Soil Properties, Growth Yield and Nutrient Content of Maize, Pepper and Amaranthus as Influenced by Organic and Organomineral Fertilizer

D. I. Akanni, S. O. Ojeniyi and M. A. Awodun

Federal College of Agriculture, P.M.B. 623, Akure, Ondo State, Nigeria

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Abstract: The effectiveness of newly developed organic and organomineral fertilizer (OMF) in improving nutrient availability soil physicochemical properties and performance of maize (*Zea mays*), pepper (*Capsicum annum*) and amaranthus (*Amaranthus cruentus*) was studied in experiments carried out at Akure in rainforest zone of Nigeria. Soils at sites of experiment were low in organic matter, N and P. Application methods of OMF were also studied in relation to performance of amaranthus. OMF, organic and NPK fertilizer (NPK) at 300 kg/ha increased soil and plant N, P, k, Ca, Mg and yield of maize, pepper and amaranthus. The 3.0 t/ha OMF gave highest maize cob and grain weight, whereas NPK gave highest number of pepper fruits. Increase in maize grain weight given by NPK and 3.0 t/ha OMF were 130% and 390% respectively. Increase in number of pepper fruits given by OMF, organic and NPK were 56%, 50% and 91% respectively. Fresh matter and leaf yield of amaranthus were increased by OMF applied by spot, ring and broadcast methods. Broadcast gave highest values of yield parameters, soil and plant nutrients content and highest soil moisture content.

Key words: Organic and organomineral fertilizer (OMF), physicochemical properties, rainforest zone, fresh matter, leaf yield, soil moisture content.

1. Introduction

Integrated application of organic and mineral fertilizer is widely accepted as the approach to sustain crop production and maintain soil fertility in the humid tropics. Problems that adversely affected total dependence on either organic or mineral fertilizers have been highlighted by researchers [1-5]. These include high cost and scarcity of mineral fertilizer and increased soil acidity, nutrient imbalance and physical degradation of soil. Organic manure is not often available in sufficient quantity for large farms, aside from its low quality, transportation and handling problems.

Recently, organic and organomineral fertilizer

(OMF) that combine attributes of organic manure and mineral fertilizer were developed and manufactured in Nigeria by state governments. OMF is composed of animal and plant wastes, sorted city refuse fortified with N or NP fertilizers. Compared with mineral fertilizer, OMF is expected to release more nutrients, control soil acidity, have residual effect on soil fertility and crop performances [4, 5] and improve soil physical properties. Some studies showed that pacesetter OMF manufactured by Oyo State Government gave significant increases in yield of maize [6-8] and pepper [9]. Olowokere [2-3] found that poultry manure based OMF developed at Agronomy Department, University of Ibadan increased significantly yield of pepper, tomato and okra in derived savanna zone of Southwest Nigeria. Studies by Ojeniyi et al. [7, 8] affirmed that OMF

Corresponding author: M. A. Awodun, Ph.D., lecturer, research fields: agronomy of crops, plant nutrition. E-mail: m_awodun@yahoo.com.

improved macronutrient availability in soil and for crop uptake. OMF was recommended for maize at 10 t/ha [7, 8] and 3.0 t/ha for pepper and tomato [3] and 4.5 t/ha for okra [3].

This work is based on the use of sunshine OMF developed by Ondo State Government of Nigeria. The OMF is composed from city wastes, poultry manure, and cow dung fortified with urea and super-phosphate fertilizers. Its effect on soil physical and chemical properties, growth and yield of maize, pepper and amaranthus were investigated in separated field experiments conducted at Akure in Southwest Nigeria. Hitherto effects of OMF on soil physical properties [10] and nutrient uptake have not received research attention.

2. Materials and Methods

2.1 Field Experiments

In May 2007, the first experiment was conducted at Federal College of Agriculture, Akure on a sandy-loam alfisol. The soil was cultivated in 2006 to okra. Soil was manually cleared. Treatments were (a) control, (b) NPK 15:15:15 fertilizer at 300 kg/ha, (c) OMF 3.0 t/ha and (d) OMF 1.5 t/ha. Treatments were replicated three times on single strands of maize spaced at 80 cm × 40 cm given 62,500 plants/ha. Treatments were applied by ring method 2 weeks after planting and weeding was done 4th and 7th weeks after planting. Ten plants were selected per plot for determination of leaf area using formula length and breadth × 0.65 [11] and cob weight and weight of 400 grains were determined.

In the second experiment carried out at another site, four treatments were applied to pepper and replicated three times. They were (a) control, (b) OMF 3 t/ha, (c) organic fertilizer 3 t/ha and (d) NPK 15-15-15 fertilizer at 250 kg/ha. Ten plants were selected for determination of plant height, number of leaves and fruits per plant.

The third experiment was carried out in June 2008 using amaranthus transplanted at 50 cm × 50 cm.

OMF at 3 t/ha was applied being different methods i.e. ring application, spot application and broadcast in addition to a control without treatment. Treatments were replicated three times using randomized complete block design. Data were collected on number of leaves per plant and fresh matter yield per ten plants.

2.2 Soil Chemical and Physical Analysis

After land clearing in each site, surface (0-15 cm) soil samples were collected for chemical analysis. During harvests, samples were also taken per plot. Samples were air-dried and 2 mm sieved. Soil N was determined using micro kjeldahl method, organic carbon by wet oxidation method, P by Bray-1 extraction followed by molybdenum blue colorimetry, K, Ca and Mg were extracted using ammonium acetate, K and Ca determined using flame photometer and Mg by atomic absorption spectrophotometer.

Soil physical properties were determined in three replicates plot. Soil thermometer was inserted to 10 cm depth for determination of temperature; bulk density was determined using steel core and gravimetric moisture content using core samples with oven set at 100 °C for 24 hours.

2.3 Leaf Analysis

Before harvests, leaf samples were collected for each crop, samples were oven-dried at 65 °C for 24 hrs and ground. Total N was determined by micro-kjeldahl approach; nitric perchloric acid mixture was used for extraction K, Ca, Mg and P. The K, Ca and Mg were determined on atomic absorption spectrophotometer and P using molybdenum blue method. OMF and organic fertilizers were analyzed as for the leaf. The least significant difference at $P = 0.05$ was used to compare mean data.

3. Result and Discussion

The soil cropped to maize had 1.67 organic matters (OM), 0.07% N, 4.3 mg/kg available P, 0.28, 0.40 and

0.78 cmol/kg, exchangeable K, Mg and Ca, respectively. Soils were low in OM, N, P and Ca, hence, they require application of fertilizers. OMF had 1.4% N, 0.42% P and 0.14% K and values for organic were 1.8% N, 0.11% P and 0.35% K.

Relative to control, NPK fertilizer (NPK), organic fertilizer (organic) and OMF application at 1.5 and 3.0 t/ha increased soil OM, N, P, K Ca and Mg under maize (Table 1), pepper (Table 2) and amaranthus (Table 3). The treatments also increased maize N, Ca, Mg (Table 4), pepper N, P, K, Ca (Table 5) and amaranthus N, P, K, and Mg (Table 6) significantly. NPK and 3.0 t/ha OMF also increased maize P and K, but the increases

Table 1 Effect of sunshine organomineral fertilizer (OMF) on soil chemical properties (maize experiment).

Treatment	OM (%)	N (%)	P (mg/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
Control	1.34	0.08	4.8	0.16	0.80	0.70
NPK fertilizer	1.38	0.08	5.7	0.19	0.83	0.73
OMF 1.5 t/ha	1.78	0.09	6.4	0.24	0.92	0.82
OMF 1.5 t/ha	1.55	0.09	5.8	0.22	0.87	0.77
LSD (0.05)	0.04	NS	0.6	NS	0.04	0.07

Table 2 Effect of sunshine organomineral fertilizer (OMF) on soil chemical properties (capsicum experiment).

Treatment	OM (%)	N (%)	P (mg/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
Control	1.21	0.02	4.1	0.16	0.83	0.78
OMF	1.38	0.08	5.0	0.22	0.96	0.89
OMF (unfortified)	1.38	0.08	5.2	0.23	1.01	0.90
NPK fertilizer	1.26	0.09	5.9	0.25	1.14	0.94
LSD (0.05)	NS	0.02	0.3	NS	0.04	0.09

Table 3 Effect of sunshine organomineral fertilizer (OMF) on soil chemical properties (amaranthus experiment).

Treatment	OM (%)	N (%)	P (mg/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
Control	5.4	1.95	0.072	5.0	0.36	0.72
OMF ring	5.5	2.24	0.076	6.3	0.83	0.83
OMF spot	5.5	2.53	0.081	6.2	0.89	0.89
OMF broadcast	5.8	2.78	0.087	7.1	0.93	0.93
LSD (0.05)	NS	0.3	NS	2.1	0.50	0.21

Table 4 Effect of sunshine organomineral fertilizer (OMF) on leaf nutrient content of maize (%).

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Control	0.50	0.28	0.81	0.68	0.58
NPK fertilizer	0.61	0.28	0.91	0.71	0.61
OMF 3.0 t/ha	0.69	0.34	1.11	0.87	0.77
OMF 1.5 t/ha	0.65	0.27	0.74	0.79	0.65
LSD (0.05)	0.03	NS	NS	0.03	0.04

Table 5 Effect of sunshine organomineral fertilizer (OMF) on leaf nutrient content of capsicum pepper (%).

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Control	0.54	0.19	0.82	0.62	0.60
OMF	0.65	0.24	0.88	0.69	0.62
Organic	0.82	0.27	1.92	0.74	0.67
NPK fertilizer	0.83	0.30	1.21	0.81	0.71
LSD (0.05)	0.02	0.02	0.06	0.02	NS

were not significant. The increases given by OMF, organic and NPK in respect of pepper Mg were not significant, also Ca in case of amaranthus.

Under Maize OMF improved soil physical properties as indicated by reduced bulk density and increased moisture content, whereas NPK did not influence soil physical properties. OMF also reduced day time soil temperature though insignificantly (Table 7). As opposed to NPK, OMF also improved soil physical properties under pepper (Table 8). In amaranthus experiment, soil bulk density and temperature were 37, 8, 36.5, 35.6 and 34.1 °C respectively. Values for soil bulk density were 1.04, 0.96, 0.98 and 0.92 g/cm³, while values for soil moisture were 7.0, 7.4, 7.6 and 8.4% respectively (LSD_{0.05} = 0.03).

Therefore OMF also improved soil physically. NPK and OMF increased yield components of maize significantly, and 3.0 t/ha OMF gave highest values of leaf area, cob weight and grain yield. Values of leaf area for control, NPK, 3.0 and 1.5 /ha OMF were 240, 288, 289 and 252 cm² respectively. Values for cob weight were 0.20, 0.46, 0.98 and 0.20 kg and values for 400 grains were 21, 25, 30 and 21 gm. The 3.0 t/ha OMF were 130% and 390% and increases in grain weight were 19% and 43% respectively. NPK, organic and organomineral fertilizers also increased performance of pepper. Values for number of leaves per plant for control, OMF, organic and NPK increased number of fruits by 56%, 50% and 91% respectively.

Values for fresh matter yield of amaranthus and number of leaves were significantly increased by OMF applied by ring, spot and broadcast methods relative to control. Broadcast which most improved soil chemical (Table 3) and physical properties, and leaf K and Ca (Table 6) gave highest values of yield

Table 6 Effect of sunshine organomineral fertilizer (OMF) and placement method on nutrient of amaranthus (%).

Treatment	N	P	K	Ca	Mg
Control	0.64	0.14	0.65	0.61	0.51
OMF ring	0.91	0.29	0.48	0.71	0.70
OMF spot	0.80	0.24	0.72	0.67	0.58
OMF broadcast	0.74	0.27	0.83	0.71	0.69
LSD (0.05)	0.12	0.07	0.14	NS	0.10

Table 7 Effect of sunshine organomineral fertilizer (OMF) on soil physical properties (maize experiment).

Treatment	Temperature (°C)	Bulk density (g/cm ³)	Moisture content (%)
Control	30.4	1.26	1.80
NPK fertilizer	29.5	1.25	2.53
OMF 3.0 t/ha	29.0	0.00	3.93
OMF 1.5 t/ha	29.2	0.98	3.35
LSD (0.05)	NS	0.17	NS

Table 8 Effect of sunshine organomineral fertilizer (OMF) on soil physical properties (pepper experiment).

Treatment	Temperature (°C)	Bulk density (g/cm ³)	Moisture content (%)
Control	33.0	1.05	7.1
OMF	31.8	0.98	7.4
OMF(unfortified)	31.5	0.98	8.3
NPKF	32.5	1.03	7.2
LSD (0.05)	1.7	NS	0.2

parameters. It is indicated that amaranthus responds to availability of OM, P, K, Ca and moisture in soil. Fresh matter yield for control, ring, spot and broadcast applications were 1.0, 1.60, 1.46 and 1.96 t/ha (LSD_{0.05} = 0.21) respectively.

Organic, OMF and NPK increased soil and plant N, P, K and MG which is attributable to presence of organic matter in case of organic and OMF. Increased presence of N, P and K in soil due to application of NPK fertilizer should have enhanced nutrient release from organic matter in soil due to enhanced microbial activity. The three materials significantly increased performance of maize, pepper and amaranthus which is attributable to release of nutrients for crop uptake. Ojeniyi et al. [12] found that pacesetter organomineral fertilizer alone or combined with poultry manure increased tissue P, K, Ca, Mg and Zn in maize and soil exchangeable cations. Adeoye et al. [6] also found that OMF composed from poultry manure, cowdung, sawdust, water hyacinth and city refuse significantly

increased yield of maize at 3.0 and 1.5 t/ha compared to 300 kg/ha NPK fertilizer. Fagbola et al. [9] in a pot experiment observed that yield of pepper was increased by pacesetter.

Unlike NPK organic and OMF also improved soil physical properties as indicated by reduced bulk density and enhanced moisture content. These effects should have enhanced root growth, nutrient uptake and yield of crops. Studies by Ojeniyi et al. [12-14] have shown that applications of organic wastes such as goat and poultry wastes reduced soil bulk density and increased moisture content. Similar observation was made by Busari et al. [10]. The organic wastes should have stimulated biological activities, and this should have led to loosening and perforation of soil matrix, and hence reduction in soil density and enhanced root growth, water and nutrient uptake [15]. For example length of tap root of pepper recorded for the control, OMF, organic and NPK were 17.9, 18.4, 21.2 and 21.3 cm respectively. Busari et al. [10] indicated that improvement in soil physical properties due to integrated application of poultry manure and NPK fertilizer increased hydraulic conductivity and aggregate stability which made the soil more productive when planted to crops.

Organic fertilizer gave higher terminal soil nutrients content than OMF. This is attributable to gradual release of nutrients from it. Nutrients in OMF should have been more quickly mineralized and released due to presence of mineral fertilizer, thereby becoming more subjected to leaching.

Broadcast of OMF was more effective in increasing soil nutrient content and yield of amaranthus than spot and ring applications. In Ghana it was also found that broadcast of cowdung increased maize yield compared to spot application. This was attributed to overall improvement of soil physical, chemical and microbiological properties by broadcast method [16].

4. Conclusions

Synthesized organic and organomineral fertilizer

were effective in improving significantly nutrient availability, nutrient uptake and yield of maize and vegetable crops. Soil physical properties were also improved. The materials are recommended for sustainable crop production and soil fertility management.

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