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Enhancing the Yield Characteristics of Groundnut (*Arachis hypogaea* L.) at Different Organo-mineral Fertilizer Rates

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Authors' contributions

This work was carried out in collaboration between all authors. Author JDN designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors FAN and JOS managed the analyses of the study. Author JOS managed the literature searches. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

A field fertilizer trial on groundnut (*Arachis hypogaea* L.) was conducted in 2014/2015 cropping season at the Crop Research Farm of the Department of Crop Science, University of Calabar, Calabar, Nigeria (04º 5'E and 07º 25'E., 37 meters above sea level) located in the coastal Cross River high rainforest. Groundnut performance was evaluated using four rates of Jonker^R organo-mineral fertilizer (OMF) at 0, 2.0, 2.5 and 3.0 t ha^{-1} in randomized complete block (RCB) design in four replications. Result obtained showed that organo-mineral fertilized had favourable effect on groundnut and produced significantly ($p \leq 0.05$) highest fresh pod weight (491.5 gplot^{-1}), shelling percentage (72.89%), 100-seed weight (92.89 g), seed yieldplot^{-1} (246.78 gplot^{-1}) and seed yield (2.80 tha^{-1}) at 3.0 t OMF ha^{-1}. This level of fertilizer could be adequate for increased groundnut yield and should be adopted by farmers in the study area.

Keywords: Groundnut; organo-mineral fertilizer; rainforest; yield attributes.

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1. INTRODUCTION

Groundnut is an annual underground pod bearing plant in the family *Fabaceae.* It is widely cultivated in the warm tropical and subtropical areas and is both a food and an industrial crop commonly cultivated by smallholder farmers in Nigeria which accounts for 10 and 39 % of total global production and Africa's output respectively [1]. In advanced countries like the US where groundnut is popularly known as peanut, it is mainly cultivated as an oil crop. The seed is a balanced food containing 45% high quality edible oil, 25 % proteins, 21% carbohydrates, 48 % edible fats and 21 % nutritional fibre including the B-group vitamins, vitamin E and minerals [1,2]. After oil extraction, the residual groundnut cake is used as protein concentrate in livestock feeds while the haulms are an excellent animal food in Northern Nigeria especially in the dry season when fresh forage is scarce. As a nodulating legume, groundnut plant plays an important agronomic role in the farming system as a soil fertility enhancer through N-fixation by rhizobium bacteria which colonize root nodules [2].

Commercial groundnut cultivation in Nigeria is mainly practiced in the Northern parts of the country particularly in the Sudan and Guinea Savannah zones where the crop is well adapted. However due to unsatisfied demand for the crop and the associated high prices of groundnut seeds, the crop is now cultivated outside its traditional areas and has become popular in the farming systems of southern Nigeria.

But soils of the humid tropics are predominantly Ultisols and Oxisols which are acidic in nature and usually have challenges associated with aluminum toxicity, low nutrient reserves/status, nutrient imbalance and multiple nutrient deficiencies which can adversely affect crop production if not managed effectively [3,4,5].

High soil acidity is one of the most serious constraints to crop production particularly for legume crops which require moderate - neutral soil conditions for nodule formation and effective N-fixation and other biological processes which enhance soil productivity [6]. Deficiency of Phosphorous which is one of the major nutrients required by groundnut is commonly encountered on acid soils, resulting in poor growth, reduced pod formation and seed development, low seed oil content and inferior yield [7,8].

Declining soil productivity resulting from severe soil degradation in most sub-Saharan African countries has been noted as one of the most common constraints to increasing farm productivity in the sub-region. Shifting cultivation and land fallowing have long been adopted by traditional farmers to restore the fertility of land naturally but these practices are no longer feasible due to inappropriate farming practices and the prevailing low per capita crop land resulting from high population density in developing countries [9,10].

Soil productivity can be improved by application of synthetic fertilizers but the level of fertilizer consumption in sub-Saharan Africa is has been very low between 8.4 – 13.0 kg/ha of arable land compared to the world average of 93 kg/ha [11,12]. Low fertilizer use has been implicated in declining soil fertility and accelerated soil degradation through nutrient mining particularly in peasant production systems [13]. Increased use of mineral fertilizers therefore has great potential for boosting food production to reverse the declining trend in per capita crop production currently experienced in many parts of the sub-Sahara African region.

However, synthetic fertilizers are scarce and often unavailable to traditional farmers due to defective government policies on agricultural growth enhancement supplies. Even if available and affordable to farmers, the long-term sole use chemical fertilizers at relatively high levels often leads to degraded soil structure and micronutrients deficiencies which in turn leads to long-term crop yields decline [14,15].

One of the sustainable ways to maintain or improve the productivity of soil is by maintaining its organic matter through the use of organic manures. Unlike mineral fertilizers which have concentrated nutrients that are readily available to crops, organic manures/fertilizers typically contain low levels of plant nutrients which are released slowly to crops. This makes them unsuitable and ineffective as fertilizer in the short-run on highly degraded soils of the humid tropics.

Combining organic and inorganic nutrient sources such as organo-mineral fertilizer could be more effective in improving soil fertility through enhanced fertilizer efficiency. Organo-mineral fertilizer has higher nutrient content and higher residual effect than either mineral or organic manure alone. It also has higher buffering capacity, improves soil microbial activity including symbiotic N fixation, reduces the possibility of Al^{+3} and Mn^{+2} toxicity and improves soil structure and water-holding capacity. Organic-based fertilizers are not easily leached and are less likely to pollute the ground water unlike mineral fertilizers [16].

Adequate research attention has been given to groundnut to boost its productivity in the major producing areas but such attention is still lacking in the Calabar Agricultural Zone where the cultivation crop is becoming popular among peasant farmers. The need to extend agronomic investigations on the crop to boost productivity in the area was the objective of this work.

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment was conducted at the University of Calabar Crop Teaching and Research Farm, Calabar (04º 57'N and 08º 19'E, 37 m above sea level). The mean annual rainfall in the area ranges from 2500 to 3500 mm and mean minimum and maximum temperatures range are 27ºC and 35ºC, respectively, while relative humidity is between 75 – 85 % [17]. The vegetation of the area comprises shrubs mixed with broadleaf species such as *Chromolaena odorata*, *Aspillia africana* and *Ageratum cornyzoides* and grasses which were predominantly *Panicum maximum*.

Surface soil samples at the site had sandy texture with sand, silt and clay contents of 83.3, 7.7 and 9.0 %, respectively. Soil was acidic (pH 5.6) with low nutrient contents having 0.96 % organic carbon and 0.08 % total Nitrogen. Available Phosphorous was 42.25 mg/kg and exchangeable Calcium, Magnesium, Potassium, Sodium, acidity and effective cation exchange capacity (ECEC) were all very low with values of 3.2, 0.4, 0.08, 0.05, 1.20 and 4.93 cmol/kg, respectively, indicating low fertility status.

The site was manually cleared of the vegetation and tilled using a machete and spade. After tilling, raised beds measuring 2.5 m wide and x 5.0 m long (12.5 m^{-2}) and 30 cm high were constructed. Each bed was separated by 1.0 m wide paths while blocks were spaced 1.2 m apart.

2.2 Treatments and Experimental Design

Treatments evaluated were four rates of organ-mineral fertilizer (OMF) which were: 0, 2.0, 2.5 and 3.0 t/ha laid out in randomized complete block (RCB) design replicated in four blocks. OMF was incorporated into the beds and mixed thoroughly during seedbed preparation. Treatments were randomly assigned to plots in each block using random number tables.

2.3 Sowing of Groundnut and plot Maintenance

Healthy uniform size seeds of an erect medium maturing local groundnut variety known as 'Graffi' were sown one per hole 3 – 5 cm deep at 30 cm x 30 cm (0.09 m^{-2}) on 24 April. Seeds were treated with *Apron Star* seed dresser to control soil-borne pathogens and diseases to enhance germination and seedling establishment. Each plot contained eight (8) rows of 16 plants giving 128 plants $plot^{-1}$ while plant population was 111,111 plants ha^{-1}.

2.4 Maintenance of Experimental Plots

Plots were weeded regularly using a hand-held hoe. Cross bunds were constructed and maintained to control erosion within the plots. Soil was gathered at the base of plants to provide loose soil for easy penetration of pegs and to cover the pods exposed by splash erosion.

2.5 Data Collection and Analysis

Data collected on yield parameters to evaluate the effect of treatment on the crop were total pods $plant^{-1}$, viable pods/plant, pod fresh weight $plant^{-1}$, 100-seed weight (g $plot^{-1}$), seed weight $plot^{-1}$ and seed yield h^{a-1}. Eight plants at the center of each plot constituted the sample plants. Data generated were analyzed statistically using analysis of variance (ANOVA) and significant ($p \leq 0.05$) treatment means were compared using Fisher's Least Significant Difference (LSD) at 5 % level of probability [18].

3. RESULTS AND DISCUSSION

Organo-mineral fertilizer significantly ($p \leq 0.05$) influenced all the yield and yield parameters of groundnut assessed except shelling percentage (Table 1). The number of pods per plant was higher in fertilized plants than in unfertilized (control) plants with highest pods in plant fertilized with 3.0 t ha^{-1} organo-mineral fertilizer, followed by 2.5, 2.0 t ha^{-1} and least in the control. Plants that received the highest OMF rate

Table 1. Influence of organomineral fertilizer (OMF) rates on growth and yield parameters of groundnut in Calabar

OMF rate (t/ha)	Pods $Plant^{-1}$	Pod weight (g $plot^{-1}$)	100-seed weight (g)	Shelling %	Seed yield (g $plot^{-1}$)	Seed yield (t ha^{-1})
Control	15.2	442.7	85.2	68.2	123.9	1.88
2.0	17.4	476.7	89.7	68.9	145.9	2.38
2.5	20.2	489.5	90.7	70.5	168.9	2.65
3.0	22.8	491.5	92.9	71.9	210.9	2.85
LSD (0.05)	1.2	6.6	2.9	ns	12.2	0.10

averagely produced seven more pods which represents 33.33 % higher pod yield $plant^{-1}$ than the control.

Pod weight per plot was also higher in fertilized plots than in the control. Plots fertilized with 2.5 and 3.0 t ha^{-1} organo-mineral fertilizer had higher pod weight than those fertilized with 2.0 t ha^{-1} organo-mineral fertilizer which in turn had higher pod weight than control plots.

Groundnut seed size represented by 100-seed weight also increased in fertilized plots and was significantly ($p \leq 0.05$) higher and similar in all fertilized plots than zero fertilizer plots. Seed size increase in fertilized plots ranged from 4.5 - 7.7 g at the lowest and highest fertilizer rates respectively.

The shelling percentage of groundnut was not affected significantly ($p \leq 0.05$) by any fertilizer rate. However, this parameter ranged from 68.2 % in control plots to 69.9 – 71.9 % in fertilized plots. Similar values of this parameter have been obtained in Iran [19].

Seed yield of groundnut in plots and on hectare basis showed a similar trend and was more in fertilized plots than in the control. The yield increased significantly ($p \leq 0.05$) as fertilizer rates were increased and maximized in plots treated with OMF at 3.0 t ha^{-1} with correspondingly highest seed yield per hectare which was 34.0 % higher than in the control. Enhanced seed yield attributes of groundnut obtained in fertilized plots indicates that the crop responds favourably to organomineral fertilizer and highest values recorded with increasing fertilizer rates probably implies that higher yield is still possible at rates above 3.0 t ha^{-1}.

The maximum seed yield of 2.85 t ha^{-1} obtained in the Calabar Agricultural Zone is comparable to the best kernel yield of 3.03 t ha^{-1} obtained in Iran [21] but better than the maximum yield of 2.3 t ha^{-1} recorded in the Sudan Savanna area of Nigeria where the crop is traditionally cultivated [20]. This suggests that with good agronomic practices commercial groundnut cultivation is possible in the study area.

4. CONCLUSION

Groundnut responded to application of organomineral fertilizer. Application of the nutrient at 3.0 t ha^{-1} had the best influence on the growth and yield of groundnut indicating that better crop performance could still be possible at higher rates of the fertilizer in the study area.

DISCLAIMER

Some part of this manuscript was previously presented in the following conference.
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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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