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Full Length Research Paper

Effects of de-oiled palm kernel cake based fertilizers on sole maize and cassava crops

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A study was conducted to determine the effect of de-oiled palm kernel cake based fertilizer formulations on the yield of sole maize and cassava crops. Two de-oiled palm kernel cake based fertilizer formulations A and B were compounded from different proportions of de-oiled palm kernel cake, urea, muriate of potash and single super phosphate. Two separate experiments were performed. Experiment one tested the effect of the fertilizer formulations on maize yield parameters. The treatments were 300 and 400 kg/ha rates of the fertilizer formulations A and B and conventional NPK 20:10:10 fertilizer (C) and a control (zero fertilizer). Experiment two tested the effect of the formulations on cassava yield parameters. The treatments were as in experiment one except that the conventional NPK 15:15:15 fertilizer was used in the place of NPK 20:10:10. The experiments showed that the de-oiled palm kernel cake based fertilizer formulations improved soil physical and chemical properties. Grain yield in maize and tuber yield in cassava were increased significantly by the application of the fertilizer formulations. The 300 kg/ha rate of formulation A was found to produce the highest grain yield in maize, while 400 kg/ha rate of formulation B gave the highest tuber yield in cassava. The two de-oiled palm kernel cake based fertilizer formulations induced better yield performances in both crops than the conventional fertilizers. Nutritional values of the two crops were raised by the application of the fertilizer formulations.

Key words: De-oiled seed cake, palm kernel, fertilizer.

INTRODUCTION

De-oiled seed cake (Doc) is a by product of oil seed from oil extraction plants. It has the potential of being used as fuel and feed stock for animals. The nutrient composition of de-oiled seed cake also suggests that it could be used in the formulation of Doc based fertilizers (Chaturvedi et al., 2009).

The scarcity and expensive nature of inorganic fertilezers coupled with the negative impact on the environment has led to the use of organic fertilizers in crop production. Organic farming has been advocated and currently farmers are being encouraged to reduce the use of chemicals to minimize the negative influences of these materials on the environment. However, inorganic fertilizers cannot be completely removed from the farm because of the obvious importance to crop as compared to organic fertilizers. One of such areas where inorganic fertilizer is preferred to organic manure is the fast release of nutrient to crop. Organic fertilizer on the other hand has a slow but more lasting release of nutrient to the crop as well as improving the soil structure. Oil seed cake as manure has been shown to increase total N, total carbon, cation exchange capacity (CEC), soil respiration and decrease particle size (Abdechamid et al., 2004). Yassim and Ismail (1994) have shown that seed cake of cotton and sunflower apart from improving soil fertility also prove effective in nematode control in cowpea plant.

A Doc based fertilizer made up of de-oil seed cake and inorganic fertilizer will not only minimize the hazard to

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environment caused by the use of only inorganic fertilizer but at the same time harness the benefits of the two type of fertilizers in crop production. The objective of this study was to determine the effect of Doc based fertilizers on the yield of maize and cassava crops.

MATERIALS AND METHODS

Two field experiments were carried out at the research farm of Resource Improvement and Manufacturing Company Limited, Nnewi, Nigeria. The de-oiled seed cake based fertilizers A and B formulations were made up of different proportions of de-oiled palm kernel cake, urea, muriate of potash and single super phosphate. Two conventional fertilizer formulations: NPK 20:10:10 and NPK 15:15:15 were purchased from the depot of Enugu State Agricultural Development Project (ENADEP). Orba Super II hybrid maize seed obtained from Premier Seed Nigeria Limited was used. An early maturing cassava variety from the collection of the Department of Crop Science, University of Nigeria, Nsukka, was used.

Experiment one

Effect of de-oiled palm kernel cake based fertilizer formulations A and B and NPK 20:10:10 fertilizer on the yield of maize

The experiment was laid out in a randomized complete block design (RCBD) in four replications. The treatments were two rates (300 and 400 kg/ha) each of the fertilizer formulations; A, B and NPK 20:10:10 (C) and a control (zero fertilizer). The land was ploughed and harrowed and marked out into blocks. Each block was divided into seven plots each measuring 3 x 4 m. Distance between blocks and plots is 1.0 m. The maize seeds were sown on flats at a spacing of 75 x 30 cm at two plants/stand in April. The fertilizer treatments were applied 14 days after sowing. Weeding and earthening up was done with hoe. Records were taken on cob length, cob width, dry grain yield/plant, dry grain yield/ha and shelling percentage.

Experiment two

Effect of de-oiled palm kernel cake based fertilizer formulations A and B and NPK 15:15:15 fertilizer on tuber yield of cassava

The experiment design was as in experiment one. The treatments are two rates (300 and 400 kg/ha) each of the palm kernel based fertilizer formulations A, B and NPK 15:15:15 (C) and a control (zero fertilizer). The land was ploughed, harrowed and ridged. The cassava cuttings were planted at the spacing of 1.0 x 1.0 m. The fertilizer treatments were however applied once at six weeks after planting. The plots were kept weed free with hoed. Harvesting was done at eight months after planting. Records were taken on number of tubers/plant, tuber yield/plant, average tuber yield and fresh tuber yield/ha.

Proximate analysis

Samples of maize grain and cassava tuber were labeled properly according to treatments and taken to the Department of Crop Science laboratory for proximate analysis.

Soil data

Soil samples were collected at random from the experimental site before ploughing at the depths of 0 to 20 cm and 20 to 40 cm. The samples were bulked together to form a composite sample from which a sub-sample was taken to the laboratory for analysis of physical and chemical properties of the soil before treatment application. Another soil sample was collected from the plots 4 weeks after treatment application and properly labeled in polybags and was also analyzed for soil physical and chemical properties.

Data analysis

The yield data collected were subjected to analysis of variance as outlined by Steel and Torrie (1980) for RCBD experiment. The LSD procedure as outlined by Obi (2001) was used at 5% probability level for the separation of treatment mean for significant difference.

RESULTS

The result of the soil analysis of physical properties of the soil of the experimental sites before treatment application indicated that the soil was sandy clay loam. The chemical properties of the soil presented in Table 1 shows that the soil was acidic. The soil was also low in organic carbon and other major nutrient elements such as N, K, Mg and Ca in both 0 to 20 cm and 20 to 40 cm soil depth. The chemical composition of the soils 4 weeks after treatment application in the maize plot (Table 2) shows that pH did not differ much among the treatments. It ranged between 4.7 and 6.3 among the treatments. The result also revealed that organic carbon, N, Ca^{+}, K^{+} and P^{+} content were higher in plots that received fertilizer treatments than the control. Al^{+} content was lower in the soil treated with formulation A and B when compared with those treated with conventional NPK 20:10:10 fertilizer and control. CEC was lower in the control and soils treated with conventional NPK 20:10:10 than formulation A and B. The NPK 20:10:10 fertilizer however had higher CEC than the control. Base saturation maintained the same trend as CEC.

Analysis of soils from the cassava plot 4 weeks after treatments application revealed that pH levels were almost the same across the treatments (Table 3). Organic carbon, N, Mg and P were higher in the areas that received fertilizer treatments than control. Formulation A and B had higher Ca than C and control. Potassium was almost the same across the treatments, while Al content was lower in the areas that received fertilizer treatments than control. Cation exchange capacity and base saturation were highest in soils that received formulation A and B fertilizer than C and the control.

The effect of the treatments on maize crop is presented in Table 4. The result shows that the yield parameters were increased significantly by the application of the

Table 1. The chemical properties of the soils of the experimental site.

Sample	Depth (cm)	pH H_2O	pH KCl	OC (%)	N (%)	Na^+ (Cmol/kg)	K^+ (Cmol/kg)	Ca^{2+} (Cmol/kg)	Mg^{2+} (Cmol/kg)	Al^{3+} (Cmol/kg)	CEC (Cmol/kg)	BS (%)	Al (Sat)	Av.P (ppm)
Maize Plot	0-20	4.1	3.8	1.20	0.105	0.71	0.03	1.03	1.00	6.2	9.0	31	69	4.58
	20-40	5.2	4.5	1.28	0.112	0.67	0.02	1.04	0.86	4.9	8.5	35	65	3.95
Cassava Plot	0-20	4.9	4.4	1.17	0.124	0.62	0.03	1.12	1.03	5.8	8.0	33	67	5.64
	20-40	4.7	4.6	1.37	0.118	0.60	0.03	1.46	0.66	5.3	7.0	34	66	5.27

Table 2. Mean values of chemical properties of soil from the maize plots four weeks after fertilizer application.

Sample	Depth (cm)	pH H_2O	pH KCl	OC (%)	N (%)	Na^+ (Cmol/kg)	K^+ (Cmol/kg)	Ca^{+2} (Cmol/kg)	Mg^{2+} (Cmol/kg)	Al^{3+} (Cmol/kg)	CEC (Cmol/kg)	BS (%)	Al (Sat)	Av.P (ppm)
Control	0-20	5.0	4.4	1.22	0.105	0.62	0.02	1.03	1.01	5.8	5.6	30	68	5.57
	20-40	5.1	4.5	1.37	0.118	0.60	0.03	1.04	0.86	5.4	5.2	33	64	4.97
A1	0-20	6.3	5.7	1.69	0.146	0.73	0.05	4.82	1.28	3.0	8.4	69	31	18.83
	20-40	5.8	5.0	1.73	0.150	0.67	0.04	2.41	1.53	2.2	7.8	65	35	15.97
A2	0-20	5.1	4.4	1.89	0.164	0.70	0.06	5.89	1.34	3.2	7.2	61	59	19.40
	20-40	5.2	4.7	1.33	0.115	0.67	0.04	3.86	1.20	2.8	8.0	65	59	16.92
B1	0-20	5.3	4.8	3.22	0.178	0.67	0.03	4.69	1.73	2.6	6.4	68	60	17.96
	20-40	4.8	4.4	1.45	0.125	0.70	0.05	1.69	1.90	3.2	6.8	58	76	13.99
B2	0-20	5.4	4.8	1.89	0.164	0.68	0.07	4.20	1.78	3.4	9.0	59	51	15.92
	20-40	5.2	4.8	1.90	0.164	0.67	0.07	2.89	1.40	2.1	8.8	55	61	14.45
C1	0-20	5.0	4.6	1.85	0.160	0.67	0.05	1.52	1.34	3.2	6.0	40	80	16.92
	20-40	4.7	4.3	1.57	0.136	0.67	0.04	1.52	1.38	4.2	5.2	44	76	12.96
C2	0-20	5.0	4.4	1.65	0.143	0.67	0.05	1.52	1.17	4.0	5.6	40	80	14.38
	20-40	4.8	4.4	1.01	0.137	0.67	0.03	1.50	1.16	4.8	5.2	46	74	13.25

A1 = 30 0 kg/ha of formulation A, A2 = 400 kg/ha of formulation A, B1 = 300 kg/ha of formulation B, B2 = 400 kg/ha of formulation B, C1 = 300 kg/ha of NPK 20:10:10, C2 = 400 kg/ha of formulation NPK 20:10:10.

Table 3. Mean values of chemical properties of soils from cassava plots four weeks after fertilizer application.

Treatment	Depth (cm)	pH H_2O	pH KCL	OC (%)	N (%)	Na^+ (Cmol/kg)	K^+ (Cmol/kg)	Ca^{+2} (Cmol/kg)	Mg^{+2} (Cmol/kg)	Al^{+3} (Cmol/kg)	CEC (Cmol/kg)	BS (%)	Al Sat. (%)	Av.P (ppm)
Control	0-20	5.0	4.3	1.16	0.101	0.53	0.02	1.03	0.92	6.4	7.8	30	70	5.98
	20-40	5.1	4.6	1.34	0.116	0.51	0.03	1.42	0.87	5.1	6.8	37	63	5.76
A1	0-20	5.1	4.7	2.74	0.234	0.70	0.05	3.83	1.63	4.6	11.0	68	62	17.45
	20-40	5.3	4.5	2.45	0.185	0.64	0.05	3.24	1.34	4.0	9.25	65	55	15.72
A2	0-20	5.3	4.7	2.25	0.265	0.67	0.06	4.34	1.85	4.2	15.68	72	62	18.26
	20-40	4.9	4.4	2.13	0.197	0.67	0.04	3.34	1.48	3.2	11.54	62	88	16.72
B1	0-20	5.2	4.9	2.55	0.205	0.65	0.07	3.54	1.55	3.8	12.68	62	60	16.88
	20-40	4.8	4.5	2.25	0.147	0.63	0.04	3.34	1.20	3.1	10.88	54	86	16.05
B2	0-20	5.9	5.3	2.65	0.250	0.67	0.08	4.24	1.72	2.6	14.55	64	36	18.79
	20-40	6.2	5.3	2.33	0.192	0.69	0.04	3.76	1.36	1.6	11.44	73	21	15.98
C1	0-20	6.1	5.5	2.14	0.184	0.67	0.04	2.96	1.19	2.8	10.65	65	35	15.71
	20-40	5.9	5.2	2.17	0.180	0.67	0.03	2.48	1.09	2.4	9.08	63	27	14.98
C2	0-20	5.0	4.3	2.16	0.192	0.64	0.05	2.83	1.17	2.7	11.88	67	33	16.40
	20-40	5.0	4.3	2.02	0.185	0.68	0.05	2.72	1.02	2.5	10.02	65	32	15.82

fertilizer treatments. The 300 kg/ha rate of de-oiled seed cake based fertilizer formulation A produced the highest cob length and width. It however did not differ significantly from the control and the two rates of the conventional NPK 20:10:10 fertilizer, C. The highest grain yield/plant and grain yield/ha were realized from plots that received 300 kg/ha of formulation A. The effect of the formulation A fertilizer differed significantly from those of formulations B and C at both rates and also from the control. It was also observed that the 300 kg/ha rate of the two Doc based fertilizer formulations performed better than the 400 kg/ha rate. However, the higher rate of formulation C performed better than the lower rate of 300 kg/ha. Formulation A also produced the highest shelling percentage among the treatments. There was however no significant differences between the effects of the rates of the two Doc based formulations and the 400 kg/ha rate of formulation C.

Table 5 shows the result of the effect of the fertilizer treatments on tuber yield attributes of cassava. Application of the fertilizer treatments significantly improved the yield attributes. The 400 kg/ha of formulation B produced the highest number of tuber/plant and differed from the 300 kg/ha of the same formulation and the rates of the other formulations (A and C) as well as the control. The 400 kg/ha rate produced higher number of tubers than the 300 kg/ha rate in all formulations. A similar trend was observed in tuber yield/plant. However, the highest tuber yield obtained from 400 kg/ha rate of formulation B did not differ significantly from the rates of formulation A. There was no significant difference in the effects of rates of formulation A and B on average tuber weight. They however, differed significantly from rates of formulation C and the control. The 400 kg/ha rate of formulation B produced the highest tuber yield/ha which differed significantly from the other treatments. The 400 kg/ha rate

Table 4. Effects of application rates of the Doc based fertilizer formulations A, B and NPK 20:10:10 fertilizer on maize yield attributes.

Treatment	Cob length (cm)	Cob girth (cm)	Grain yield/plant (g)	Grain yield/ha (ton)	Shelling percentage
Control	9.94	10.84	79.82	4.20	72.79
A1	17.23	15.88	139.52	7.34	80.72
A2	16.55	14.98	138.44	7.29	81.34
B1	16.75	15.20	123.55	6.50	80.08
B2	15.82	14.60	121.46	6.39	79.68
C1	14.87	13.50	109.15	5.74	77.69
C2	15.23	15.05	128.15	6.47	79.90
LSD(0.05)	1.93	1.00	10.20	0.78	1.21

Table 5. Effects of application rates of the Doc based fertilizer formulations A, B and NPK 15:15:15 fertilizer on cassava tuber yield attributes.

Treatment	Number of tubers/plant	Tuber yield/plant (kg)	Average tuber weight (kg)	Tuber yield/ha (ton)
Control	5.33	1.27	0.24	12.67
A1	7.33	2.95	0.40	29.25
A2	8.00	3.34	0.42	33.41
B1	7.33	2.76	0.39	27.67
B2	9.33	3.87	0.42	38.16
C1	5.67	1.99	0.36	19.99
C2	6.33	2.05	0.32	20.50
LSD(0.05)	1.28	1.03	0.15	4.31

Table 6. Effects of application rates of the Doc based fertilizer formulations A, B and NPK 20:10:10 fertilizer on nutritional value of maize grain.

Treatment	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)
Control	8.30	4.60	2.80	1.20	9.20
A1	11.00	4.17	2.33	1.50	11.90
A2	11.00	4.10	2.30	1.53	10.97
B1	9.70	4.20	2.30	1.40	12.50
B2	9.83	4.40	2.30	1.80	12.27
C1	8.77	4.60	2.40	1.30	12.80
C2	8.80	4.60	2.60	1.37	11.60
LSD(0.05)	ns	ns	Ns	Ns	Ns

differed significantly from the 300 kg/ha rate in the two Doc based formulation and the conventional formulation C. The analysis of the maize grains for some nutritional parameter presented in Table 6 indicated non significant treatment effect on the content of these nutrient parameters. However, the fertilizer treatments improved the protein content. The Doc based fertilizers produced higher percentage protein than NPK 20:10:10. A similar trend was noted on percentage ash. It was also observed that maize that received fertilizer contained more moisture than the control. Table 7 shows nutrient composition of the cassava tubers as a result of the treatments. The result reveals significant treatment effects on percentage protein, starch, fibre and ash and non significant effect on fat, fibre and moisture. The 300 kg/ha of Doc based formulation A and B produced highest percentage protein. They however, differed significantly only from the control. Formulation B at 300 kg/ha gave the highest percentage starch but only differed significantly from the control. Fibre was also higher in cassava that received the Doc based fertilizer formulations A and B than the one that received conventional

Table 7. Effects of application rates of the Doc based fertilizer formulations A, B and NPK 15:15:15 fertilizer on nutritional value of fresh cassava tuber.

Treatment	Protein (%)	Starch (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)
Control	0.6	33.9	0.2	0.6	0.8	49.8
A1	0.9	34.4	0.2	1.0	0.8	50.6
A2	0.8	37.1	0.4	0.8	0.8	51.6
B1	0.9	38.6	0.3	0.9	0.9	45.8
B2	0.6	36.8	0.2	0.5	0.9	48.9
C1	0.8	34.3	0.3	0.5	0.6	43.3
C2	0.7	36.9	0.1	0.4	0.7	51.6
LSD(0.05)	0.28	3.61	0.36	0.45	0.31	11.02

fertilizer C and the control.

DISCUSSION

Using the criteria recommended by Ibedu et al. (1988), the soil of the experimental site contained low levels of plant nutrient elements. The acidic nature of the soil is not a favourable soil characteristic. Low soil pH impedes the activities of soil microbial organisms some of which are involved in the mineralization of organic matter in the soil. The improved condition of the soil after treatment application is an indication that apart from releasing nutrient element to the soil, the formulations improved other soil properties which are indices for measuring soil fertility which agrees with the findings of Abdechamid et al. (2004) and Yassim and Ismail (1994). The Doc based fertilizers consists of both organic manure and chemical fertilizer components and combine the advantages of the two types of fertilizer in improving soil fertility. Chemical fertilizers are known for fast release of nutrient. Organic manure apart from supplying nutrient to the soil conserves soil moisture, moderates soil pH, improves bulk density, increase carbon dioxide level in plant canopy, alleviates the toxicity of A^{3+}, improves aeration and activity of beneficial soil microbes, increase cation exchange capacity and retards nitrification for longer time (Jat et al., 2002). Combined fertilization has been shown to decrease soil acidity, increase humus content and total N and increase available P and K in the soil (Bagheri et al., 2011; Kaur et al., 2008). Ayeni (2010) has shown that the combination of cocoa pod ash and NPK 20:10:10 fertilizer significantly increased soil organic matter, N, P and K.

The increased yield resulting from the application of fertilizer was as a result of the improved soil fertility. It has been shown that crops respond more to fertilizer application in soil that is low in fertility (Tisdale and Nelson, 1975). Combined application of organic and inorganic fertilizers has been reported to increase plant growth and yield (Mahmoud., 2009; Patil, 2010; Nyangani, 2010; Milosevic and Milosevic, 2009). The better effect on yield realized from 300 kg/ha rate relative to the 400 kg/ha rate of the Doc based formulation may be as a result of excessive nutrient supplied by the 400 kg/ha rate, resulting to high vegetative growth at the expense of yield in the crop. This suggests that rates higher than 300 kg/ha should not be used in maize. Formulation A induced better crop performance than B and C in maize, an indication that it provided better soil condition for maize production than the other formulations. On cassava production, formulation B was the best among the formulations, suggesting that formulation B provides more favourable soil condition conducive for cassava production. The 400 kg/ha rate of B appeared to support cassava production than the 300 kg/ha rate. The improved nutritional value of the crop resulting from the application of the formulations may be attributed to the increased soil fertility. Increase in yield attributes and nutritional value of crops arising from the use of combination of organic and chemical fertilizers has also been reported (Bagheri et al., 2011).

Conclusion

This study shows that the de-oiled palm kernel cake based fertilizer formulations improves soil physico-chemical properties and therefore enhances soil fertility. Crop yield and nutritional quality were increased by the application of the de-oiled palm kernel cake based fertilizer formulations. The de-oiled palm kernel cake based fertilizer formulation A at 300 kg/ha is also recommended for maize production, while formulation B at 400 kg/ha rate is recommended for cassava production.

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