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INFLUENCE OF ORGANIC AND INORGANIC FERTILIZERS ON THE YIELD OF SOME ARABLE CROPS IN SOUTHWESTERN NIGERIA

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Abstract

Two field experiments were conducted at the Teaching and Research Farm of the University of Ibadan from 1995 through 1999 cropping seasons to evaluate the effect of organic and inorganic fertilizers on the yield of maize (Zea mays L.), melon (Citrullus vulgaris L) and cassava (Manihot esculenta Crantz). The first experiment consisted of organic (a mixture of domestic waste and cow dung applied at 10 t ha^{-1}), inorganic (150 kg N ha^{-1} supplied as urea (UR) and 50 kg P ha^{-1} as single super phosphate) and a mixture of the organic and inorganic fertilizers. The second experiment evaluated the effect of two types of organic industrial waste: palm kernel de-oiled cake (PKDOC) and shea nut de-oiled cake (SNDOC) fortified with various levels of inorganic fertilizers {Urea (UR) and Sokoto rock phosphate (SRP)} compared with NPK 15:15:15 on grain yield. The highest mean maize grain yield (2.78 t ha^{-1}) for 1995 and 1996 was obtained from plots treated with a mixture of organic and inorganic fertilizers. Plots treated with organic and inorganic fertilizers combined and those that received organic fertilizer alone, significantly ($P \leq 0.05$) outyielded the control. Combined application of organic and inorganic fertilizer resulted in a yield increase of 43 and 32% in 1995 and 1996, respectively in melon seed compared with organic fertilizer application. However, fertilizer types had no-significant effect on cassava fresh tuber yield. The result of these studies indicated that a mixture of organic and inorganic fertilizers could be more beneficial to crops than the use of either pure organic or inorganic fertilizer under the tropical soil condition.

Key words: Fertilizer, industrial-waste, maize, melon, yield.

Introduction

The attainment of sustainable food security still remains an uphill task in Nigeria as in other African countries. Neither are human needs in terms of food demand satisfied nor natural resources protected. Since 1960, per capita food production has been on the decline (2% annually) relative to population growth, which has been on the increase (2.5% annually).

With the increasing population and its associated demographic dynamism, the traditional method of farming (shifting cultivation) which used to ensure adequate food supply with reduced or minimal environmental hazards is no longer sustainable. The fallow period that serves as soil fertility restoration phase has been drastically reduced due to population pressure on land. Between 1960 and 1990, per capita arable land declined from 0.29 to 0.05 hectare (Cleaver and Schreiber, 1994).

Consequently, to feed the rapidly increasing population, alternative land use methods have to be adopted. These include: expansion of cultivated areas which has resulted to moving on to marginal lands (Matlon and Spencer, 1984) and intensification of cropping with a view to reducing the need to cultivate marginal land (MWangi, 1997). The latter is the more favoured because in most part, land is extremely scarce (Binswanger, 1990). Furthermore, 30% of the useable land area is degraded (Cleaver and Schreiber, 1994).

Soil fertility maintenance under intensive cropping has been a major challenge that is still elusive. This has been attributed to the inherent nature of Nigerian soils and other environmental related constraints. An attempt to correct the problems associated with the soil fertility with external input like mineral fertilizer alone has proved abortive (Agboola and Fayemi, 1972). The low nutrient holding potential of the clay mineral makes the soil susceptible to nutrient imbalance and acidification upon the continuous addition of inorganic fertilizer more especially in the humid forest area. In few of the areas where this does not occur, procurement of the input is quite expensive to the farmers, majority of who operates on a small-scale basis. There is a positive correlation between soil organic matter (SOM) level and plant utilization of applied inorganic nutrients (Agboola, 1991, IFA and FAO, 2000) and an improved soil physical properties over a long period of cultivation (Hera, 1993) which involve biological processes. This understanding has called for investigations into plant nutrients and soil fertility management options that are adapted to site characteristics and to locally available resources-integrated plant nutrient management systems. This soil fertility management system pays attention to the interaction between organic and inorganic plant nutrients in crop production more especially in the low input cropping systems (Hera, 1996). Reports on the response of crops to continued application of organic and inorganic fertilizer in Nigeria (Agboola and Obi, 1977, Agboola, 1987) and other parts of the tropics has been promising (Isherwood, 1998). However, there is the need to widen the scope of our knowledge on the use of industrial organic waste, animal and domestic waste in combination with inorganic fertilizer in the production of some common arable crops. Consequently, these trials were initiated to assess: (i) the effect of combined application of animal and domestic wastes and inorganic fertilizers on the yield of some selected common arable crops of southwestern Nigeria. (ii) the potentials of some N and P fortified industrial organic wastes as sources of plant nutrient (fertilizer).

Materials and Methods

Site description

Two field experiments were conducted at the Teaching and Research Farm University of Ibadan during 1995 through 1999 cropping seasons. Ibadan lies on Latitude 7° 30′ N and Longitude 3° 54′E with annual rainfall ranging from 1000 to 1600mm. The rainfall pattern is often bimodal, with a long (April to July) and a short (August to October) rainy seasons separated by a short period of dryness in August. The mean monthly temperature ranges between 21.3 and 31.2 °C and the relative humidity is often over 80% on the average.

The soil of the experimental site is Egbeda series (Oxic tropdualf- USDA soil taxonomy or Ferric Luvisol-FAO/UNESCO). The soil is basically formed *in-situ* on biotic gneiss and greyish in the top 10 cm, changing brownish with depth (Smyth and Montgomery, 1962). The textural analysis showed that it contains 800g kg^{-1} sand, 80g kg^{-1} silt and 120 g kg^{-1} clay at 0-15 cm depth. The pH is 5.7, with organic C of 11.8 g kg^{-1}, total N of 1.70 g kg^{-1}, available P of 1.46 mg kg^{-1} and CEC of 4.92 $Cmolkg^{-1}$.

The site was first cleared from forest in 1950 and used as paddock. It was later planted to elephant grass and grazed for 2-3 years. Since then it has been under intensive arable crops (cassava, maize and legumes) cultivation. No fertilizer was applied to the site during the previous cultivation. The major vegetation at the commencement of the experiment was mainly *Euphorbia heterophylla*, *Panicum maximum* and *Mucuna mucunoides*.

Experiment 1

The first experiment was conducted during 1995 and 1996 cropping seasons to determine the influence of organic and inorganic fertilizers and their mixtures on the performance of maize, melon and cassava intercrop. The treatments consisted of (i) organic fertilizer (equal mixture of domestic waste and cow dung applied at 10 t ha^{-1}), (ii) inorganic fertilizer (150 kg N ha^{-1} supplied as urea and 50 kg P ha^{-1} as single super phosphate (ssp)) based on pre-cropping soil test value, (iii) a mixture of organic and inorganic fertilizers (5 t ha^{-1} of domestic waste and cow dung mixed with 75 kg N ha^{-1} as urea and 25kg P ha^{-1} as ssp), and (iv) the control (no fertilizer). The treatments were laid out in a randomized complete block design (RCBD) with three replications. Each experimental unit measured 15 x 10 m with 1m alley between respective units. The test crops were Cassava (TMS 30572) was planted at a spacing of 1 x 1 m spacing, maize (TZE. Comp. 311) at a spacing of 100 x 50 cm and two plants per hill, while melon was planted at a spacing of 100 x 100 cm in the intercrop. Regular weedings were carried out up to the harvesting of maize and melon after which cassava formed adequate canopy to suppress the weeds.

Experiment 2

The second experiment was conducted during 1998 and 1999 cropping seasons. It had two types of organic industrial wastes: Palm kernel deoiled cake (PKDOC) and shea nut deoiled cake (SNDOC) as the base organic fertilizer. Each of the PKDOC and SNDOC was fortified with urea and sokoto rock phosphate (SRP) at various ratios of 5:4:1; 7:2:1; 8:1:1 and 10:0:0 of either of the industrial waste: urea: SRP, respectively. The checks were NPK 15:15:15 at 350 kg ha^{-1} based on soil test results and the no fertilizer plots, giving 10 treatment combinations. The treatments were laid-out in a RCBD with three replicates. Each experimental unit measured 15 x 10 m with 1 m alley in between respective treatment plots. Maize (TZE. Comp. 311) was sown at a spacing of 75 x 25 cm in May of each year. Two weedings were carried out at 3 and 7 weeks after sowing (WAS).

Data collection and analysis

Pre-planting composite surface (0-15) soil samples were taken for the two experiments and later bulked. The samples were air-dried and passed through 2 mm sieve for routine soil analysis (pH, organic C, N, P, exch. Cation (K, Ca, Mg, Na) and particle size analysis (IITA, 1982). Yield data were collected for each crop at harvest. A total of 20 plants each of cassava, maize and melon were harvested from the middle row of each treatment for yield determination.

All the data were subjected to analysis of variance using Statistical Analysis Systems (SAS) using general linear model (PROC GLM) (SAS Inst. 1998). Mean differences were separated among treatments using Duncan's Multiple Range Test (DMRT) at 5%.

Results

Experiment 1 - Effect of fertilizer types on crop yield

Maize grain and melon seed yields increased significantly ($p < 0.05$) with the application of inorganic and a mixture of organic and inorganic fertilizers. However, these fertilizers did not show any significant effect on cassava fresh tuber yield. (Table 1).

Maize grain yield from the inorganic fertilizer (150 kg N ha^{-1} and 50 kg P ha^{-1}) treated plots and those from the organic and inorganic fertilizers combined (5 t ha^{-1} domestic waste and cow dung mixed with 75 kg N ha^{-1} and 25 kg P ha^{-1}) did not differ significantly. However, the average grain yield for the two-year trial showed that combined application of organic and inorganic fertilizers resulted in approximately 7% higher grain yield relative to the application of inorganic fertilizer alone. Yields from all the treatments were significantly ($p < 0.05$) higher than what was obtained from control plot in 1995. In 1996, only yield from plots treated with inorganic fertilizer and those of the organic and inorganic fertilizers combined significantly ($P \leq 0.05$) outyielded the control by 68 and 71%, respectively (Table 1).

Significant ($P \leq 0.05$) higher melon seed yield (0.30 and 0.34 t ha^{-1}, respectively) were obtained from plots treated with a combination of organic and inorganic fertilizers compared with those recorded from organic fertilizer and no-fertilizer treatments in 1995 and 1996, respectively. Average yield for the two years showed that seeds from plots treated with combined organic and inorganic fertilizers combined out-yielded those of the inorganic fertilizer by 18%, although they did not differ significantly.

Effects of fertilizer types on cassava fresh tuber yields were not significant for the two years of the trial. However, higher yields of 23.8 and 21.8 t ha^{-1} were recorded from plots that received organic and a combination of organic and inorganic fertilizers, respectively in 1995. In 1996, organic fertilizer treated plots out-yielded inorganic fertilizer, organic + inorganic fertilizer and the control plots by 20, 15 and 32%, respectively.

Experiment 2 - Effect of organic industrial waste fortification on maize yield

All the fortified organic industrial waste significantly ($p < 0.05$) increased maize grain yield irrespective of the fortification ratio (Table 2). PKDOC fortified with urea and SRP at the ratio of 5:4:1 gave the highest maize grain yield of 2.63 and 2.68 t ha^{-1} in 1998 and 1999, respectively. These yields were significantly ($P \leq 0.05$) higher than those obtained from maize crops that received either PKDOC or SNDOC fortified with urea and SRP at the ratios of 8:1:1 and 1:0:0 and the control respectively. Although maize crops that received either PKDOC or SNDOC fortified with urea and SRP at the ratio of 5:4:1 out-yielded the NPK 15:15:15 treated plants, the yield differences were not significant. The application of 100% organic industrial waste (SNDOC) gave the lowest yield of 1.86 and 1.20 t ha^{-1} in 1998 and 1999, respectively, among the fertilized plots.

Discussion

The impressive maize yield recorded from the fortification of the organic industrial wastes (PKDOC and SNDOC) with mineral fertilizers (urea and SRP) could be ascribed to the multifaceted role of such fertilizer combinations. Zaharah and Bah (1997) recorded similar observation when rock phosphate fertilizer was applied in combination with organic manure. Some investigations carried out in some West African states (Nigeria and Ghana) by International Fertilizer Development Centre (IFDC, 1994). Results showed that combined application of mineral fertilizer and farmyard manure alleviated soil fertility constraints associated with Al and Mn toxicity and consequently enhanced the yield of millet for over ten years.

The result of this study showed higher maize grain and melon seed yield with the application of a fertilizer mixture of organic and inorganic fertilizers compared to other treatments. This agrees with the observation of Hera (1996), who reported that mixing of inorganic fertilizer with organic materials ensured better fertilizer use efficiency. The 7% higher maize grain yield (2 years average) recorded from the combined application of organic and inorganic fertilizers relative to those that received inorganic fertilizer alone could be attributed to multiple functions. Juma (1994) reported that the efficacy of organic and inorganic mixed fertilizers over mineral or organic fertilizer lies on the ability of the organic materials in the mixture to temporarily inhibit and hold nutrients in transient condition via microbial activities. This ensures that the swift release of mineral nutrients of the mineral fertilizer and losses are minimized.

The highest maize yield recorded from the application of mineral fertilizer in the first year experiment may be as a result of quick nutrient release pattern of the fertilizer. However, the inorganic fertilizer did not out-yield the combined application of organic and inorganic fertilizer in the second year. This observation buttressed the reports of Parr *et al.* (1990) and Rodales (1995) that the use of inorganic fertilizer alone could not guarantee a long time sustainable crop yield. The inability of 100% organic fertilizer application to comparatively improve maize grain yield significantly could be linked to its slow nutrient release pattern (Titiloye, 1982) and low quality in terms of nutrient content (Yates and Kiss, 1992).

The non-significant effect of various fertilizer types on the yield of cassava could be attributed to the inherent ability of cassava to perform well even in low nutrient status soils relative to other crops (Juo, 1985) and lack of cassava tuber yield's response to the application of nitrogen. The higher tuber yield obtained from the organic fertilizer treated plots could be ascribed to the slow nutrient release pattern of the fertilizer, which may have coincided with and favoured the later stage (tuber enlargement and filling) of the cassava growth.

The consistently higher yield recorded in this study with the application of organic and inorganic fertilizer mixture has demonstrated that fertility problem of tropical soil could be reduced through the combined use of a mixture of organic and inorganic fertilizers. The ability of the fortified organic industrial wastes to give higher maize yield than NPK 15:15:15 applied at similar rates has demonstrated that such organic wastes could be economically disposed and used as fertilizer, and by so doing both environmental hazards and the fertility problems of tropical soils could be reduced.

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Table 1: Effect of organic and inorganic fertilizers and their mixture on maize, melon seed and cassava fresh tuber yield (t ha^{-1})

Fertilizer type	Maize grain yield		Melon seed yield		Cassava fresh tuber yield	
	1995	1996	1995	1996	1995	1996
Organic	2.28	1.56	0.17	0.23	23.80	21.80
Inorganic	2.86	2.59	0.25	0.28	20.90	17.40
Inorganic + organic	2.72	2.83	0.30	0.34	21.30	18.40
No. fertilizer	1.20	0.82	0.13	0.11	20.30	14.40
LSD (0.05)	0.85	1.20	0.11	0.09	Ns	Ns

Organic = 10tha^{-1} cow dung + domestic waste
Inorganic = 150kg N + 50kg P ha^{-1}
Inorganic + Organic (5tha^{-1} cow dung + domestic waste mixed with 75kg N and 25kg P ha^{-1}
No fertilizer = Control
Ns = Not significant.

Table 2: Effect of fortified PKDOC and SNDOC on maize grain yield (t ha^{-1})

Type of organic industrial waste and fortifiers	Level (ratio) of fortification (%)	Mean maize grain yield (t ha^{-1})	
		1998	1999
*PKDOCK + Urea + SRP**	50 + 40 + 10	2.63a	2.68a
	70 + 20 +10	2.50a	2.54a
	80 + 10 + 10	2.40b	2.32ab
	100 + 0 + 0	2.21b	2.26b
***SNDOC + Urea + SRP	50 + 40 + 10	2.50a	2.49a
	70 + 20 + 10	2.43a	2.35a
	80 + 10 + 10	2.15b	2.30b
	100 + 0 + 0	1.86bc	1.20bc
NPK	15 : 15 : 15	2.40a	2.33a
Control (No. fertilizer)	0 + 0 + 0	1.05c	0.96c

Means followed by the same letter(s) in the same column are not significantly different at $P \leq 0.05$ (DMRT).

*PKDOC = Palm kernel deoiled cake
**SRP = Sokoto rock phosphate
***SNDOC = Shear-nut deoiled cake