COMPARATIVE EFFECTS OF COMMERCIAL LIME ($CaCO_3$) AND GROUND EGGSHELL ON THE UPTAKE OF CALCIUM AND DRY MATTER YIELD OF MAIZE IN AN ULTISOL OF SOUTHEASTERN NIGERIA

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ABSTRACT

Greenhouse study was carried out to investigate the comparative effect of commercial lime ($CaCO_3$) and ground eggshell on the uptake of calcium and dry matter yield of maize in an ultisol of Southeastern Nigeria using maize (variety Oba supper 92) as the test crop. The soil was acidic and deficient in N, O.C., K, Ca and Mg. Commercial lime (0.5tons/ha) and ground eggshell (0, 2, 4, and 6ton/ha) were used for the study; they were replicated three times. The experiment lasted for 8 weeks in the greenhouse and soil samples were taken from each pot at 2, 4, 6 and 8 weeks and air-dried for the determination of pH and total calcium. At 8 weeks after planting, plants were harvested and dry matter yield and plant calcium content was determined. From the result, ground eggshell and $CaCO_3$ significantly ($P<0.05$) increased the soil pH over the control from 4.6 to 6.6 and 7.6 respectively. Soil pH increased as the rate of treatment increased. There was a significant increase in soil total calcium over the control at 2 weeks after planting, after which only 2, 4 and 6tons/ha ground eggshell increased same over the control. Plant dry matter yield was also significantly increased over the control at 2 and 6tons/ha ground eggshell application from 9.5 to 10.84 and 12.36 respectively. It can therefore be concluded that ground eggshell is a promising soil amendment for increasing soil pH and dry matter yield of maize in Umudike Ultisol; 6 tons/ha rate of its application is also recommended.

Keywords: Commercial lime, eggshell, dry matter yield and maize

INTRODUCTION

Soils of Southeastern Nigeria are dominated by ultisols, with a pH value of less than 5.5 (Ahn, 1993) and these soils are acidic in nature and also, they are highly weathered (Brady and Weil, 1999). The acidity of this region is as a result of heavy rainfall and excessive leaching of basic cations leaving the exchange complex dominated by Al^{3+} and H^{+} ions (Ogunwale *et al.*, 2002). Also, the development of acid soils may be as a result of continuous use of nitrogenous fertilizers (Ano and Agwu, 2005) and other fertilizer salts like potassium chloride and magnesium sulphate which increases the concentration of Aluminum in the soil solution and hence depresses the pH level of the soil.

Soil acidity has been tagged a problem to global food production (Chude *et al.*, 2004) and the most notable effects of soil acidity is the drastic reduction in crop yield which is as a result of decrease in nutrient element uptake especially phosphorus, Nitrogen and Potassium (Mullins *et al.*, 2005). The presence of high amount of Aluminum (Al) and Manganese (Mn) in the soil solution of acid mineral soil is detrimental to plant growth (Onyekwere *et al.*, 2005). Soil acidity is one of the limiting factors affecting crop yield (Ojo *et al.*, 2003) in the tropics. In order to improve acidic soils for better crop performance, liming is inevitable. Liming not only raises the soil pH, it also affects the solubility and availability of most plant nutrients, by reducing toxic concentrations of Aluminum and Manganese (Onyekwere *et al.,* 2005). These liming materials could either be conventional or non-conventional. Attention is now being shifted to the use of non-conventional limes because the conventional ones are unavailable and costly.

The use of non-conventional lime like eggshell ash, palm bunch ash, cocoa husk ash etc is beneficial because they serve as liming materials in reducing the acidity of the soil and also serve as sources of nutrient (Ojeniyi, 2002). Eggshell which was the waste material used in this study and it is always available throughout the year because of the numerous fast food centres in the area. Investigations on the use of local sources of liming materials in Nigeria soils have been carried out by some researchers like (Obi and Ekperigin, 2001) who worked on the effects of waste as an alternative liming material in acid soil management. Other researchers include (Owolabi *et al.,* 2003). Most of their interests were how to improve the crop yield, but this study will investigate on how to reduce the soil acidity (increase the soil pH), especially active and exchangeable acidity using ground eggshell and commercial lime such as calcium carbonate ($CaCO_3$).This study was aimed at comparing the effectiveness of ground eggshell and commercial lime in ameliorating soil acidity and to determine the effects of eggshell and commercial lime on the calcium content and dry matter yield of maize in the greenhouse.

MATERIALS AND METHODS

Soil Sampling and Analysis

Site Location

The Experiments were conducted at the Michael Okpara University of Agriculture, Umudike. Umudike lies within latitude 05^0 29' N and longitude 07^0 33' E with an elevation of 122m above the sea level. Surface soil samples (0-15cm) were collected from the Eastern farm of Michael Okpara University of Agriculture, Umudike. The samples were air-dried and passed through a 2mm mesh to separate fine earth particles from coarse fraction.

Routine Analysis

The particle size analysis was carried out using the Bouyoucos hydrometer method Soil pH was determined using the glass electrode pH meter in a soil to water ratio of 1:2.5. Soil Exchangeable Acidity/Aluminium was determined by titration method (Mc Lean, 1965). Soil Organic carbon was determined by Walkley and Black (1934) method. Soil Total Nitrogen was determined using the micro-kjeldahl digestion and distillation method (Jackson, 1964). The available phosphorus was determined using Bray and Kurtz (1945) No. 2 method. The Exchangeable Bases were determined by leaching the soil with 1N NH_4OAC (Ammonium acetate) at pH 7. Calcium and Magnesium were determined using the EDTA titration method while potassium and sodium were determined by flame photometry. The effective cation exchange capacity was calculated as the sum of exchangeable bases (Ca, Mg, K, Na) and exchangeable acidity, expressed in $Cmolkg^{-1}$. The percentage base saturation was determined using the equation.

% Base saturation

$$= \frac{Total\ exchangeable\ bases}{ECEC} \times \frac{100}{1}$$

Eggshell Analysis

Large quantities of chicken eggshell were collected from the fast food stores in town, sun-dried, milled and sieved with 0.5mm screen. Total calcium was determined by first digestion using 1:1 mixture of concentrated $HN0_3$ and H_20_2.The calcium was determined complexiometrically (EDTA titration) using calcium meter indicator (Vogel 1965).

Green House Experiment

Five kilograms (5kg) of the soil samples were weighed into 5 different perforated plastic buckets, ground eggshell (0, 2, 4 and 6 tons / ha) and $CaC0_3$ (0.5 tons/ha) were added to each of the plastic buckets. This treatment was replicated three times and they were arranged as a randomized complete block design (RCBD). Each treatment was thoroughly mixed together with the soil and maize (*Zea mays*) variety (Oba super 92) planted at the rate of 2 seeds per pot (bucket) and thinned to one stand 2 weeks later. The experiment was raised in the greenhouse for 8 weeks and the above-ground portion was harvested. Soil samples were taken from each pot at 2, 4, 6, and 8 weeks and were air-dried for the determination of pH and total calcium.

Plant Dry Matter Determinations

At 8 weeks after planting in the greenhouse, the maize plant was harvested and weighed. It was oven-dried to obtain a constant weight for the determination of the dry matter yield.

The dry matter yield was calculated thus;

Initial weight of sample = x

Final weight of sample = y

$\therefore$ % dry matter = $\frac{y}{x}$ x $\frac{100}{1}$ (Eteng, 2011)

Statistical Analysis

Data generated from the laboratory and greenhouse experiments were subjected to analysis of variance (ANOVA) and means which were separated using Fischer's Least Significant Difference at 5% level of probability.

RESULTS AND DISCUSSION

The results of soil physico-chemical determinations are shown in Table 1. The soil was loamy sand with pH of 4.60; it was also inadequate in most nutrients such as % organic carbon, % total nitrogen and the exchangeable bases. However, the available P was adequate (Akinrinde and Obigbesan, 2002). This was as expected, as the ultisols of southeastern Nigeria are reportedly low in exchangeable bases (Nwite *et al.*, 2009; Ezekiel *et al.*, 2009). This low Nitrogen could be because of high rate of mineralization and subsequent high rate of leaching that accompany heavy rains associated with the southeast (Osodeke, 1996).

Some chemical properties of the ground eggshell used in the experiment is as shown in Table 2. The result that was obtained showed that the ground eggshell contains a relatively high amount of total calcium (65.96%), as well as pH (8.90). These potentials make it a reliable liming material.

Effects of Ground Eggshell And $CACO_3$ On Soil PH At 2, 4, 6 And 8 Weeks after Planting

The effects of ground eggshell and $CaCO_3$ on soil pH at 2, 4, 6 and 8 weeks after planting are as shown in Fig. 1. The soil pH was significantly ($P<0.05$) increased by all the treatments applied. At 2, 4, 6, and 8 weeks after planting, 6t/ha of the ground eggshell gave the highest value. From the result of the ground eggshell analysis in Fig 1, it was observed that it contains 63.9% calcium content and had high pH value of 8.90. This could be some of the factors that contributed to this result. Also, Stadelman (2000) reported that eggshell contains calcium carbonate (94%), magnesium carbonate (1%), calcium phosphate (1%) and organic matter (4%). These are the main agents for acidity amelioration.

Effects of Ground Eggshell and $CaC0_3$ On Soil Total Calcium at 2, 4, 6, and 8 Weeks after Planting

The effects of ground eggshell and $CaC0_3$ on soil total calcium at 2, 4, 6 and 8 weeks after planting are shown in figure 2. The soil total calcium was significant ($P<0.05$) over the control by the treatment applications. 6t/ha of the ground eggshell gave the highest increase at 2 weeks after planting. However, at 4 weeks after planting, 4t/ha gave the highest increased of total calcium value while 6t/ha gave the least. This may be due to some microbiological activities at that stage which were not investigated in this study. At 6 and 8 weeks after planting, however, the 6t/ha rate of the ground eggshell gave the highest value of soil total calcium again, which were significant over the control and 0.5t/ha of $CaC0_3$. Domestic wastes have been found to improve the availability of nutrients in soils e.g. Calcium (Onwuka *et al.*, 2009).

Effects of Ground Eggshell and $CaC0_3$ on Maize Dry Matter Yield and Calcium Uptake

The effects of ground eggshell and $CaC0_3$ on maize dry matter yield and total calcium content are as shown in Table 3. Ground eggshell significantly ($P<0.05$) increased plant dry matter yield over the control and $CaC0_3$. 6t/ha of ground eggshell gave the highest yield after 8 weeks of planting. Calcium content however was highest at the application of 2t/ha of ground eggshell. This result is in line with the findings of Azeez *et al.*, 2011 who reported that calcium uptake by maize plant was highest at 2.4t/ha of ground egg shell and decreased at a higher rate of application. This could be due to the necessity of the plant to balance up the various nutrients to be taken from the soil.

CONCLUSION

The results show that the ground eggshell and $CaCO_3$ treatments significantly ($P<0.05$) increased the soil pH and soil total calcium over the control at different application rates, with ground eggshell effective. It implies that ground eggshell is a promising soil amendment for increasing soil pH and dry matter yield of maize in Umudike ultisol; 6t/ha rate of its application is also recommended.

Table 1: Physico-chemical properties of soils before experimentation

Parameters	Values
Soil pH (1:2.5 H_2O)	4.50
Soil pH (1:2.5 KCl)	3.80
Total Nitrogen (%)	0.082
Organic carbon (%)	0.94
Available P (mg/kg)	25.18
Exchangeable K (cmol/kg)	0.26
Exchangeable Na (cmol/kg)	0.15
Exchangeable Ca (cmol/kg)	0.40
Exchangeable Mg (cmol/kg)	1.60
TEB (cmol/kg)	2.41
Exchangeable acidity (cmol/kg)	1.60
ECEC (cmol/kg)	4.01
Base saturation (%)	60.10
Sand (%)	85.00
Silt (%)	6.00
Clay (%)	9.00
Soil texture	LS

LS = loamy Sand

Table 2: Some properties of the ground eggshell

Parameter	Value
pH (water)	8.90
pH (KCl)	8.80
Total Calcium (%)	63.96

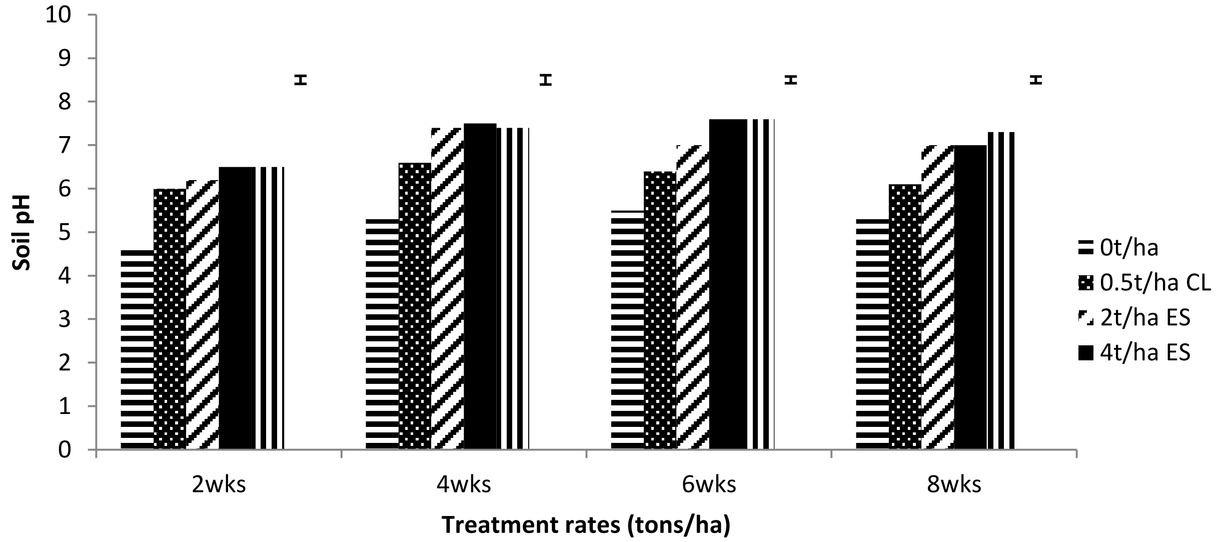

Fig. 1: Effects of ground eggshell and $CaCO_3$ on soil pH at 2, 4, 6 and 8 weeks after planting

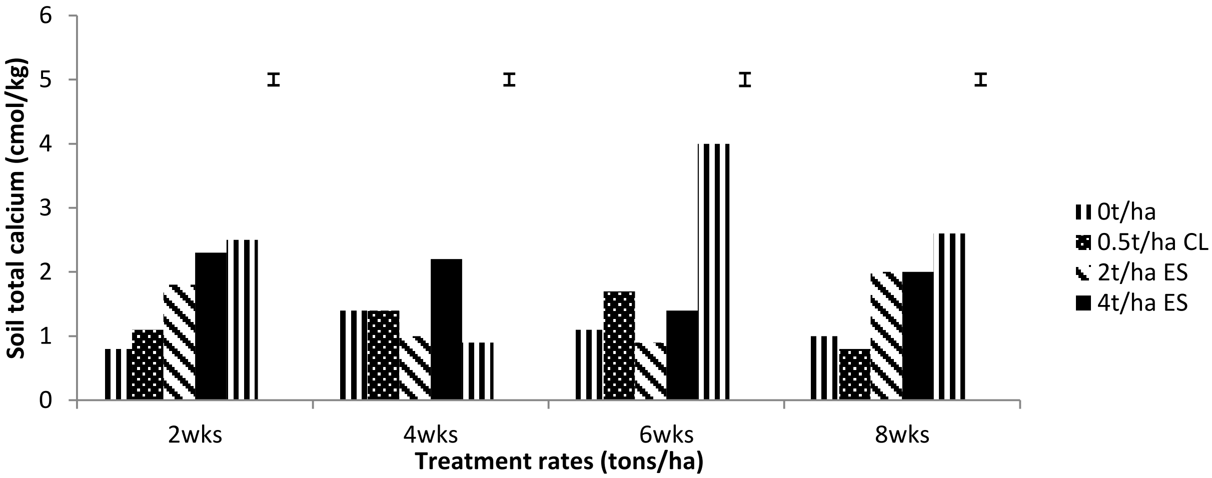

Fig. 2: Effects of ground eggshell and $CaCO_3$ on soil total calcium at 2, 4, 6 and 8 weeks after planting

KEY
0 t/ha= Control ES = Ground eggshell

Table 3: Effects of ground eggshell and CaCO3 on Plant dry matter yield and Total calcium in maize

Treatment	Rate (tons/ha)	Dry matter yield (g)	Plant total calcium (%)
Control	0	9.50	4.80
$CaCO_3$	0.5	9.00	4.00
Ground eggshell	2	10.84	5.60
Ground eggshell	4	8.06	2.40
Groundeggshell	6	12.36	4.00
LSD (0.05)		0.11	0.20

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