COMPARATIVE EFFECT OF LIME AND PALM BUNCH ASH ON SOIL PH AND MAIZE YIELD IN OWERRI SOUTHEASTERN NIGERIA

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Abstract
A field experiment was carried out to evaluate the comparative effects of lime (CaO) and Palm Bunch Ash (PBA) on soil pH and yield of maize in Owerri, Imo state Nigeria. Lime and Palm Bunch Ash each at 2, 4, 6 and 8 tons/ha and an unamended (control) treatment were arranged in a randomized complete block design with 3 replications. The parameters measured were plant height, number of leaves, leaf area and dry matter (leaf and stem) at tasseling. Other parameters were days to 50 % tasseling and silking, anthesis-silking interval, grain filling period, physiological maturity and grain yield. The result showed that soil pH increased from 5.00 to 6.25, 6.46, 6.82 and 7.26 in response to application of 2,4,6 and 8 tons/ha lime and 6.00, 6.37, 6.15 and 7.06 in response to application of 2,4,6 and 8 tons/ha PBA. Application of lime and PBA generally increased plant height, number of leaves, leaf area, leaf dry matter and stem dry matter relative to when no amendment was applied. Application of lime and PBA also hastened maturity of maize by reducing days to 50 % tasseling, days to 50 % silking, anthesis silking interval and physiological maturity. Comparatively, PBA rates produced higher grain yields than lime while PBA at 8tons/ha produced the highest yield. However, there were no significant differences between the rates of lime and PBA in most of the parameters. This implies that higher rates of PBA are not necessary for correction of soil acidity and improvement of maize growth and yield. In addition, lower rates of PBA (2 to 4 tons/ha) were sufficient to raise soil pH to levels considered adequate for maize production in southeastern Nigeria. We therefore recommend the application of 2 to 4 tons/ha PBA as a substitute for lime in the correction of soil acidity for maize production in the southeast rainforest zone of Nigeria

Key words: *Lime, Maize, Palm Bunch Ash, Soil acidity, yield*

Introduction

Maize (*Zea mays*) production is constrained by soil acidity (low soil pH). However, maize is grown on approximately 8 million hectares of acidic soils worldwide (Duque-Varges *et al*., 1994). On these soils, maize yield is reduced due to aluminum and manganese toxicity and calcium, magnesium, phosphorus and molybdenum deficiencies (Von Uexkull and Bosshart, 1989). In tropical Africa, acidic soils occupy more than 29% of the total land area having developed due to high average rainfall which causes leaching of soil nutrients (Maduako, 1991). Soil acidity is usually amended by the use of liming materials such as limestone which contains calcium oxide and magnesium carbonate. Lime application raises soil pH and significantly reduces exchangeable aluminum thus allowing a more efficient uptake of nitrogen and phosphorus (Brady and Weil, 1999). Due to unavailability and high cost of acquiring the conventional liming materials, the average resource poor farmer in the rural area may not be able to afford these materials. Consequently, the application of organic waste has become a viable option to manage problems associated with soil acidity (Onwuka *et al*., 2007). The organic matter increases the cation exchange capacity of the soil, so that as the base saturation increases, the relative amount of acid cations decreases. Palm bunch ash supplies organic matter, nitrogen, phosphorus, calcium and magnesium (Adjei-Nsiah, 2012) and therefore could be used as an alternative to conventional liming materials. Palm bunch ash results from incineration of oil palm bunch waste. The empty fruit bunch is one of the major wastes generated from processing fresh fruit bunch and there is great potential of reducing conventional liming material cost by recycling palm bunch ash. This study was conducted to evaluate the comparative effects of lime (CaO) and palm bunch ash on soil pH and yield of maize in Owerri, Imo State Nigeria. This was with a view to utilize palm bunch ash as a substitute for conventional lime in order to correct soil acidity for production of maize.

Materials and Methods

The location for the study was the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology Owerri (Latitude 5^0 $20^{!}$ N and 5^0 $27^{!}$ N and Longitude 7^0 $00^{!}$ E and 7^0 $07^{!}$ E), found within the Southeast humid forest zone of Nigeria. A composite sample of soil from the experimental site was taken at a depth of 0-20 cm. The physical and chemical properties of the soil are presented in Table 1. Lime (CaO) and Palm Bunch Ash each at 2, 4, 6 and 8 tons/ha and an unamended(control) treatment were arranged in a randomized complete block design with 3 replications. The lime was obtained from Imo State Agricultural Development Programme (ADP) while the palm bunch ash was collected from an oil palm mill in Owerri West Local Government Area in Imo State. The soil amendments (lime and PBA) were evenly broadcasted on each plot one week before planting and worked into the soil with

a garden fork. Each plot measured 11.25m^2 (3 x 3.75m) with a 1m alley between plots. Some chemical properties of the PBA obtained from analysis are presented in Table 2. Two seeds of maize (OBA SUPER II) were sown per hole at a spacing of 0.75 x 0.25 m. This was later thinned to one plant per stand to give a population of 53,333 plants ha^{-1}. NPK fertilizer (20:10:10) was applied in two split doses at 3weeks after planting (WAP) and tasseling, at the rate of 600 kg/ha (0.675 kg/plot). The parameters measured were plant height, number of leaves, leaf area and dry matter (leaf and stem) at tasseling. Other parameters were days to 50 % tasseling and silking, anthesis-silking interval, grain filling period, physiological maturity and grain yield. Plant height was measured from ground level to the last fully opened leaf, while leaf area was determined by the methods of Francis *et al*. (1969). The number of leaves was determined by physical counting of the fully opened leaves. To determine dry matter, plants were cut at ground level and separated into leaf and stem before drying in the oven at 60^{0}C to constant weight. Days to 50% tasseling and silking were determined by reckoning number of days from sowing to the time 50% of the plants in each plot tasseled and silked. Anthesis-silking interval was calculated as the difference between the days to 50% silking and 50% tasseling for each plot. Physiological maturity was determined as the number of days from sowing to time of black layer formation, while grain filling duration was the difference between the number of days to black layer formation (physiological maturity) and 50% silking. Grain yield was determined after harvesting at 15WAP. At harvest, soil samples were taken from each plot and used to determine the soil pH (Table 3). Data generated were subjected to analysis of variance (ANOVA) as described by Wahua (1999) while significant means were separated using the Least Significant Difference (LSD) at 5% level of probability.

Results

Application of lime and PBA at 2, 4, 6 and 8 tons/ha significantly increased the soil pH from 5.00 to 6.25, 6.46, 6.82 and 7.26 and 6.00, 6.37, 6.15 and 7.06 respectively. There were no significant differences between the pH increases from lime and that of PBA rates.

As shown in Table 3, when compared to the control (0 tons/ha) application of lime at 2, 4 and 6 tons/ha significantly increased maize height by 18.5, 21.9, and 21.9 %, respectively while application of PBA at 2,4,6 and 8 tons/ha significantly increased maize height by 32.6, 25.2, 24.0 and 36.6 % respectively. Lime significantly increased number of leaves at 2(18.9%), 6(16.4%) and 8(19.6%) tons/ha relative to the control, while PBA significantly increased number of leaves at 2(14.4%), 4(19.6%) and 8(18.9%) tons/ha relative to the control. In response to application of 4, 6, and 8 tons/ha of lime, leaf area significantly increased by 25.8, 30.6, and 26.1 % , respectively compared to when no lime was applied. In response to application of 2, 4 and 8 tons/ha of PBA, leaf area increased by 25.7, 37.4 and 40.0 % compared to when no PBA was applied. Accumulation of stem dry matter significantly increased by 51.7 and 56.2 % with the application of 2 and 8tons/ha of lime and by 80.8, 61.9, 77.6 and 153.5 % with the application of 2, 4, 6 and 8 tons/ha of PBA. Similarly, accumulation of leaf dry matter significantly increased by 40.6 and 63.2 % with the application of 2 and 8 tons/ha of lime and by 44.4, 49.6 and 101.5 % with the application of 2, 6 and 8 tons/ha of PBA.

The number of days to 50 % tasseling was reduced by 5.0, 7.0, 8.0 and 8.0 days in response to application of 2,4, 6 and 8 tons/ha of lime and by 7.0, 7.0, 7.0 and 8.0 days in response to application of 2, 4, 6 and 8 tons/ha of PBA(Table 4). Similarly, number of days to 50 % silking was reduced by 8.0, 11.0, 11.0 and 8.0 days in response to application of 2,4, 6 and 8 tons/ha of lime and by 10.0, 10.0, 11.0 and 11.0 days in response to application of 2, 4, 6 and 8 tons/ha of PBA. Lime application significantly reduced anthesis-silking interval (ASI) by 45.4, 59.1, 45.4, and 36.3 % when 2, 4, 6 and 8tons/ha of lime were applied and by 45.4, 45.4, 49.9 and 45.7 % when 2, 4, 6 and 8 tons/ha of PBA were applied. Grain filling duration increased by 15.8, 12.3 and 14.0 % with application of 2, 4 and 6 tons/ha of lime. Application of 2, 4, 6 and 8 tons/ha of PBA increased grain filling duration by 12.3, 13.2, 13.3 and 14.2 %. Lime application significantly reduced days to physiological maturity by 6.6 and 6.3 % when 4 and 8 tons/ha of lime were applied, while PBA rates did not reduce days to physiological maturity significantly. Grain yield was significantly increased by 45.8 and 55.9 % when 2 and 4 tons/ha of lime were applied and by 49.3, 49.3 and 64.3 % when 2, 6 and 8 tons/ha of PBA were applied.

Discussion

The analysis of soil samples taken after harvest revealed that application of PBA at different levels raised soil pH, just like lime, from 5.00 to values considered adequate for maize production on acid ultisols of southeastern Nigeria (Okigbo, 1972; Juo and Ballaux, 1977). The basic cations such as Ca and Mg released by PBA must have replaced aluminum on the colloidal complex (Brady and Weil, 1999; Sun *et al*., 2000), thereby reducing acidity. In this study, application of 2 to 4 tons/ha of lime and PBA was sufficient to raise soil pH to these levels which are adequate for maize production.

Application of lime and PBA significantly enhanced maize vegetative and reproductive growth as well as grain yield. PBA produced about the same level of effect as lime or even better for most of the parameters measured. For instance, application of PBA resulted in larger leaf area and higher accumulation of dry matter than application of lime. PBA

supplies potassium, phosphorus, nitrogen, organic matter in addition to calcium and magnesium while lime only supplies calcium. These additional nutrients, particularly N, must have been responsible for improved leaf area development leading to enhancement of radiation use efficiency and higher dry matter accumulation. Leaf expansion is sensitive to N supply (Gimmenz *et al.,*2007) and radiation interception is reduced under low N supply (Vos *et al*., 2005).

Increase in the reproductive parameters when no soil amendment was applied, indicate a delay in the attainment of maturity by maize on acid soils. Application of lime and PBA hastened maturity of maize by reducing the number of days to 50 % tasseling, days to 50 % silking and physiological maturity. Application of PBA also increased grain filling duration and grain yield almost as much as lime application. Increase in grain yield may have resulted from increased dry matter available for remobilization to the kernels (Setter and Meller, 1984) prompted by reduced ASI and extended grain filling (Bolanos, 1995).

Comparatively, PBA rates produced higher grain yields than lime while PBA at 8 tons/ha produced the highest yield. However, there were no significant differences between the rates of lime and PBA in most of the parameters.

Conclusion

The results from this study show that PBA was as effective as lime in the reduction of soil acidity and enhancement of maize growth and yield. Therefore PBA can serve as a replacement for lime in maize production. Furthermore, the different rates of lime and PBA did not show significant differences in most of the growth parameters. This implies that higher rates of PBA are not necessary for correction of soil acidity and improvement of maize growth and yield. Considering that lower rates of PBA (2 to 4 tons/ha) were sufficient to raise soil pH to levels considered adequate for maize production in southeastern Nigeria, the application of 2 to 4 tons/ha PBA is recommended as a substitute for lime in the correction of soil acidity for maize production in the southeast rainforest zone of Nigeria.

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Table 1 Physical and Chemical properties of soil from the experimental site (0 – 20cm)

Soil Properties	**Value**
Sand (%)	87.50
Silt (%)	5.88
Clay (%)	6.62
Texture (%)	Loamy Sand
pH (H_20)	5.00
P(mg/kg)	17.80
N(%)	0.1
Organic carbon(%)	0.6
Organic matter (%)	1.05
	------cmol kg^{-1}--------
Ca	0.5
Mg	0.1
K	0.11
Na	0.55
Al	1.0
H	0.4
ECEC	2.66

Table 2: Some chemical properties of palm bunch ash used in the experiment

Ash properties	**Value**
Organic carbon(%)	0.57
Total Nitrogen(%)	0.09
P(ppm)	250.13
K (cmol kg^{-1})	40.42
Ca (cmol kg^{-1})	34.10
Mg (cmol kg^{-1})	25.12
Na (cmol kg^{-1})	18.21
pH (H_20)	10.26

Table 3 Effect of lime and palm bunch ash on pH at harvest and maize vegetative parameters

Treatment/ Rate		**pH**	**Height (cm)**	**Number of leaves**	**Leaf area (cm^2)**	**Stem dry matter (g/plant)**	**Leaf dry matter(g/plant)**
Control	0	5.22	134.44	10.20	3578.43	54.33	28.98
Lime	2	6.25	159.63	12.13	4260.80	82.43	40.74
	4	6.46	163.87	11.60	4502.85	60.18	35.52
	6	6.82	163.83	11.87	4674.61	74.04	40.53
	8	7.26	158.47	12.20	4512.47	84.84	47.29
PBA	2	6.00	178.23	11.67	4498.15	98.24	41.84
	4	6.37	168.30	12.20	4916.05	87.95	38.02
	6	6.15	166.77	11.33	4139.54	96.47	43.36
	8	7.06	183.67	12.13	5010.06	137.75	58.40
$LSD_{0.05}$		0.55	25.08	1.41	866.08	21.25	11.67

Table 4 Effect of lime and palm bunch ash on maize reproductive parameters

Treatment/ Rate		**days to 50% tasseling**	**days to 50% silking**	**ASI (days)**	**Grain filling duration(days)**	**Physiological maturity(days)**	**Grain yield (tons/ha)**
Control	0	61.00	68.00	7.33	38.00	106.00	2.27
Lime	2	56.00	60.00	4.00	44.00	104.00	3.31
	4	53.67	56.67	3.00	42.67	99.00	3.54
	6	53.33	57.33	4.00	43.33	100.67	2.62
	8	53.33	60.00	4.67	39.37	99.33	2.85
PBA	2	53.67	57.67	4.00	42.67	100.00	3.39
	4	53.67	57.67	4.00	43.00	100.67	3.11
	6	53.67	57.33	3.67	43.04	100.67	3.39
	8	53.00	56.97	3.98	43.38	100.01	3.73
$LSD_{0.05}$		4.76	5.04	1.22	3.02	6.04	0.96