the number of grains and grain weight per cob. The data revealed that application of organics especially poultry manure, vermicompost and gliricidia had significant effect on number of grain rows as well as grain weight per cob. This increase could be attributable to increased availability of plant nutrients especially N, P and other nutrients by application of organics than lime. This was reflected in number of grains and grain weight per cob where similar trend was also observed, which could be due to improved grain filling compared to other treatments. Farhad et al. (2009) also indicated a similar increase in grain weight by application of different rates of poultry manure.

The maize grain yield for two year average indicated that the application of soil amendments significantly increased the yield as compared to control (Figure 2). Though the lime application significantly increased the grain yield, application of organics such as poultry manure and vermicompost recorded highest on par yield followed by *gliricidia* (3.47 t ha^{-1}) and coconut husk compost + lime (3.03 t ha^{-1}). Similar increase in maize yield by organics especially by poultry manure and vermicompost was also reported by Amusan *et al*. 2011. The poultry manure amended plots recorded significantly higher stover yield (12.67 t ha^{-1}) followed by vermicompost (11.05 t ha^{-1}) and *gliricidia* (10.85 t ha^{-1}) application mainly by improved availability N and P. Though the lime application raised the soil pH and lowered exchangeable Al^{3+}, the addition of organic manures significantly increased the growth and yield parameters because of additional nutrient supply especially nitrogen and phosphorus besides improved microbial activity. A similar report of increased maize yield by application of organics was reported by Boateng et al.

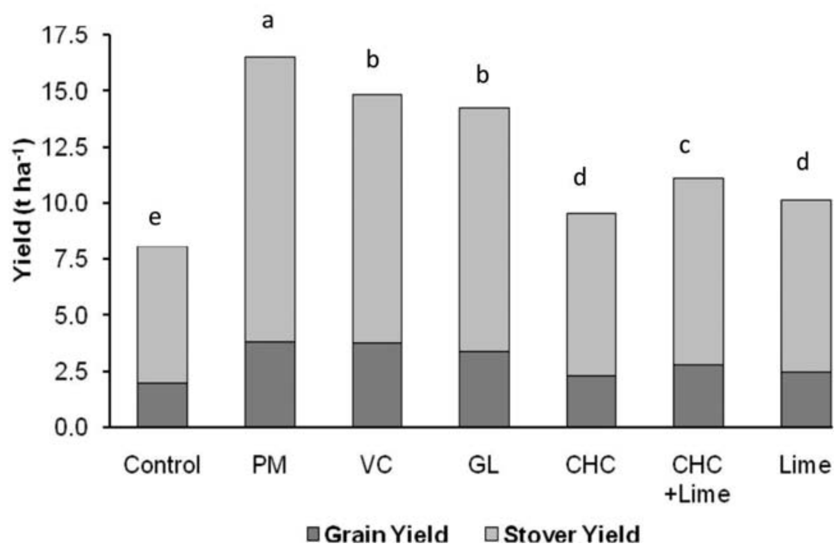

Fig. 2: Effect of application of soil amendments on grain and Stover yield (pooled mean)

The effect of soil amendments on root parameters like root length and root volume was presented in Figure 3. Although no significant difference was found in root length by application of soil amendments especially organics, significant differences were observed in root volume by application of N rich organic sources like poultry manure (327%), vermicompost (229%) and *gliricidia* (241%) as compared to only 99% increase by lime application. The increased root volume is attributed by growth of more fibrous roots which could be due to reduction of phytotoxic Al^{3+} concentration resulting in enhanced root activity, increased nutrient up take (Le Van et al.1994) as well as nitrogen availability, which can also be seen from positive correlation obtained between $KMnO_4$ hydrolysable N and root volume (R^2= 0.42*). The improved root volume might have helped in increasing volume of soil foraged by the roots thereby increasing nutrient availability and uptake, which in turn resulted in increased growth and yield of maize.

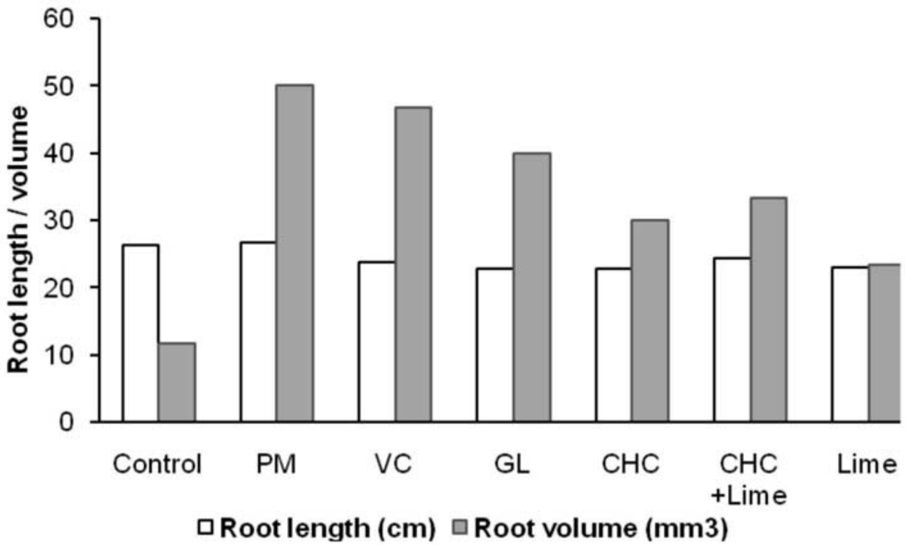

Fig. 3: Effect of application of lime and organics on root growth

Soil fertility

The application of lime and other organic materials increased the soil pH as compared to control. Lime application either alone or in combination with coconut husk compost significantly increased the soil pH from 4.2 to 6.9 (Table 2). Among the organic materials used significant increase was found in poultry manure and coconut husk compost applied plots. These organic materials except gliricidia characteristically have a pH between 6.5 to 8.0 and large amounts of total base cations like calcium (Ca) and magnesium (Mg). The pH increase was attributable to proton exchange in initial stages followed by decomposition of organic materials by microbial decorboxylation resulting in consumption of protons and raise in soil pH (Noble et al. 1996). The application of amendments also resulted in decrease in exchangeable Al^{3+}, which was not detected in lime treated soils, while significant reductions were found in other treatments *viz*., poultry manure, coconut husk compost + lime mainly due to increase in pH above 5.5 where soluble and exchangeable Al^{3+} are precipitated into insoluble form (Haynes and Mokolobate 2001). This reduction in exchangeable Al^{3+} is significant to crop growth as it is most toxic to plant roots (Vieira *et al*. 2008).

Table 2. Effect of soil amendments on selected soil properties

Treatment	pH 2mM $CaCl_2$	Ex.Al^{3+} (cmol kg^{-1})	P_{Bray} (mg kg^{-1})	DTPA extractable micronutrients (ppm)		
				Fe^{2+}	Mn^{2+}	Zn^{2+}
Control	4.26^{d}	0.95^{e}	5.0^{d}	11.94^{d}	13.79^{d}	0.72^{c}
Poultry Manure	5.31^{b}	0.06^{a}	17.2^{a}	7.34^{b}	6.96^{b}	3.77^{a}
Vermicompost	4.65^{cd}	0.28^{c}	13.9^{b}	9.98^{c}	11.23^{c}	4.32^{a}
Gliricidia	4.48^{d}	0.43^{d}	15.0^{a}	10.34^{cd}	12.27^{cd}	2.96^{b}
C Husk Compost	5.16^{bc}	0.20^{b}	9.7^{c}	9.77^{c}	11.55^{cd}	2.80^{b}
C Husk Compost + Lime	6.43^{a}	0.03^{a}	5.2^{d}	6.76^{ab}	5.34^{ab}	1.20^{c}
Lime	6.94^{a}	0.00^{a}	5.9^{d}	5.08^{a}	4.35^{a}	1.11^{c}

Figures having different superscript letters in each column indicate statistical significance at $p < 0.05$

The application of organic amendments significantly increased the availability of phosphorus which is otherwise deficient in acid soils. Though extractable P_{Bray} content of soils amended with lime (18%) increased as compared to control, significant increase was observed in soils applied with organics such as coconut husk compost (94%), vermicompost (178%), *gliricidia* (200%) and poultry manure (244%). This increase could be attributed to release of inorganic P from decaying residues, blockage of P adsorption sites by organic molecules released from the residues, increase in pH and complexation of soluble Al and Fe by organic molecules (Iyamuremye and Dick 1996).

In acid soil micronutrients especially Fe^{2+} and Mn^{2+} are found in levels exceeding the critical limits required for crop growth. The observations indicated that application of soil amendments significantly reduced the DTPA extractable Fe^{2+} and Mn^{2+} in lime applied alone and in combination with coconut husk compost mainly attributable to increase in soil pH which was evidenced from significant negative correlation obtained between soil pH and DTPA-Fe^{2+} (R^2 = -0.83**) and DTPA-Mn^{2+} (R^2= -0.73**). Among the organics the decrease was in the order of poultry manure > vermicompost > coconut husk compost > gliricidia. In contrast DTPA-Zn^{2+} significantly increased in poultry manure and vermicompost application followed by gliricidia and coconut husk compost compared to control.

The study indicated the potential of locally available non conventional sources of liming materials in improving growth and yield of maize besides increasing soil pH and nutrient availability. Among the organics used poultry manure and vermicompost significantly increased the grain yield of maize followed by gliricidia mainly because of increased nutrient availability especially nitrogen. In terms of improving soil pH poultry manure and coconut husk compost performed on parity. If the nutrient availability of coconut husk compost is improved by addition of poultry manure or other N rich sources at the time of composting, it can be a potential source of soil amendment as well as nutrient source in a small holder farms with low input agricultural systems.

ACKNOWLEDGEMENTS

The authors are thankful to Director, CARI, Port Blair for his guidance and support at various levels. The help and support received from technical, research and supporting staff of Division of Natural Resource Management and Project Monitoring and Evaluation Cell, CARI, Port Blair are thankfully acknowledged.

REFERENCES

Berek, A.K., Radjagukguk, B. & Mass, A. (1995). The effect of different organic materials on the alleviation of Al toxicity in soybean on a red-yellow podzolic soil. In: Date R.A., Grundon N.J., Rayment G.E., Probert M.E.(eds.): Plant – soil interactions at low pH: Principles and management. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Biswas, T.D. & Mukherjee, S.K. (1994). Text book on soil science. McGrow Hill Company Ltd. New Delhi, India.

Boateng, A.S., Zickermann J. & Kornahrens, M. (2006). Poultry manure effect on growth and yield of maize. West Africa Journal of Applied Ecology, 9: 1-11.

Bray, R.H. & Kurtz, L.T. (1945). Determination of total, organic, and available forms of phosphorus in soils. Soil Science, 59**:** 39-45.

Chandrashekara, S. I., Harlapur, S., Muralikrishan & Girijesh, G.K. (2000). Response of maize to organic manures with inorganic fertilizers. Karnataka Journal of Agricultural Sciences, 13**:** 144 - 146.

Clapham, W.M. & Zibilske, L.M. (1992). Wood ash as a liming amendment. Communications in Soil Science & Plant Analysis, 23: 1209–1227.

Farhad, W., Saleem, M.F., Cheema, M.A., & Hammad, H.M. (2009). Effect of poultry manure levels on the productivity of spring maize (Zea mays L.). The Journal of Animal and Plant Sciences, 19(3): 122-125.

Gaume, A., Mächler, F. & Frossard, E. (2001). Aluminium resistance in two cultivars of *Zea mays* L.: Root exudation of organic acids and influence of phosphorus nutrition. Plant and Soil, 234: 73–81.

Haynes, R.J. & Mokolobate, M.S. (2001). Amelioration of Al toxicity and P deficiency in acid soils by additions of organic residues: a critical review of the phenomenon and the mechanisms involved. Nutrient cycling in Agroecosystems, 59**:** 47-63.

Iyamuremye, F. & Dick, R.P. (1996). Organic amendments and phosphorus sorption by soils. Advances in Agronomy, 56**:** 139-185.

Le Van, H., Kuraishi, S. & Sakurai, N. (1994). Aluminum induced rapid root inhibition and changes in cell wall components of squash Seedlings. Plant Physiology,106: 971-976.

Lindsay, W.L. & Norvell, W.A. (1978). Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Science Society of America Journal, 42: 421–42.

Materechera, S.A. (2012). Using wood ash to ameliorate acidity and improve phosphorus availability in soils amended with partially decomposed cattle or chicken manure. Communications in Soil Science & Plant Analysis, 43**:** 1773 – 1789.

Mitchell, C.C. & Tu, S. (2005). Long term evaluation of poultry litter as a source of nitrogen for cotton and corn. Agronomy Journal, 97: 399-407.

Noble, A.D., Zenneck, I. & Randall, P.J. (1996). Leaf litter ash alkalinity and neutralisation of soil acidity. Plant and Soil, 179: 293-302.

Onwuka, M.I., Osodeke, V.E. & Okolo (2007). Amelioration of soil acidity using cocoa husk ash for maize production in Umudike area of South Nigeria. Tropical and Subtropical Agroecosystems, 7: 41-45.

Rengel, Z. (2003). Handbook of Soil Acidity, Marcel Dekker, Inc, New York.

Vieira, C.B.F., He, Z.L., Bayer, C., Stoffella, P.J. & Baligar, V.C. (2008). Organic amendment effects on the transformation and fractionation of aluminum in acidic sandy soil. Communications in Soil Science and Plant Analysis, 39**:** 2678 – 2694.

Warren, J.G., Phillips, S.B., Mullins, G.L., Keahey, D. & Penn C.J.(2006): Environmental and production consequences of using alum-amended poultry litter as a nutrient source for corn. Journal of Environmental Quality, 35: 172-182.

Publish With Us

http://www.asapb.org/journal.html