# Response of Okra to Organic and Inorganic Fertilization

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**ABSTRACT**: **Problem Statement**. Continuous use of mineral fertilizer in tropical soils is associated with reduced crop yield, increased soil acidity and nutrient imbalance. A combination of organic materials and mineral fertilizer is better fertilizer management for these soils. **Approach**:Performance of Okra (*Abelmoschus esculentus* L Moench) was assessed using synthetic NPK fertilizer alone, organic materials alone, or a mix of the two. **Results**:Application of 60 kg N + 2.5 Mt·ha$^{-1}$ organic fertilizer produced the tallest plants, 57 cm. Application of 60 kg N + 2.5 Mt·ha$^{-1}$ poultry manure (PM) and with *Gliricidia* leaves produced plants of 53 and 51 cm, respectively. Stem circumference and leaf area followed the same trend. Application of 60 kg N + 2.5 Mt·ha$^{-1}$ Organic-based Fertilizer (OBF) produced the highest yield, 3.58 Mt·ha$^{-1}$ which was similar to 3.29 and 3.20 Mt·ha$^{-1}$ from applications of 60 kg N + 2.5 Mt·ha$^{-1}$ PM and *Gliricidia* leaves, respectively. Okra leaf N and P contents were increased by 37 and 130% respectively, with *Gliricidia* leaves. **Conclusion:** Complementary application of 2.5 tonnes OBF and 60kg N as NPK 20-10-10 most favoured Okra growth and yield.
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## INTRODUCTION

Soil productivity maintenance is a major constraint of tropical agriculture. Crop cultivation is usually moved between fields to utilize only fertile soils for some years without use of fertilizers. However, this cannot be sustained to meet increased demand of an increasing population.

Tropical soils are adversely affected by sub-optimal soil fertility and erosion, causing deterioration of the nutrient status and changes in soil organism populations (Economic Commission for Africa, 2001). Use of inorganic fertilizers can improve crop yields and soil pH, total nutrient content, and nutrient availability, but its use is limited due to scarcity, high cost, nutrient imbalance and soil acidity. Use of organic manures as a means of maintaining and increasing soil fertility has been advocated (Rodale, 1984; Alasiri and Ogunkeye, 1999; Smil, 2000). Animal manures, when efficiently and effectively used, ensure sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields (Sharma and Mittra, 1991; Abou El Magd et al., 2005). Manures are usually applied at higher rates, relative to inorganic fertilizers. When applied at high rates, they give residual effects on the growth and yield of succeeding crops (Makinde and Ayoola, 2008) Improvements of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocating use of organic materials (Bayu et al., 2006). Organic manures improve soil fertility by activating soil microbial biomass (Ayuso et al., 1996). Application of manures sustains cropping system through better nutrient recycling (El-Shakweer et al., 1998). Manures provide a source of all necessary macro- and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil (Abou El-Magd et al., 2006).

Mixing organic and inorganic fertilizers may be a sound soil fertility management strategy in many countries. Apart from enhancing crop yields, the practice has a greater beneficial residual effect that can be derived from use of either organic or inorganic fertilizers applied alone. Makinde et al. (2001) reported that maize (*Zea mays* L.) yields obtained from application of a combination of synthetic fertilizer and manure improved yield over that from manure alone. Akande et al. (2003) reported that combined use of ground rock phosphate applied together with poultry manure significantly improved growth and yield of Okra (*Abelmoschus esculentus* L Moench) compared to application of each material separately. Akanbi et al. (2005) reported that the combined application of 4 Mt·ha$^{-1}$ of maize straw compost and N mineral fertilizer at 30 kg·ha$^{-1}$ improved plant growth and gave higher tomato (*Lycopersicum esculentum* L.) yields than other combinations. *Gliricidia sepium* (Jacq) Kunth is a common tropical legume tree, usually planted as a wind break and to trap atmospheric nitrogen to recycle into the soil as well as to generate biomass for feeding livestock. It is commonly used in alley farming systems in Africa. This study was conducted to determine effects of poultry manure, *Gliricidia* leaves and NPK 20-10-10 applied individually, and in combination, on growth and yield of okra and on soil nutrient dynamics.

## MATERIALS AND METHODS

Field experiments were conducted in at the Institute of Agricultural Research and Training, Ibadan. Nigeria, Lat. 7°22.5'N and Long. 3°50.5'E. There is a bimodal rainfall pattern, with a long rainy season, usually between March and July and a short rainy season, usually extending from September to early November, after a short dry spell in August and a longer dry period from December to February.

The soil was a Plinthic Luvisol which was plowed and disked to establish the seed bed. The soil was sampled for routine analyses before planting. The experiment was arranged in a randomized complete block design with 8 treatments replicated 3 times. There were individual applications of NPK 20-10-10 and three organic materials [organic–based fertilizer (OBF); a blend of maize stover and poultry manure compost; poultry manure (PM) alone, and *Gliricidia* leaves alone]. Each organic nutrient source was also applied in mixes with the mineral fertilizer. An unfertilized treatment, which would mimic use of uncultivated land, served as the control. The manure was well rotted chicken litter that had stabilized for about 100 days; the *Gliricidia* was harvested leaves sun dried for 7 days. The full rate of NPK 20-10-10 (120 kg $ha^{-1}$) and the full rate of organic based fertilizers were applied at 5 Mt·$ha^{-1}$. The organic fertilizers were also applied at 2.5 Mt.$ha^{-1}$ mixed with 60 kg $ha^{-1}$ of NPK (20–10–10).

Plot size was 6 × 2 m with 0.5 m between plots. Treatment blocks were spaced 1 m apart. Organic fertilizers were applied 2 weeks before planting. The inorganic fertilizer was applied 2 weeks after planting, both for the individual and combined applications. Two seeds of okra (cv. V - 35) were planted per hill and later thinned to one plant at a spacing of 60 × 30 cm inter- and intra-row, respectively. The variety is a dwarf, early-maturing, cultivar that flowers in about 35 days and sets fruit after 50 days. As fruits are harvested, more flowers are initiated and more fruits formed in 5 and 7 days. There can be as many as 10 harvests, depending on frequency of harvest and water availability.

One hundred-mL of Galex® (metobromuron+metolachlor, Novartis, Nigeria) and 500 mL of Round-up® (glyphosate, Monsanto, Switzerland) each in 15 L of water were applied to control weeds. Nuvacron® (Monocrotophos; Novartis, Switzerland) was applied at 40 mL in 15 L of water to control insects. The experiment was repeated on the same plots .There was no plowing or disking. The site was manually cleared. All cultural practices were repeated.

**Soil analysis**:

Particle size distribution was determined with a hydrometer (Bouyoucos, 1962) using sodium hexa meta-phosphate as the dispersing agent. Soil pH was determined in distilled water at a 1:1 (w/v) soil to water ratio. Exchangeable bases were extracted with neutral 1 M $NH_4OAC$ at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer. Exchange acidity was determined by titration of 1 M KCl extract against 0.05 M NaOH to a pink end point using phenolphthalein as indicator (McLean, 1982).

**Manure:**

The poultry manure was applied to supply 395-240-50 kg·$ha^{-1}$ of NPK at the unmixed rate, and 198-120-25 kg·$ha^{-1}$ of NPK in the mixed treatment. The OBF mix was applied to supply 365-225-55 kg·$ha^{-1}$ of NPK for the unmixed rate and 183-113-28 kg·$ha^{-1}$ NPK in the mixed treatment. *Gliricidia* leaves were applied to supply 390-235-60 kg·$ha^{-1}$ of NPK at the unmixed rate and 195-118-30 kg·$ha^{-1}$ NPK in the mixed treatment.

**Data collection**

At six weeks after planting, data on plant height, stem circumference and leaf area to assess plant growth were taken from 5 plants/plot. Fruits were harvested at four day intervals with 9 harvests. Numbers and weights of fruit were determined. Yield was computed on fresh weight basis and leaf nutrient contents determined.

**Data analysis**

Data were subjected to analysis of variance using the Mixed Model procedure in SAS (ver. 6.0, SAS, 1994). Means were separated with Duncan's Multiple Range Test.

## RESULTS

**Weather:**

Total annual rainfall was 1465 mm in 2005 and 1603 mm in 2006. Average monthly temperature ranged from a minimum of 16.8°C in January to 34.3°C in February when the monthly relative humidity ranged from 73.8% in January to 94.0% in

August in 2005. In 2006, average monthly temperature ranged from a minimum of 18.9°C in December to a maximum of 33.6°C in February when the monthly relative humidity ranged from 70.7% in October to 94.7% in March.

**Soil analysis:**

The soil was 89.2% sand, 6% clay and 4.8% silt, slightly acidic (pH 5.9) and with a total N content of 0.07%. Available phosphorous was 7.92 mg $kg^{-1}$ and exchangeable potassium was 0.17 mg $kg^{-1}$. Contents of Ca, Na and Mg were 0.63, 0.04 and 0.42 mg $kg^{-1}$, respectively, and exchangeable acidity was 0.12 mg $kg^{-1}$ (Table 1).

**Organic materials:**

There was little difference in the treatment materials (Table 1). Poultry manure had a pH 6.6, total nitrogen content of 7.9%; 4.8% available P and 1.0% exchangeable K. The OBF had a pH 6.4, total nitrogen content of 7.3%; 4.5% available P and 1.1% exchangeable K. The *Gliricidia* leaves had a pH 6.3, total nitrogen content of 7.8%; 4.7% available P and 1.2% exchangeable K.

**Plant height:**

Nutrients supplied in the form of NPK, OBF, PM, *Gliricidia sepium* alone, or in combination, affected okra plant height, stem circumference and leaf area (Table 2). Plants treated with OBF combined with NPK had the tallest plants. Poultry litter and *Gliricidia* leaves mixed with NPK produced plants with comparable heights. The unmixed OBF and PM had shorter plants that were similar in height. Plants treated only with NPK were shorter than plants treated with any of the organic materials mixed with NPK that were comparable with each other. Plants from the control had significantly shorter plants than from any of the fertilizer types.

**Stem circumference:**

Stem circumference was affected by treatment (Table 2). The OBF-NPK mix treatment produced plants with the greatest stem circumference. The PM and *Gliricidia* mixed with NPK produced plants with similar stem circumferences. Treatment with the OBF-NPK mix produced plants with greater stem circumference than those receiving only organic manures. Stem circumference with NPK alone was significantly higher than from the organic materials. The control had smallest circumference of 40 mm.

**Leaf area:**

Okra plant leaf area was highest with the OBF-NPK mix (Table 2). The PM and *Gliricidia* leaves mixed with NPK had similar leaf areas. The manure-NPK mixes produced leaf areas comparable to those from plants receiving PM and *Gliricidia*, without NPK, and were higher than the control. Leaves from plants treated only with NPK and only with OBF were smaller than from the mixed materials. Controls had the smallest leaves.

**Fruit yield:**

Okra fruit yield was lowest for the control (Table 2). The highest fruit yield was from application of the OBF-NPK mix. Yields from PM and *Gliricidia* leaves-NPK mixes were similar. Yields from NPK alone and from PM and *Gliricidia* leaves alone were significantly lower than from the OBF-NPK mix. Yields from all other fertilizer types were similar (Table 2).

**Number of fruits/plant:**

Number of fruits/plant was affected by fertilizer treatment (Table 2). The OBF-NPK mix had higher number of fruits/plant than from PM and *Gliricidia* leaves. All other fertilizer types had comparable number of fruits/plant. However, plants from the control had significantly lower number of fruits/plant than from any of the fertilizers, either used alone or mixed.

**Leaf Nutrient composition:**

Plants treated only with *Gliricidia* leaves had the highest contents of N and P, while leaves from plants treated with the mix of *Gliricidia* and NPK had lower N and P contents (Table 3). Poultry manure alone produced leaves with N and P that were lower, as did plants receiving the PM-NPK mix. When OBF was used alone, it produced leaves that had N and P contents of 4.69 and 0.63%, respectively; plants receiving the OBF-NPK mix produced leaves with N and P contents of 4.96 and 0.53%, respectively. The OBF used alone produced leaves with the highest K content, followed by plants treated with *Gliricidia* leaves.

**Soil nutrient dynamics:**

At the end of the first season, soil pH was lower with the application of the *Gliricidia* leaves-NPK mix. The PM-NPK mix and *Gliricidia* leaf alone or NPK alone had soil pH of 5.9. However, the OBF-NPK mix; PM alone and OBF alone increased soil pH. The OBF alone had the highest soil N content followed by *Gliricidia* leaves alone. (Table 4). At the final harvest, soil pH generally increased from 5.9 to a range of 6.0 to 6.7, and was 5.8 due to treatment with the OBF-NPK mix (Table 5). The highest N content, 0.16%, was from the poultry manure only treatment.

Table 1: Soil physical and chemical properties prior to cropping and manure analysis.

| Parameter | Soil | Poultry litter | OBF[a] | *Gliricidia* |
|---|---|---|---|---|
| pH in $H_2O$ | 5.90 | 6.60 | 6.40 | 6.30 |
| Organic carbon (%) | 0.42 | 6.90 | 6.70 | 6.85 |
| Total N (%) | 0.07 | 7.90 | 7.30 | 7.80 |
| Available P ($mg \cdot kg^{-1}$) | 7.92 | 4.80 | 4.50 | 4.68 |
| Exchangeable K ($mg \cdot kg^{-1}$) | 0.17 | 1.00 | 1.10 | 1.15 |
| Exchangeable Ca ($mg \cdot kg^{-1}$) | 0.63 | 0.11 | 1.10 | 0.11 |
| Exchangeable Na ($mg \cdot kg^{-1}$) | 0.04 | 0.26 | 0.30 | 0.28 |
| Exchangeable Mg ($mg \cdot kg^{-1}$) | 0.42 | 0.93 | 0.87 | 0.90 |
| Exchangeable acidity ($mg \cdot kg^{-1}$) | 0.12 | 0.46 | 0.32 | 0.48 |
| ECEC[b] ($mg \cdot kg^{-1}$) | 1.38 | 3.46 | 2.29 | 2.92 |
| Mn ($mg \cdot kg^{-1}$) | 4.93 | 38.20 | 29.60 | 35.70 |
| Zn ($mg \cdot kg^{-1}$) | 2.95 | 27.86 | 24.20 | 20.60 |
| Cu ($mg \cdot kg^{-1}$) | 0.31 | 3.90 | 4.10 | 3.70 |
| Fe ($mg \cdot kg^{-1}$) | 4.98 | 3.68 | 2.75 | 2.60 |

[a] OBF = organic-based fertilizer, a blend of maize stover and poultry manure compost.
[b] ECEC = Effective cation exchange capacity.

Table 2: Effect of organic and Inorganic fertilizers on okra growth and yield.

| Treatment | Height (cm) | Stem circumference (mm) | Leaf area ($cm^2$) | Fruit yield (t/ha) | Number of fruits |
|---|---|---|---|---|---|
| Control (Fo) | 37.0c[a] | 40.5c | 77.5c | 1.51c | 112c |
| NPK (F1) | 49.8b | 51.0ab | 90.0b | 2.96b | 192ab |
| OBF (F2) | 51.9ab | 49.0b | 92.2b | 3.10ab | 193ab |
| PM (F3) | 51.8ab | 48.5b | 95.9ab | 2.90b | 172b |
| *Gliricidia* (F4) | 45.9b | 48.0b | 96.1ab | 2.80b | 163b |
| ½ F1 + ½ F2 | 57.1a | 57.0a | 112.8a | 3.58a | 225a |
| ½ F1 + ½ F3 | 52.9ab | 54.5ab | 108.1a | 3.29ab | 208ab |
| ½ F1 + ½ F4 | 51.1ab | 53.0ab | 105.4a | 3.20ab | 205ab |

[a] values in a column followed by the same letter are not significantly different, DMRT, $P \leq 0.05$.

Table 3: Nutrient composition of Okra leaves from plants treated with organic and inorganic fertilizers measured at the last harvest.

| Treatment | % N | % P | % K | % Mg | Zn (mg/kg) | Fe (mg/kg) |
|---|---|---|---|---|---|---|
| Control (Fo) | 4.09 | 0.40 | 1.49 | 0.74 | 194.25 | 227.33 |
| NPK (F1) | 4.95 | 0.49 | 1.41 | 0.80 | 190.17 | 304.42 |
| OBF (F2) | 4.69 | 0.63 | 1.58 | 0.64 | 164.67 | 223.92 |
| PM (F3) | 4.91 | 0.83 | 1.48 | 0.68 | 133.92 | 196.92 |
| *Gliricidia* (F4) | 5.61 | 0.92 | 1.45 | 0.78 | 159.25 | 161.92 |
| ½ F1 + ½ F2 | 4.96 | 0.53 | 1.43 | 0.74 | 136.50 | 309.67 |
| ½ F1 + ½ F3 | 4.93 | 0.53 | 1.45 | 0.77 | 162.58 | 172.17 |
| ½ F1 + ½ F4 | 5.33 | 0.47 | 1.50 | 0.81 | 164.33 | 212.42 |

Table 4: Effect of organic and inorganic fertilizers on selected soil chemical properties at the end of the first year

| Treatment | pH | Exchangeable Ca | Mg | K | Na | H | CEC | C | N | Av P | Mn | Cu | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | --------------- C mol kg $^{-1}$ ---------- | | | | | | % | % | % | --------- C mol kg $^{-1}$ -------- | | | |
| Control (Fo) | 5.9 | 0.91 | 0.43 | 0.21 | 0.03 | 0.12 | 1.77 | 0.47 | 0.11 | 6.58 | 10.90 | 0.59 | 4.38 | 5.23 |
| NPK (F1) | 5.9 | 0.82 | 0.35 | 0.17 | 0.04 | 0.12 | 1.49 | 0.63 | 0.06 | 13.63 | 15.43 | 0.59 | 3.93 | 3.66 |
| OBF (F2) | 6.4 | 1.09 | 0.63 | 0.22 | 0.05 | 0.13 | 2.11 | 0.78 | 0.15 | 19.40 | 10.30 | 0.51 | 4.98 | 3.82 |
| PM (F3) | 6.3 | 1.08 | 0.76 | 0.20 | 0.02 | 0.13 | 2.15 | 0.96 | 0.05 | 20.16 | 9.60 | 0.50 | 6.44 | 5.62 |
| Gliricidia (F4) | 5.9 | 0.70 | 0.33 | 0.15 | 0.03 | 0.12 | 1.33 | 0.70 | 0.12 | 12.37 | 15.04 | 0.38 | 3.22 | 2.78 |
| ½ F1 + ½ F2 | 6.1 | 0.91 | 0.40 | 0.17 | 0.04 | 0.12 | 1.66 | 0.61 | 0.07 | 14.43 | 11.15 | 0.44 | 2.73 | 1.49 |
| ½ F1 + ½ F3 | 5.9 | 1.00 | 0.46 | 0.14 | 0.04 | 0.12 | 1.71 | 0.90 | 0.08 | 16.64 | 12.01 | 0.54 | 5.64 | 4.77 |
| ½ F1 + ½ F4 | 5.5 | 0.60 | 0.35 | 0.17 | 0.09 | 0.11 | 1.31 | 0.67 | 0.08 | 14.13 | 16.03 | 0.48 | 3.70 | 3.51 |

Table 5: Effect of organic and inorganic fertilizers on selected soil chemical properties at the end of the second year.

| Treatment | pH | Exchangeable Ca | Mg | K | Na | H | CEC | C | N | Av P | Mn | Cu | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -------------- C mol kg $^{-1}$ ---------- | | | | | | % | % | % | --------- C mol kg $^{-1}$ -------- | | | |
| Control (Fo) | 6.10 | 0.87 | 0.62 | 0.38 | 0.05 | 0.16 | 1.79 | 0.58 | 0.12 | 5.38 | 11.82 | 0.74 | 4.97 | 6.04 |
| NPK (F1) | 6.10 | 0.94 | 0.59 | 0.39 | 0.06 | 0.15 | 1.89 | 0.61 | 0.08 | 15.22 | 12.10 | 0.42 | 5.04 | 5.87 |
| OBF (F2) | 6.50 | 0.81 | 0.74 | 0.28 | 0.03 | 0.14 | 1.78 | 0.60 | 0.07 | 19.48 | 11.04 | 0.50 | 5.71 | 4.66 |
| PM (F3) | 6.70 | 0.97 | 0.89 | 0.35 | 0.09 | 0.16 | 2.04 | 0.68 | 0.16 | 22.64 | 12.67 | 0.87 | 6.32 | 6.17 |
| Gliricidia (F4) | 6.40 | 1.14 | 0.68 | 0.19 | 0.08 | 0.15 | 1.66 | 0.57 | 0.08 | 20.07 | 12.07 | 0.53 | 5.11 | 5.82 |
| ½ F1 + ½ F2 | 5.80 | 1.08 | 0.69 | 0.22 | 0.10 | 0.18 | 1.87 | 0.63 | 0.11 | 19.47 | 13.01 | 0.64 | 4.38 | 6.70 |
| ½ F1 + ½ F3 | 6.00 | 0.99 | 0.75 | 0.31 | 0.02 | 0.16 | 1.59 | 0.66 | 0.06 | 18.16 | 12.07 | 0.60 | 6.10 | 5.23 |
| ½ F1 + ½ F4 | 6.10 | 0.89 | 0.82 | 0.21 | 0.07 | 0.16 | 2.00 | 0.67 | 0.14 | 19.32 | 11.84 | 0.81 | 5.27 | 5.84 |

**DISCUSSION**

Fertilizer is one of the most important inputs contributing to crop production because it increases productivity and improves yield quantity and quality. The general low ambient soil nutrient content made the soil suitable for study of responses to fertilizer. Application of organic materials generally resulted in growth which compared favorably with NPK fertilizer alone. The combination of organic materials with reduced NPK fertilizer rates produced plants that were similar to unmixed NPK fertilizer. This indicated that the high dose of organic manures can be reduced by half and mixed with a reduced rate of NPK fertilizers as reported by Akande et al. (2003). The nutrient use efficiency of crops is better with a mix of manure and inorganic fertilizer (Murwira and Kirchmann, 1993). Nutrients seemed more available to okra plants with the mixes than the organic materials alone. The OBF-NPK mix supported okra growth better than NPK alone. Fertilization gave significantly higher fruit yields. Application of a mix of organic materials and inorganic fertilizers can be used to sustain okra in the tropics. A similar trend of response had been earlier observed with other crops such as: maize (Makinde et al., 2001); with sorghum- *Sorghum bicolor* L (Bayu et al., 2006) and with rice - *Oryza sativa* L (Satyanarayana et al., 2002)

It appears N from *Gliricidia* leaves was more readily available to the plants than N from poultry manure and OBF. Lowered K content as a result of some treatments may be due to complexes formed with native soil K which causes the release of nitrogen in the NPK fertilizer.

Application of organic materials increased soil pH. This confirms findings of Akande et al. (2003) that application of organic materials could ameliorate slightly acidic tropical soil to improve crop production. *Gliricidia* leaves will require combination with NPK to release nitrogen to the soil. Application of organic materials increased soil available P, showing the potentials of the organic materials as source of P to the soil.

Application of organic based fertilizer, poultry manure, *Gliricidia* leaves and inorganic fertilizer enhanced plant growth and development when compared to untreated controls. Organic manures can be used to provide nutrition to okra and attain yields that generally are comparable to that obtained with mixtures of organic and mineral fertilizer. A comparable level of productivity can be achieved with a lowered level of mineral fertilizer combined with manures. The amount of manure required for optimum production can reduce the inorganic fertilizer requirement for okra.

**REFERENCES**


1. Abou El-Magd, M. M. Hoda, A. Mohammed and Fawzy, Z.F. 2005. Relationship, growth and yield of broccoli with increasing N, P or K ratio in a mixture of NPK fertilizers. Annals Agriculture Science Moshtohor, 43 (2):791-805 (As cited by Abou El – Magd et al., 2006). http://www.insipub.com/jasr/2006/791-798.pdf
2. Abou El-Magd, M.A. El-Bassiony, M. and Fawzy, Z.F. 2006. Effect of organic manure with or without chemical fertilizer on growth, yield and quality of some varieties of Broccoli plants. J. of Applied Science Res., 2 (10):791-798. http://www.insipub.com/jasr/2006/791-798.pdf.
3. Akanbi, W.B., Akande, M.O. and Adediran J.A. 2005. Suitability of composted maize straw and mineral nitrogen fertilizer for tomato production J. of Veg. Science, 11 (1): 57-65. DOI: 10.1300/J484v11n01_06 http://haworthpress.com/web/JVS
4. Akande, M. O., Oluwatoyinbo, F. I., Adediran, J. A., Buari, K. W. and Yusuf, I. O. 2003. Soil amendments affect the release of P from rock phosphate and the development and yield of okra. J of Veg. Crop Production,9(2):3–9. http://www.haworthprss.com/store/product.asp?sku=J068
DOI: 10.1300/JO68v09n02_02
5. Alasiri, K.O. and O.O. Ogunkeye. 1999. Effect of different levels of poultry manure on seed yield of Okra. Proceedings 25th Annual conference of Soil Science Society of Nigeria, 21st – 25th November, 1999. Benin, Nigeria.
6. Ayuso, M. A. Pascal, J. A. Garcia C. and Hernandez, 1996. Evaluation of urban waste for Agricultural use. Soil Science plant Nutrition 42:105-111. http:/ci.nii.ac.jp/cinii/servlet/QuotDisp? LOCALID = ART 000186051
7. Bayu, W., Rethman, N.F.G., Hammers, P.S. and Alemu, G. 2006. Effects of farmyard manure and inorganic fertilizers on sorghum growth, yield and Nitrogen use in a semi arid area of Ethiopia. J. plant Nutrition, 29:391-407. http://www.informatworld.com/smpp/content content
DOI: 10.1080/019041605000320962.
8. Bouyoucos, G. J. 1962. Hydrometer methods improved for making particle size analysis of soils. Soil Science Society of America Proceeding 26: 464-465.
9. Economic Commission of Africa, 2001. State of the Environment in Africa. Economic Commission of Africa, P.O.Box 3001, Addis Ababa, Ethiopia, ECA/FSSDD/01/06. http://www.uneca.org/water/State_Environ_Afri.pdf
10. El-Shakweer, M.H.A., El – Sayed, E.A. and Ewees, M.S.A, 1998. Soil and plant analysis as a guide for interpretation of the improvement efficiency of organic conditioners added to different soil in Egypt. Communication Soil Science Plant Anal., 29:2067-2088. hhtp/cat.inist.fr/?aModele = AfficheN cpsidt = 2440011.
11. Khanna SS, Tomar NK, Gupta AP 1983. Efficiency of incubated phosphate fertilizers varying in water solubility with organic matter to wheat. Proc. Third Int. Congr. Phosphorus Compounds. 4-6 October, 1983. Brussels Belgium, pp. 567 – 580.
12. Makinde, E.A and A. A. Ayoola, 2008. Residual influence of early season crop fertilization and cropping system on growth and yield of cassava. American J. of Agric. and Biological Science. 3(4): 712-715. http://www.scipub.org/fulltext/AJAB/AJAB34712-715.pdf
13. Mclean, E. O. 1982. Soil pH and lime requirement, In: Methods of soil Analysis. Part 2 Agron. 9(2nd ed.) ASA, SSSA, Madison, Wisc pp. 199 -224
14. Rodale, R 1984. Alternative Agriculture. J. Soil Water Conservation. 39:294-296. http://www.jswconline.org/content/349/5/294.extract.
15. Sharma, A.R. and B. N. Mittra, 1991. Effect of different rates of application of organic and c. *Journal of Agricultural Science (Cambridge)* 117: 313-318. DOI:10.1017/S0021859600067046 http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=5179468&fulltextType=RA&fileId=S0021859600067046
16. Statistical Analysis System, SAS, 1994. SAS user's guide. Statistics 1994 edn, Statistical Analysis System Institute, Cary, NC.
17. Smil, V. 2000. Phosphorus in the Environment: Natural Flows and Human Interferences. Annual Review of Energy and Environment. 25: 53-88 (DOI:146/annurev.energy.25.1.53) http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.energy.25.1.53


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