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Residual Influence of Early Season Crop Fertilization and Cropping System on Growth and Yield of Cassava

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Abstract: Problem Statement: In assessing fertilizer effects to sustain an intensive cropping system, the residual effects of fertilizer applied to preceding maize on the growth and yield of cassava and the effects of intercropping with soybean were studied in field experiments at Ibadan, Nigeria. **Approach:** Maize, established in April was fertilized using either organic manure or inorganic fertilizer or a mixture of organic manure and inorganic fertilizers. Organic manure was an equal mixture of domestic waste collected from a composted refuse dumping site applied at l0 t ha^{-1}. Inorganic fertilizer was 150kg N supplied as urea and 50 kg P ha^{-1} as Single Super phosphate fertilizer. The mixture of organic and inorganic fertilizer treatment was 5 tonnes organic manure and 75kg N+25 kg P ha^{-1}. Cassava was established in June and soybean planted in July, after harvesting maize. **Results:** Organic fertilizer treatment gave the tallest Soybean plants of 53 cm. Plants from sole inorganic fertilizer and from a mixture of organic and inorganic fertilizers had comparable heights but were significantly lower than plants from sole organic fertilizer application. Organic fertilizer application gave the highest seed yield of 481 kg ha^{-1} that was significantly higher than 380 kg ha^{-1} observed from a mixture of organic and inorganic fertilizers. Stover yield followed the same trend as seed yield. Cassava plant height was increased with fertilization but was reduced with intercropping. Sole organic fertilization had the tallest plants of 206 cm. Plant leaf area was neither significantly affected by fertilizer type nor cropping system. Fresh root yield was significantly reduced by 16% with soybean intercropping. Sole organic fertilizer application gave the highest yields of 22 tons ha^{-1} in sole crop and 18 tons ha^{-1} in intercrop with soybean. **Conclusion:** Cultivating an early season maize crop, followed by a cassava-soybean intercrop is more favored with application of 10 tons ha^{-1} organic fertilizer.

Key words: Fertilizer; residual effect cassava, yield

INTRODUCTION

Fallowing land for some years, to maintain soil fertility can no longer meet-up with the demand for food crop production due to high pressure on the limited arable lands. Soil fertility maintenance is very essential in achieving and maintaining high crop yields over a period of time. There is the need to apply fertilizers to maintain soil fertility. Use of mineral fertilizers has been found more convenient than the use of organic fertilizers that have traditionally been used in pre- industrial age. It however often leads to a decrease in soil organic matter content and increased soil erosion[8]. It also results in soil physical degradation; increased soil acidity level and soil nutrient imbalance[11]. A reduced dependence on chemical fertilizer has been advocated[13]. Organic manure when efficiently and effectively used ensures sustainable crop productivity by immobilizing nutrients that are susceptible to leaching[2].

Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect[14], supporting better root development, leading to higher crop yields [1] Improvement of environmental conditions as well as the need to reduce costs of fertilizing crops are also important reasons for advocating increased use of organic materials[6]. They improve the soil fertility status by activating the soil microbial biomass[5]. They are required in rather large quantities to meet up with crops' nutrient supply. Application of organic manures sustains cropping system through better nutrient recycling[9]. They play a direct role in plant growth as a

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source of all necessary macro and micronutrients in available forms during mineralization, thereby improving both the physical and the biological properties of the soil[2].Organic manures decompose to give humus which plays an important role in the chemical behaviour of several metals in soils through the flavonic and humic acid contents, which have the ability to retain the metals in complex and chelate forms[2]. Organic manures also improve the water holding capacity of the soil; improve the soil structure and the soil aeration[7].

Cassava based cropping systems are more prevalent than other cropping systems in several countries in sub-Saharan Africa. Cassava (*Manihot esculenta* Crantz) is the most important root crop in Nigeria in terms of food security, employment creation and income generation for farm families [15]. It is well suited to intercropping with short-duration crops such as maize, cowpea, and soybean. It is often left to continue growing after the other short duration crops, such as maize have been harvested in the early season. A leguminous crop like soybean (*Glycine max*. L. Merrill) could also be cultivated in the late season because of their inherent advantages such as short growth period; low canopy plant structure; drought tolerance; as well as ability to fix atmospheric N in their root nodules, which make it highly advantageous to grow in relay or mixed cropping systems. There is the need to investigate the sustainability of supply of nutrients for optimal performance of the cropping system.

This study was conducted to assess the residual effects of fertilizer applied to early season crops on sole crop and intercropped cassava.

MATERIALS AND METHODS

Field experiments were conducted in the growing seasons of 2003 and 2005 at the Federal College of Agriculture, Ibadan (lat.7^0 22½' N and long.3^0 50½' E) in the degraded rainforest zone of Nigeria. The region usually experiences a bimodal rainfall pattern, with a long raining season, usually between March and July and a short rainy season, usually extending from September to early November, after a short dry spell in August. Total annual rainfall was 1528mm in 2003 and 1147mm in 2004. Average monthly temperature ranged from a minimum of 19.10 ^{0}C in December to a maximum of 33.87 ^{0}C in March. The mean monthly relative humidity ranged from 73% in December/ January to 94% in August.

The experimental site was a Plinthic Luvisol. It was manually slashed and mechanically ploughed and harrowed to enable good land preparation. The soil was sampled for routine analysis before planting. The pre-cropping soil analysis data is presented in Table 1. The top 30cm of the soil had a pH (H_20) of 6.0.

Table 1: Pre-cropping soil characteristics and manure chemical analysis

	Soil Sample	Manure
pH	6.0	7.6
Organic Matter	31.0 g kg^{-1}	221.4 g kg^{-1}
Organic Carbon	18.0”	128.5 “
Total N	1.8 “	12.9 “
Available P	1.84 ppm	11.0 “
Exchangeable K	0.30 cmol kg^{-1}	4.5 “
Exchangeable Ca	3.57 “	10.8 “
Exchangeable Na	0.43 “	1.5 “
Exchangeable Mg	0.51 “	0.7 “
Exchangeable Acidity	0.11 “	
ECEC	4.92 “	
Sand	724.00 g kg^{-1}	
Silt	131.00 “	
Clay	145.00 “	

The experiment was laid out in a split-plot design with nutrient source as the main factor and cropping system as the sub-factor. There were four main treatments and two sub-treatments. The main treatments were: 1 Organic fertilizer 2 Inorganic fertilizer 3 Mixture of organic and inorganic fertilizers 4 No fertilizer - Control. The organic fertilizer was an equal mixture of domestic waste collected from a composted refuse dumping site and cow dung, applied at 10 t ha^{-1}. Inorganic fertilizer was Urea, applied to supply 150 kg N and Single Super phosphate fertilizer, to supply 50 kg P ha^{-1}. The mixture of organic and inorganic fertilizer treatment was half the rates for the sole organic and sole inorganic fertilizer treatments (5 t ha^{-1} manure + 75 kg N and 25 kg P ha^{-1}). The fertilizers were applied to early season maize crop. The sub-treatments were: (i) Sole Cassava; (ii) Cassava / soybean intercrop. Sub-plot size was 5.5x4.0m, with a 2m margin round each sub-plot. Cassava was planted at the end of June. Soybean seeds were drilled in-between the cassava rows after two weeks. The soybean was sown at 5cm intra-row spacing to have a population of 200,000 plants ha^{-1}. Weeding was done manually at 3 and 8 weeks after Planting (WAP). Soybean was harvested 16 WAP. The cassava was harvested 9 Months After Planting (MAP).

Data collection: Data were taken from 3 plants per plot to assess growth and yield. Soybean plant height was assessed at 10 WAP while the height and average leaf area of cassava were assessed at harvest for growth. Seed and stover yields were assessed for soybean and fresh tuber weight taken to assess cassava yield.

Data analysis: The analysis of variance (ANOVA) procedure was carried out to determine the differences in parameters. Significantly-different mean values were compared using Duncan's Multiple Range Tests (DMRT) at 0.05 level of probability.

Table 2: Effect of cropping system and fertilizer type on cassava growth and yield

	Plant Height (cm)		Leaf Area (m^2 plant)		Root Yield (t ha^{-1})	
	Intercrop	Sole Crop	Intercrop	Sole Crop	Intercrop	Sole crop
No Fertilizer	174	199ab	2.01	1.80	16.16	19.34b
Organic	187	206a	1.92	2.11	18.24	22.81a
Org + Inorg	183	188b	2.12	2.12	17.88	19.39b
Inorganic	185NS	195ab	2.02NS	2.11NS	16.36NS	19.18b

RESULTS

Soybean growth and yield: Soybean plant height was significantly affected by fertilizer type. Sole organic fertilizer treatment gave the tallest plants of 53 cm (Fig. 1). Plants from sole inorganic fertilizer and from a mixture of organic and inorganic fertilizers were comparable but were significantly lower than plants from sole organic fertilizer application. Organic fertilizer application gave the highest seed yield of 481 kg ha^{-1}. It was significantly higher than 380 kg ha^{-1} observed from a mixture of organic and inorganic fertilizers. (Fig.2). Stover yield followed the same trend as seed yield. Organic fertilizer treatment gave the highest yield of 714 kg ha^{-1} which was significantly higher than a yield of 564 kg ha^{-1} got from a mixture of Organic and inorganic fertilizers (Fig. 2).Sole inorganic fertilizer treatment gave even a significantly lower yield (334 kg ha^{-1}).

Cassava growth and yield: Cassava plant height was increased with fertilizer application but was generally reduced by intercropping with soybean. Sole organic fertilizer treatment had the tallest plants. (Table 2). Cassava plant leaf area was neither significantly affected my fertilizer type nor cropping system. Application of a mixture of organic and inorganic fertilizers however, had the highest leaf coverage of 2.12 m^2 plant, either in sole cassava or in intercrop with soybean (Table 2).

Cassava fresh root yield was significantly reduced by 16% with soybean intercropping. Application of sole organic fertilizer gave the highest root yields of 22 and 18 tons ha^{-1} in sole and intercrop, respectively (Table 2).

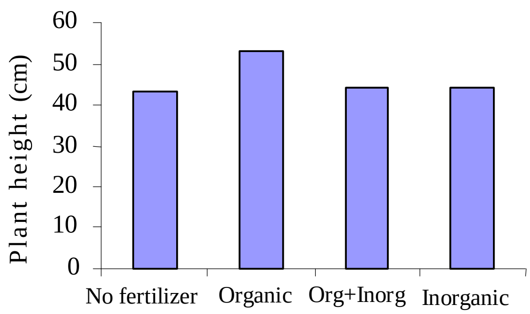

Fig. 1:Effect of Fertilizer type on soybean plant height (cm)

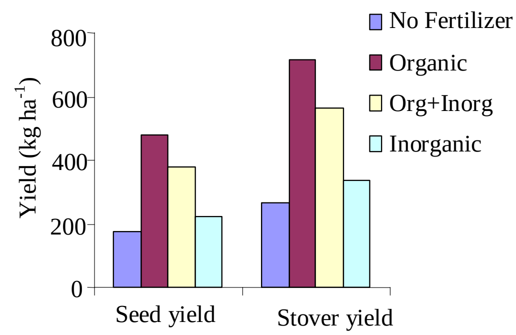

Fig. 2: Effect of fertilizer type on soybean seed and Stover yield

Average cassava root yield was reduced by 20%, a level comparable with yield from sole cropping.

DISCUSSION

Highest soybean seed yields observed from organic fertilizer application supports earlier report of Agbim [3] that organic fertilizers are better used for sustaining long-term cultivation than inorganic fertilizers. Lower growth performance and yields observed with a combined application of organic manure and inorganic fertilizers, relative to sole organic application is an indication that a higher dose of combined fertilizer will be required to support an intensive cropping system that involves early and late season crops. Sole inorganic fertilizer treatment that gave even a significantly lower seed yield further confirms the need for an increased rate of fertilizer, to support the cropping system.

The observed reduction in cassava growth and yield due to intercropping was a result of competition for growth factors. Prabhakar *et al.* [12] and Karmik *et al.*[10] had earlier observed that competition exists among crops planted in mixtures for soil nutrients. Cassava growth in intercrop with cowpea has also been reportedly significantly reduced[4].

Organic manure applied at 10 t ha^{-1} to early season maize has shown the evidence of capability to support both the early and the late season crops. Reducing the rate of organic manure to 5 t ha^{-1} and complement with inorganic nutrients has shown the ability to support only the sole crop late season, not with an intercrop. Nutrients supplied in the combined treatment seemed not sufficient enough to support the intensive cropping system. A higher dose of combined fertilizers will be required to support both the early season sole maize and the late season cassava - soybean intercrop.

CONCLUSION

Cultivating an early season maize crop, followed by a cassava-soybean intercrop is more favored with application of 10 t ha^{-1} organic fertilizer. Reducing the rate to 5 t ha^{-1}, complemented with inorganic source 75kg N and 25 kg P ha^{-1} will only support the early season maize and a sole late season cassava. Soybean intercropping reduces cassava growth. Comparable cassava yield in intercrop, as with sole cropping is achieved, only with sole organic fertilizer application.

To support a cropping system of an early maize, followed by a cassava-soybean intercrop, with combined organic and inorganic fertilizer, a higher dose than 5 t ha^{-1} manure, complemented with inorganic source 75kg N and 25 kg P ha^{-1} will be required.

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