# Soil Plant Nutrients and Maize Performance as Influenced by Oilpalm Bunch Ash plus NPK Fertilizer

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**ABSTRACT:** The work investigated the effects of combined application of oilpalm bunch ash (OPBA) with NPK fertilizer (NPK) on soil and plant nutrient content and maize performance at two sites in southern Nigeria. Six treatments: control, OPBA at 4 t/ha, NPK (15-15-15) at 300 kg/ha, 75% NPK + 25% OPBA, 50% NPK + 50% OPBA, 25% NPK + 75% OPBA were applied to maize at Nigeria Institute for Oilpalm Research (NIFOR) Benin and Ekiadolor in rainforest zone of Nigeria. Relative to control, other treatments increased soil organic matter (OM), N, P, K, Ca, Mg and pH, and plant nutrients content, growth and cob yield. The effects were generally significant except in case of OPBA alone. The NPK, 75% NPK + 25% OPBA and 50% NPK + 50% OPBA gave significantly high and similar values of the parameters. The treatments increased cob yield by 20 – 22%, OPBA most increased soil pH and K.

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**Key words:** oilpalm bunch ash; nutrient; maize

## INTRODUCTION

Maize is staple food for an estimated fifty percent of human population in Subsahara Africa (SSA) being a source of carbohydrates, protein, iron, vitamin B and minerals. However its production is hampered by inadequate soil fertility, high cost and scarcity of the recommended NPK fertilizer. Hence the area devoted to maize continues to reduce and maize farmers shifted to more resistant crops like sorghum and millet. In Nigeria output per hectare of maize grain stand at 1.31, which is 25 percent of world total output (RMRDC, 2004), use of N fertilizers and declining soil fertility are problems for maize production in SSA. Also the present high recommended rates of NPK fertilizer (NPK) are unaffordable and do not give corresponding high yields (Uyovbisere *et al*, 2000). Therefore, there is renewed interest in the use of organic wastes as source of nutrients. Those wastes that have been found useful include animal wastes, plant wastes, ash, and agro-industrial wastes. They were found to improve soil fertility, reduce soil acidity and improve crop yield. Types of ash derived from plants also produce similar effects on maize (Nottidge *et al*, 2005a, 2005b, 2006, 2007; Ayeni *et al*, 2008; Ayeni *et al*, 2009). The wastes can be used alone or fortified with inorganic fertilizers.

The oilpalm bunch ash (OPBA) has not received adequate research attention in maize production, although study by Ojeniyi *et al* (2006) found that OPBA supplied organic matter (OM) N, P, Ca and Mg to soil and maize and increased its yield by 26% when used at 4 t/ha. It was also found to increase nutrient supply to cassava and its yield significantly (Ezekiek *et al*, 2009a, 2009b,). The OPBA results from incineration of oilpalm bunch waste. The bunch waste is generated at about 850 kg/ha on yearly basis in oilpalm plantations in Nigeria. According to Omoti *et al* (1989) there is great potential of reducing fertilizers bills by recycling empty oilpalm bunch waste. Particularly combined application of OPBA and NPK fertilizer in maize production has not received research attention. In the tropics integrated application of organic and inorganic wastes is the sustainable method of maintaining soil fertility and productivity. Hence the objective of this work is to find suitable rates for combined application of OPBA and NPK fertilizer in maize production. The effect on soil and crop nutrient content, growth and yield of maize will also be determined in relation to sole use of fertilizer and OPBA

## MATERIALS AND METHODS

### Field Experiment

Two trials were conducted at Nigerian Institute for Oilpalm Research (NIFOR) Benin (06$^o$ 33' N, 05$^o$ 37' E) and Ekiadolor (06$^o$ 34' N, 05$^o$ 38' E) in rainforest zone of Southern Nigeria. The sites were manually cleared. Ridges were made at 1 m interval and maize seedlings planted at 40 cm interval on ridges were thinned to one plant per stand.

There were six treatments applied to maize. They were: (1) control, (2) 100% oilpalm bunch ash (OPBA) at 4 t/ha, (3) 100% NPK (15-15-15) fertilizer (NPK) at 300 kg/ha, (4) 75% NPK + 25% OPBA, (5) 50% NPK + 50% OPBA, and (6) 25% NPK + 75% OPBA. Treatments were replicated three times using a randomized complete block design, and were applied three weeks after planting in ring form. NPK and OPBA were mixed. There were 75 plants per each of 15 plots in each site. Weeding was done once.

Ten plants were selected per plot. Ear leaf length and width were determined 9 weeks after treatment, and leaf area was calculated by multiplying the product of the two parameters by 0.65 (Saxena and Suigh, 1965). Plant height and stem growth (at 10 cm height) were determined. At 80 days after treatment, harvest was done and cob weight was determined.

**Leaf Analysis**

Ear leaf samples collected per plot were oven-dried at 90 $^oC$ 24 hr, milled and ashed for 6 hr. at 500 $^oC$. Nutrients were extracted using nitric perchloric acid mixture (Tel, 1984) and N was determined by microkjeldahl approach. The P in extract was determined using molybdenum blue colorimetry and read on spectrophotometer. The K was determined on flame photometer, and Ca and Mg by EDTA titration.

**Soil Analysis**

Composite soil samples collected after land clearing and soil samples collected at harvest from treatment plots were air-dried, ground and sieved using 2 mm sieve mesh. They were chemically analysed as described by Tel (1984). Organic matter was determined by wet oxidation method through chromic acid digestion. Nitrogen was determined by microkjeldahl approach; P was extracted by Bray-P1 solution and determined using the spectrophotometric method. Exchangeable K, Ca and Mg were extracted using ammonium acetate; K was determined using flame photometer, and Ca and Mg by EDTA titration method. Soil pH in ratio 1:2 water suspension was determined using a glass electrode.

Statistical analysis was performed using analysis of variance, and means separated using Fischer's least significance test at 5% level of probability.

**RESULTS AND DISCUSSION**

Data on soil properties at NIFOR and Ekiadolor sites are shown in Table 1. The soils are sandy, slightly acidic, low in organic matter (OM), total N, available P, exchangeable K and Ca.

Table 1: Soil properties at NIFOR and Ekiadolor

| Properties | NIFOR | Ekiadolor |
|---|---|---|
| Sand % | 92.3 | 93.8 |
| Silt % | 3.7 | 2.1 |
| Clay % | 4.0 | 4.1 |
| pH (water) | 5.3 | 5.5 |
| Organic matter % | 1.40 | 1.52 |
| Total N % | 0.04 | 0.07 |
| Available P mg/kg | 8.6 | 7.1 |
| Exchangeable K c mol/kg | 0.13 | 0.10 |
| Exchangeable Ca c mol/kg | 0.95 | 1.02 |
| Exchangeable Mg c mol/kg | 0.60 | 0.72 |

OPBA, NPK and their combined use at reduced levels increased soil OM, N, P, K, Ca and Mg at both sites (Tables 2 and 3). The increases were significant in case of NPK and its combined use with OPBA. However, OPBA gave highest values of soil pH and K, and had significant effect on these parameters. NPK gave highest values of soil N, P at NIFOR and P, Ca and Mg at Ekiadolor. The increases in soil nutrients due to NPK and OPBA can be adduced to increased soil OM which might be due to enhanced microbial activity. The OM is a natural source of nutrients and cation exchange. The OPBA due to its composition is also able to release macronutrients thereby increasing soil fertility and crop nutrient uptake. Analysis of OPBA as given by Ojeniyi *et al* (2006) was 1.60% OM, 0.19% N, 0.13% P, 29.8% K, 7.95% Ca and 3.2% Mg. Hence because of its high content of cations (K, Ca, Mg), OPBA was able to give highest soil pH and K. Therefore, OPBA had liming effect, and it is an effective source of K. In Ghana cocoa pod ash was used as source of K for maize (Adu-Dapach *et al*, 1994).

Table 2: Soil nutrients content as influenced by oilpalm bunch ash (OPBA) and NPK fertilizer (NPK) at NIFOR

| Treatment | pH | OM % | N % | P mg/kg | K cmol/kg | Ca cmol/kg | Mg cmol/kg | $H^+$ | ECEC cmol/kg |
|---|---|---|---|---|---|---|---|---|---|
| Control | 5.5 | 1.45 | 0.05 | 9.6 | 0.14 | 1.06 | 0.44 | 0.17 | 1.85 |
| OPBA 100% (4 t/ha) | 6.5 | 1.61 | 0.07 | 22.6 | 0.44 | 3.01 | 0.93 | 0.10 | 4.42 |
| NPK 100% (300 kg/ha) | 5.9 | 2.89 | 0.18 | 38.5 | 0.22 | 7.68 | 1.52 | 0.17 | 10.58 |
| 75% NPK + 25% OPBA | 6.4 | 3.80 | 0.17 | 35.3 | 0.24 | 7.07 | 1.65 | 0.13 | 9.39 |
| 50% NPK + 50% OPBA | 6.0 | 2.68 | 0.14 | 32.4 | 0.32 | 5.56 | 1.44 | 0.13 | 7.55 |
| 25% NPK + 75% OPBA | 6.2 | 2.38 | 0.12 | 28.4 | 0.38 | 3.73 | 1.57 | 0.13 | 6.23 |
| LSD (0.05) | 0.4 | 0.48 | 0.03 | 4.4 | 0.07 | 1.22 | NS | NS | 0.80 |

NS = Not significant

Table 3: Soil nutrient content as influenced by oilpalm bunch ash (OPBA) and NPK fertilizer at Ekiadolor
NS = Not significant

| Treatment | pH | OM % | N % | P mg/kg | K cmol/kg | Ca cmol/kg | Mg cmol/kg | $H^+$ | ECEC cmol/kg |
|---|---|---|---|---|---|---|---|---|---|
| Control | 5.3 | 1.39 | 0.08 | 14.0 | 0.11 | 1.22 | 0.37 | 0.47 | 1.69 |
| OPBA 100% (4 t/ha) | 6.2 | 1.45 | 0.09 | 21.7 | 0.36 | 2.69 | 0.69 | 0.13 | 4.20 |
| NPK 100% (300 kg/ha) | 5.7 | 2.82 | 0.16 | 39.9 | 0.19 | 7.88 | 1.46 | 0.17 | 10.09 |
| 75% NPK + 25% OPBA | 5.9 | 3.34 | 0.16 | 33.7 | 0.20 | 6.27 | 1.37 | 0.20 | 8.27 |
| 50% NPK + 50% OPBA | 6.1 | 2.48 | 0.14 | 30.3 | 0.25 | 5.10 | 1.30 | 0.13 | 6.87 |
| 25% NPK + 75% OPBA | 6.0 | 2.24 | 0.12 | 26.2 | 0.32 | 3.63 | 1.35 | 0.17 | 5.78 |
| LSD (0.05) | 0.40 | 0.38 | 0.03 | 5.8 | 0.04 | 1.30 | NS | NS | 1.56 |

Increases in plant nutrient contents given by OPBA were not significant (Tables 4 and 5). Infact tissue N was reduced relative to control by OPBA at Ekiadolor. Combined application of OPBA and NPK and NPK alone significantly increased tissue N, P, K, Ca and Mg (Tables 3 and 4). The treatments generally gave higher tissue N, P, K, Mg and Ca. Treatments 75% NPK + 25% OPBA, 50% NPK + 50% OPBA and NPK had similar values of plant N, P, K, Ca and Mg. Among the combined treatments, 25% NPK + 75% OPBA generally had least plant nutrients content. This might be due to its highest OPBA concentration. However, it gave higher nutrients content than the control and OPBA alone. It is suggested that addition of NPK to OPBA enhanced nutrients availability. This is attributable to enhanced mineralization of nutrients in OPBA.

Increased availability of nutrients in soil and maize crop led to enhanced growth and cob yield (Table 6). This affirms the importance of N, P, K, Ca and Mg to maize performance. Generally OPBA, NPK and their combinations at reduced levels significantly increased plant height, leaf area and cob weight. Treatments NPK, 75% NPK + 25% OPBA and 50% NPK + 50% OPBA with similar and highest values of soil and plant nutrients content also had highest and similar values of growth and yield parameters. OPBA which had least values of soil and plant nutrients compared with NPK and its combined applications with

Table 4: Maize nutrients content as influenced by oilpalm bunch ash (OPBA) and NPK fertilizer (NPK) at NIFOR (%)

| Treatment | N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| Control | 0.84 | 0.23 | 0.71 | 0.77 | 0.07 |
| OPBA 100% (4 t/ha) | 0.92 | 0.26 | 0.75 | 0.78 | 0.09 |
| NPK 100% (300 kg/ha) | 1.24 | 0.30 | 0.79 | 1.02 | 0.15 |
| 75% NPK + 25% OPBA | 1.31 | 0.30 | 0.78 | 1.14 | 0.13 |
| 50% NPK + 50% OPBA | 1.41 | 0.28 | 0.75 | 0.99 | 0.12 |
| 25% NPK + 75% OPBA | 1.38 | 0.28 | 0.73 | 0.83 | 0.12 |
| LSD (0.05) | 0.15 | 0.03 | NS | 0.18 | 0.03 |

NS = Not significant

Table 5: Maize nutrients content as influenced by oilpalm bunch ash (OPBA) and NPK fertilizer (NPK) at Ekiadolor (%)

| Treatment | N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| Control | 0.81 | 0.24 | 0.69 | 0.73 | 0.10 |
| OPBA 100% (4 t/ha) | 0.56 | 0.26 | 0.73 | 0.78 | 0.09 |
| NPK 100% (300 kg/ha) | 1.25 | 0.34 | 0.89 | 1.05 | 0.13 |
| 75% NPK + 25% OPBA | 1.26 | 0.29 | 0.69 | 1.11 | 0.12 |
| 50% NPK + 50% OPBA | 1.34 | 0.26 | 0.72 | 0.90 | 0.10 |
| 25% NPK + 75% OPBA | 1.31 | 0.22 | 0.70 | 0.84 | 0.11 |
| LSD (0.05) | 0.09 | NS | 0.08 | 0.17 | 0.02 |

NS = Not significant

OPBA had least values of growth and yield parameters which were not significantly different from that of control. Therefore, OPBA is less suitable for maize production compared with its combination with NPK fertilizer. Compared with control, OPBA, NPK, 75% NPK + 25% OPBA, 50% NPK + 50% OPBA, and 25% NPK + 75% OPBA increased cob weight by 11, 22, 20, 22 and 16% respectively. Therefore NPK, 75% NPK + 25% OPBA, and 50% NPK + 50% OPBA are equally suitable for maize production. Instead of the recommended 300 kg/ha NPK fertilizer, OPBA could be combined with NPK fertilizer as 215 kg NPK/ha + 1t/ha OPBA, or 150 kg NPK/ha + 2 t/ha OPBA for maize production without loss of yield, soil and plant nutrient content.

Table 6: Growth and yield of maize as influenced by oilpalm bunch ash (OPBA) and NPK fertilizer (NPK)

| Treatment | Plant height (cm) | | Leaf area ($cm^2$) | | Cob weight (g) | |
|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 1 | Site 2 | Site 1 | Site 2 |
| Control | 135.3 | 127.5 | 366 | 428 | 333 | 301 |
| OPBA 100% (4 t/ha) | 168.5 | 157.7 | 440 | 495 | 357 | 345 |
| NPK 100% (300 kg/ha) | 182.0 | 170.0 | 530 | 597 | 395 | 376 |
| 75% NPK + 25% OPBA | 177.4 | 164.3 | 507 | 572 | 387 | 374 |
| 50% NPK + 50% OPBA | 182.6 | 166.7 | 501 | 624 | 398 | 373 |
| 25% NPK + 75% OPBA | 176.3 | 167.7 | 494 | 585 | 383 | 352 |
| LSD (0.05) | 4.1 | 5.1 | 25.8 | 41.9 | 35.8 | 18.9 |

Site 1 = NIFOR, Site 2 = Ekiadolor

The findings from this work align with the observation of Ezekiel et al, (2009a, 2009b) who noted that sole and amended forms of OPBA had beneficial effects on soil chemical properties. Ojeniyi *et al* (2006, 2009), Ezekiel *et al* (2009a, 2009b) also found that OPBA used alone increased nutrient availability, controlled soil acidity and increased yield of maize and cassava.

**CONCLUSION**

Oilpalm bunch ash (OPBA) is suitable for reducing soil acidity and supplying macronutrients especially potassium. It could be combined with NPK fertilizer at 25% + 75% or 50% + 50% OPBA + NPK in order to reduce expenditure on NPK and reduce soil acidity without loss in soil fertility, nutrient availability and maize yield.

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