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Residual effects of neem *Azadirachta indica* A. Juss. (Sapindales: Meliaceae) seed-based fertilizer and NPK on the performance of *Basella alba* L. (Caryophyllales: Basellaceae) plant

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Abstract. Organomineral formulations are low input technology fertilizers, which combine the attributes of both organic and inorganic fertilizers. A completely randomized design (CRD) pot experiment was conducted in the screen house of the Department of Crop, Soil and Pest Management, of the Federal University of Technology, Akure, to evaluate the residual effects of neem *Azadirachta indica* A. Juss. (Sapindales: Meliaceae) seed based fertilizer and NPK 20:10:10 on the growth, yield and nutritional quality of *Basella alba* L. (Caryophyllales: Basellaceae). Results showed that the plots previously treated with neem seed-based fertilizer especially at 150-300 kg/ha enhanced the growth, yield and nutritional quality of *B. alba,* and increased these parameter significantly ($P < 0.05$) compared to the NPK treated and the untreated soil samples. It was therefore concluded that the Neem seed based fertilizer can serve as a viable alternative to NPK chemical fertilizers especially in rotational cropping systems owing to its prolonged soil action.

Keywords: Neem seed-based fertilizer; Organomineral; *Basella alba*; Efo amunututu; Soil nutrients.

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Introduction

Organomineral fertilizers in recent times have caught the interests of farmers and researchers in the Sub-Sahara Africa, and the attraction towards these formulations arose from certain problems and limitations associated with the use of either chemical and organic manure alone. Chemical fertilizers though possess the attribute of quick nutrient release to support high crop yield may cause pollution of ground water after crop harvest (Gordon et al., 1993). The use of inorganic fertilizers has also been reported to be characterized with apparent inability to substantially redress the chemical and physical deterioration of the soil (Adeniyan and Ojeniyi, 2005), and may be accompanied by a decline in soil organic matter content, increased soil acidity, degradation of soil physical properties and increased rate of erosion due to instability of soil aggregates (Adeoluwa and Adeogun, 2010). These are in addition to the high cost and scarcity characterizing use of inorganic fertilizers. The huge amount of organic fertilizers required to adequately support crop production, as well as the difficulty in handling manures are some of the problems of organic sources of nutrients (Makinde et al., 2010).

John et al. (2004) have advocated an integral use of organic manure and chemical fertilizers for the supply of adequate quantities of plant nutrient required to sustain maximum crop productivity and profitability while minimizing environmental impact from nutrient use. An organomineral fertilizer is a low input technology of improving the nutrient status of tropical soils for sustainable crop production. The formulation combines the attributes of both organic and inorganic fertilizers (Ayeni, 2008), possessing the dual attributes of quick and sustained nutrient release, which will benefit optimum growth and yield in crop as well as furnish soil organisms with nutrients to derive energy for their metabolic activities. Studies with maize, pepper and amaranth as test crops revealed that these crops responded favourably to the application of organomineral fertilizers (Fagbola and Ogundipe, 2007; Adeoye et al., 2008; Ojeniyi et al., 2009; Makinde et al., 2010).

The ability of a nutrient source to provide season-long nutrient release to crops, as well as leave residues in the soil to sustain another crop in rotation will go a long way to save cost of crop production. Organomineral formulations are likely to exhibit such a cost effective attribute.

The present study seeks to gain an insight into the effects of neem *Azadirachta indica* A. Juss. (Sapindales: Meliaceae) seed-based fertilizer (an organomineral formulation) residues on the growth and yield performances of *Basella alba* L. (Caryophyllales: Basella-ceae) grown as a follow-up crop in rotation where fertilizer was originally applied to maize.

Materials and materials

A screen house experiment was conducted in the screen house of the Department of Crop, Soil and Pest Management, of the Federal University of Technology, Akure, Nigeria, in 2011. Soil samples from a preliminary field experiment where neem seed-base fertilizer (an organomineral formulation) at 0 (NF), 100 (N100), 150 (N150) and 200 (N200) kg/ha with NPK at 200 kg/ha were collected into pots and transferred to the screenhouse. The experimental design was a complete randomized design (CRD) with three replications per treatment.

5 seeds of *Basella alba* were sown into each pot but were later thinned to one stand per pot after germination. Watering was done at two days interval, no fertilizer was applied, and emerged weeds were hand-pulled from the pots.

Growth parameters such as plant height and number of leaves per plant were taken on weekly basis beginning from the 3rd week up to the 10th weeks after planting (WAP). Plant height was measured using a tape in centimeters. Leaf number was determined by counting the total number of leaves of one plant stands in each pot, germination count and stem girth were also determined and recorded. At harvest, yield parameters as well as leaf area were determined. Leaf proximate, nutrient analysis and vitamin C was also carried out at *Basella alba* harvest.

Leaf samples collected per pot were oven-dried at 90 °C for 24 h, milled and ashed for 6 h at 500 °C. 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. Vitamin C was determined using ascorbic acid as the reference compound. 200 mL of the extract was pipette and mixed with 300 mL of 13.3% of TCA and 75 µL of DNPH. The mixture was incubated at 37 °C for 3 h and 500 mL of H_2SO_4 was added and the absorbance was read at 520 nm. Leaf proximate composition including the moisture content, protein, fat, ash, carbohydrate, and crude fiber were determined according to standard methods (AOAC, 1995).

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

Results and discussions

The nutrient composition of the neem seed-based fertilizer (NSBF) used in this study is presented in Table 1, while some soil properties of the experimental site are shown in Table 2. The soil is low in organic matter, total N and available P, adequate in exchangeable K and Ca, and slightly acidic. The NSBF had relatively low content of basic nutrients but a huge organic base. The critical levels of organic matter for crop production in Nigeria ecological zones is 3.0%, and the value of exchangeable Ca was 2.2 cmol/kg (Akinrinade and Obigbesan, 2000).

Table 1. Chemical analysis of neem seed-based fertilizer.

Parameters (%)	Results (%)
Organic carbon (OC)	37.4
Nitrogen (N)	7.0
Phosphorus (P)	7.0
Potacium (K)	7.0
Calcium (Ca)	6.2
Magnessium (Mg)	1.5

Source: Royal Fertilizer Plus.

Table 2. Pre-treatment soil analysis at the site of the experiment.

Parameters	Results (g kg^{-1})
pH (H_2O)	6.02
Organic Carbon (%)	1.0
Total N (%)	0.22
Available P (mg kg^{-1})	6.65
Available K (cmol kg^{-1})	0.30
Mg (cmol kg^{-1})	0.65
Ca (cmol kg^{-1})	1.7

All the rates of neem seed-based and NPK fertilizer left residues in soil, which increased vine lengths and leaf numbers of *Basella alba* relative to the control. However, the highest values were recorded for these parameters in plots treated with the organomineral fertilizer compared with NPK treatments. This could be due to enhancement of decomposition of the organic material and mineralization of nutrients especially N and P by the presence of mineral fertilizer in the organomineral formulation. Makinde et al. (2010) observed similar increase in growth parameters of *Amaranthus cruentus* when both kola pod husk and city refuse plus cow dung were fortified with NPK fertilizer, and Ayeni et al. (2008) in a related experiment detected similar increase in N and P when cocoa pod ash and poultry manure were respectively fortified with NPK fertilizer. The NSBF engendered significant influences on the vegetable starting from the 3rd week after planting. This early influence is an indication that a good percentage of the organomineral formulation was mineralized during the 12 weeks of maize growth on the field, and are available for plant uptake. Agbenin et al. (1999) has earlier reported that N mineralization from neem seed cake (NSC) was fast because between 31 to 35% of N was mineralized within eight weeks of incorporation into the soil.

The organic fraction of the organomineral formulation also presumably conferred on it the ability to release its nutrients in installments, with appreciable residual effects on the vegetable grown to succeed maize in rotation (Table 2 to 5). It has been reported that only one-fifth to half of the nutrient supplied by organic manure are recovered by the first crops following application. Much of the remaining is held in humus-like compounds subject to very slow decomposition. In this form, the elements are released very slowly, rates of 2.4% per annum being common (Brady and Weil, 2008). The NSBF increased the growth and yield parameters of *Basela alba* with increasing rates of application. Regressing growth parameters (Y) against increasing rates of the manures show positive relationships with prediction equations shown in Table 6. This is probably because higher rates of the fertilizer indicate higher amount of nutrients to be carried over to support the next crop in rotation.

Table 2. Residual effects of neem seed-based fertilizer and NPK on plant height (cm) of *Basella alba*.

Treatment	Weeks after planting							
	3	4	5	6	7	8	9	10
NF	11.83b	17.57a	23.73c	32.73c	53.30c	92.57b	116.73c	139.40c
N100	12.50ab	20.73a	27.90bc	41.23bc	79.27b	107.17b	149.93bc	186.77b
N200	9.13c	12.07b	26.13bc	45.37b	87.80b	108.80b	200.47a	233.10a
N300	14.57a	20.63a	30.30b	43.93b	71.97b	162.20a	210.80a	263.70a
NPK	8.80c	20.55a	44.75a	67.55a	118.85a	139.23a	151.13b	177.33bc

Means with the same letter in same column are not significantly different from one another.

Table 3. Residual effects of neem seed-based fertilizer and NPK on number of leaves of *Basella alba*.

Treatment	Weeks after planting								
	3	4	5	6	7	8	9	10	Leaf area (cm^2)
NF	6.67a	8.00b	9.67b	12.33b	14.67c	19.67d	24.67c	29.33c	49.00c
N100	7.33a	9.00ab	10.67b	14.00b	19.67b	22.67cd	32.67b	42.00b	60.67abc
N200	7.67a	9.00ab	11.00b	14.33b	18.00bc	26.67bc	35.00b	44.67b	61.33ab
N300	7.67a	8.00b	9.67b	13.67b	19.00b	34.00a	47.50a	57.00a	69.33a
NPK	7.50a	10.50a	14.50a	20.00a	25.50a	28.67ab	33.67b	39.67b	54.00bc

Means with the same letter in same column are not significantly different from one another.

Table 4. Residual effects of neem seed-based fertilizer and NPK on stem girth (cm) of *Basella alba*.

Treatment	Weeks after planting						
	4	5	6	7	8	9	10
NF	3.50a	3.63a	3.67a	3.77a	3.80a	3.89a	4.00a
N100	3.67a	3.70a	3.80a	3.83a	3.87a	3.93a	4.03a
N200	3.44a	3.47a	3.63a	3.69a	3.70a	3.83a	3.90a
N300	3.57a	3.80a	3.84a	4.90a	4.00a	4.05a	4.45a
NPK	3.35a	3.70a	3.80a	3.83a	3.90a	3.95a	4.20a

Means with the same letter in same column are not significantly different from one another.

Table 5. Residual effects of neem seed-based fertilizer and NPK on yield parameters of *Basella alba* plant.

Treatment	Edible yield (g/m^2)	Marketable yield (g/m^2)	Total biomass (g/m^2)
NF	44.00d	114.67c	119.33c
N100	46.33cd	117.00c	122.33c
N200	68.67b	169.67b	175.33b
N300	86.50a	209.50a	217.00a
NPK	58.67bc	153.67b	158.67b

Means with the same letter in same column are not significantly different from one another.

The effects of the various fertilizer treatments on the yield of *Basella alba* followed the same trend as the growth parameters. The regression of the various yield attributing parameters against the rates of NSBF (Table 6) indicates a perfect positive correlation. Organomineral fertilizer was found to perform better than NPK irrespective of the rate of application. This supports the works of many authors who have discovered the merits of combining organic and mineral fertilizers - as organomineral fertilizers. Kang and Balasubramanian (1990) and Babatola *et al*. (2002) recorded high yields of leafy vegetables following the application of organomineral fertilizers and suggested that high and sustained yield could be obtained with judicious and balanced NPK fertilizer combined with organic source of plant nutrients. Ipinmoroti *et al*. (2002) in their experiment indicated that quick mineralization of inorganic component and the slow nutrient release of the organic constituents of organominerals must have sustained the continous better performance of *A. cruentus* than their separate applications. Results of the effect of the different retaes of NSBF on the proximate composition of *Basella alba* is presented in Table 6. The fertilizers tested irrespective of type or application rate did not significantly affect moisture content of *Basella alba* (Table 7). NSBF at the highest rate (200 kg/ha) however recorded the lowest moisture content. This may indicate that NSBF engendered better dry matter accumulation in the vegetable (Table 8). This rate also caused significantly higher crude protein accumulation in the plants, which is an indication of higher N uptake and better N use efficiency.

Table 6. Linear correlation and regression analysis between increasing rates of NSBF (X) and growth or yield parameters of *Basella alba* (Y) (n = 3).

Parameter	Correlation coefficient	Regression equation
Plant height	+0.99	y = 112.5 + 0.77x
Leaf number	+0.94	Y = 25.4 + 0.15x
Leaf area	+0.89	Y = 50.8 + 0.09x
Stem girth	+0.73	Y = 3.5 + 0.01x
Edible yield	+0.99	Y = 6.9 + 0.40x
Marketable yield	+0.99	Y = 26.6 + 0.93x
Total biomass	+0.99	y = 29.5 + 0.95x

Table 7. Residual effects of neem seed-based fertilizer and NPK on leaf proximate composition of *Basella alba* plant.

Treatment	Moisture content (%)	Ash (%)	Protein (%)	Fat (%)
NF	18.16a	13.21a	6.52d	3.70cd
N100	18.97a	5.77c	12.62bc	2.86d
N200	18.88a	7.69b	15.23b	4.90b
N300	15.89a	7.84b	19.52a	7.77a
NPK	17.30a	7.84b	12.11c	3.92c

Means with the same letter in same column are not significantly different from one another.

Table 8. Residual effects of neem seed-based fertilizer and NPK on leaf nutrient composition of *Basella alba* plant.

Treatment	Nitrogen (%)	Phosphorus	Potassium	Vitamin C
NF	1.04d	10.43b	23.21ab	9.28c
N100	2.02bc	9.72b	19.61bc	9.28c
N200	2.44b	10.94b	16.92c	13.92b
N300	3.12a	13.66a	25.39a	18.56a
NPK	1.94c	10.63b	17.06c	9.28c

Means with the same letter in same column are not significantly different from one another.

Conclusions

Excellent growth and yield of *Basella alba* were obtained with the higher rates of the neem seed-based fertilizer. This is an indication that the organomineral formulation possesses good nutrient carry-over effects and can be recommended for use in a sustainable integrated soil nutrient management programme.

Conflicts of interest

Authors declare that they have no conflict of interests.

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