THE YIELD AND FARMER'S ECONOMIC ADVANTAGE OF MAIZE - PIGEON PEA INTERCROP AS AFFECTED BY THE APPLICATION OF ORGANIC BASE FERTILIZER

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Abstract

In this study, a three years experiment was conducted to evaluate the yield and relative economic advantage of maize-pigeon pea intercrop as affected by mycorrhiza and organomineral fertilizer in the rainforest zones of Nigeria. The experimental design was a 2x2x3 factorial in a randomized complete block design using a split plot. The Land Equivalent Ratio (LER), Relative Value Total and Replacement Value of Intercrops were used to evaluate the yield data. Data collected were analysed using analysis of variance (ANOVA) at p = 0.05. However, the application of organomineral fertilizer and arbuscular mycorrhizal fungi has significantly ($p \leq 0.05$) increased the growth and yield of both crops in sole and intercrop. Thus, the inoculation of mycorrhiza has increased the grain yield of maize and pigeon pea by 33% and 56 % respectively. Also, the application of organomineral fertilizer has increased the yield of maize and pigeon pea by 60 % and 52 % respectively. Similarly, the combined application of organomineral fertilizer with mycorrhiza has increased the yield of maize and pigeon pea by 86% and 56 % respectively. The practice of intercropping farming system had higher Land Equivalent Ratio, Relative Value Total and Replacement Value Intercrop. The study further revealed that the inoculation of mycorrhiza significantly ($p \leq 0.05$) increased the profit of farmers as its Replacement Value of Intercrops of the treatment with mycorrhiza was 3.27. Thus, mycorrhizal inoculation and these farming practice is recommended to enhance farmer's economic return and grain production for tropical farmers.

Keywords: Maize, pigeon pea, mycorrhiza, organomineral fertilizer, economic advantage, Land equivalent ratio

Introduction

Arbuscular mycorrhizal fungi is very useful in ecological restoration as it enables the establishment of host plant on degraded soil, and it also assists in improving the quality and health of the soil (Jeffries et al. 2003). AM fungi help plants to capture nutrients such as phosphorus and micronutrients from the soil which are deficient in degraded soil. Associative action of mycorrhizal fungi in legumes has a great impact on root, shoot development and phosphorous uptake which results in the enhancement of nodulation and nitrogen fixation. Arbuscular mycorrhizal fungi inoculation increases the uptake of phosphorus and other nutrients which enhanced the growth and yield of crops. However, mycorrhizal fungi play a significant role in soil aggregate stability which helps in building up soil resistance against erosion. Effective mycorrhizal colonization can also increase the nodulation and symbiotic nitrogen fixation in mycorrhizal legumes (Hamel, 2003). Furthermore, *Cajanus cajan* is an important multipurpose leguminous crop that provides food, feed, fuel and medicine. It has also been found very useful in intercropping with cereal crop such as maize and sorghum as it has the ability to replenish nitrogen in the soil, and their litter are rich in nutrient which helps to enrich the soil for an increased productivity.

The goal of organic base fertilizer is to improve the organic matter content of the soil and compliment mineral fertilizer which is expensive. Organomineral fertilizer significantly increases the yield of maize with a higher residual effect compared with the use of mineral fertilizer alone. Adeoye et al. (2008) also reported the comparative advantage of OMF over mineral fertilizer on the yield and quality of maize. OMF has been reported to sustain and improve soil organic matter as well as increase the yield of crops such as melon, yam, vegetable, cassava and ornamentals (Makinde et al. 2007).

Pigeon pea (*Cajanus cajan* (L) Millsp) is a multipurpose legume proclaiming its value as a soil builder. In terms of its ecological services, pigeon pea is useful as an alley crop, in agroforestry systems, home-gardens and as a cover crop. Thus, it is an important pulse legume grown due to its wide range of products (Dasbak and Asiegbu, 2009). Pigeon pea is an excellent source of organic nitrogen and nutrient recycling. It increases organic matter and improves the soil structure and the soil quality. Tabo et al. (1995) reported that sorghum, cassava, bambara nuts, melons and maize can be intercropped with pigeon pea. Therefore, maize (*Zea mays* (L.) is an important cereal crop grown in most tropical African countries for human consumption, for livestock feed and for industrial purposes. In many tropical

countries like Nigeria, maize is often planted in intercropping systems (Alabi and Esobhawan, 2006). However, the relative intercropping advantage of the intercropping of pigeon pea and maize has not being examined in Nigeria, despite the fact that traditional farmers have technological, sociological, cultural and socio-economic reasons for insisting on intercropping. They proved that it is an insurance against crop failure, erosion control, efficient use of land, stability of yield, risk minimization, continuous and diversified food supply and higher yields. This study was therefore designed to determine the effects of mycorrhiza and organomineral fertilizer on the yield, and the relative economic advantage of maize and pigeon pea intercrops in the systematic planting arrangement in rain forest zones of Nigeria.

Materials and methods

Description of Experimental Site

A three years experiment was carried out from 2007 to 2009 in Ekpoma, Nigeria. Ekpoma is in the humid rain forest vegetation belt of Nigeria with ultisol as its soil type. Ekpoma lies between Latitude North 6 degrees, 45 minutes, 34 seconds (6° 45' 34") and longitude East 6 degrees, 8 minutes, 27 seconds (6º 8' 27" East), with an average annual rainfall of 1500mm and a temperature that is between 15ºC – 34ºC.

Soil Analysis

Top soils (0-15 cm) were collected from the site prior to each planting season. The soils were air dried, sieved and the samples were analysed for both chemical and physical properties. Particle size analysis was carried out using hydrometer method (Bouyoucos, 1962). The pH was determined in water (ratio1:1, soil: water). However, soil pH (1:1), 20g of soil and 20ml of water was used and equilibrated for 30 minutes with an occasional stirring, and pH was determined (IITA 1979). In addition, organic carbon was determined by wet dichromate method (Nelson and Sommers, 1975), and available phosphorus in the soil was determined using Bray- 1 extraction method (Bray and Kurtz, 1945). Total nitrogen was determined by Kjeldahl method (Bremner and Mulvaney 1982). Also, exchangeable cations (potassium, calcium and magnesium) were extracted with ammonium acetate. Furthermore, potassium was determined by flame photometer while calcium and magnesium was determined using atomic absorption spectrophotometer (IITA 1979). However, effective cation exchange capacity was determined by the summation of the total exchangeable base and exchangeable acidity.

ECEC = TEB +EA (KCl) (IITA 1979).

Experiment 1: The experiment was conducted from May to December, 2007 to evaluate the comparative effects of mycorrhiza (*Glomus*

clarum) and organomineral fertilizer on growth and yield. *Glomus clarum* was obtained from the Department of Agronomy, University of Ibadan. The four varieties of pea pigeon used were: TCC 6^{A} - Short duration, TCC 8127^{C} - Short duration, IAR & T 16^{B} - Long duration and IAR & T 50 - Long duration. Land preparation was manually carried out on the field. The planting distance used was 1m x 1m in plots measuring 3 m x 3 m and the total land area was 30 m x 30 m. The experimental design was a 2 x 2x 4 factorial in a randomized complete block design. Therefore, the factors were: mycorrhizal inoculation - 2 levels, organomineral fertilizer applications-2 levels and 4 varieties of *Cajanus cajan*. *Glomus clarum* was inoculated at the rate of 300 kg ha^{-1} to pigeon pea ring application method at the depth of 0 – 5cm and 15 cm diameter at planting. The organomineral fertilizer was applied to *Cajanus cajan* at the rate of 2,000 kg ha^{-1} three weeks after planting and ring method of application was used. The growth [height (cm), stem girth (cm), number of leaves] and yield (biomass and grain yield) parameters were taken, and nitrogen fixed by the four varieties of pigeon pea were determined.

Experiment 2: Also, from May to December 2007, maize (Suwan-1-SR variety) was intercropped with the four varieties pigeon pea. The experimental design was a randomized complete block design with five treatments replicated three times. Thus, the treatments were sole maize and maize intercropped with four varieties of pigeon pea (TCC 6^{A}, TCC 8127^{C}, IAR & T 16^{B}& IAR &T 50). The planting distance of monoculture and intercrop maize was 50cm x 50 cm and that of pigeon pea was 1m x 1m within and between rows. In addition, the dimensions of the plots were 3m x 3m with the land area measuring 36 m x 36 m. Hence, the data of the growth [height (cm), stem girth (cm), number of leaves] and yield (biomass and grain yield) of the maize and pigeon pea were taken.

Experiment 3: The variety of pigeon pea IAR&T 50 was significantly ($p\leq 0.05$) higher in growth and yield which was selected for use in 2008 experiment. The land preparation and weeding was done manually. The dimension of each plot was 4 m x 3 m, and the total land area used was 45 m x 20 m. The experimental design was a 2 x 2 x 3 factorial in a randomized complete block design using a split plot. Therefore, the factors were: mycorrhizal inoculation - 2 levels, organomineral fertilizer applications-2 levels and planting systems- 3 levels (sole maize, sole *Cajanus cajan* and maize - pigeon pea intercrop). Suwan-1-SR varieties of maize and IAR&T50 long duration pigeon pea were also planted. The planting distance of monoculture and intercrop maize was 50cm x 50 cm while that of pigeon pea was 1m x 1m within and between rows. *Glomus clarum* was inoculated at the rate of 1,200 kg ha^{-1} and 300 kg ha^{-1} for maize and pigeon pea respectively using ring application method of depth 0 – 5cm at planting. Organomineral

fertilizer was applied at the rate of 2000 kg ha^{-1} three weeks after planting and ring application method was also used. However, all the yields were converted to tonnes per hectare, and the market prices of maize and pigeon pea were also determined (Table 1).

Experiment 4: The residual experiment was conducted in 2009. The experimental design was a 2 x 2 x 3 factorial in a randomized complete block design using a split plot. Therefore, the factors were: mycorrhizal inoculation - 2 levels, organomineral fertilizer applications-2 levels and planting systems- 3 levels (sole maize, sole *Cajanus cajan* and maize - pigeon pea intercrop). Suwan-1-SR varieties of maize and IAR&T50 long duration pigeon pea were also planted. The planting distance of monoculture and intercrop maize was 50cm x 50 cm, while that of pigeon pea was 1m x 1m within and between rows. Weeding was carried out manually and organomineral fertilizer was applied. The growth and yield parameters such as Plant height (cm), stem girth (cm), number of leaves, the dry matter of shoot (kg $ha^{-1)}$ and grain yield (kg ha^{-1}) were also evaluated. However, the leaf area of maize was determined according to Remison and Lucas (1982).

Table 1: Market Prices of Experimental Materials

Material	Price in Naira
Maize	110, 000 per tone
Pigeon Pea	84,000 per tone
Organomineral fertilizer	60,000 per hectare
Mycorrhiza	20,000 per hectare

Source: Market Survey (2009)

Analytical Technique

The most basic tool generally employed by agricultural scientist to evaluate intercrops is the Land Equivalent Ratio (LER) (Mead and Rilley, 1980). It is calculated as:

$$\text{LER} = \frac{P_1}{M_1} + \frac{P_2}{M_2} \qquad \ldots \quad (1)$$

Where, P_1 and P_2 are the yields of two different crops in intercrops (Maize and Pigeon peas), and M_1 and M_2 are the yields of those crops in monocultures. Therefore, any result above 1 would signify an intercrops advantage, and any result that is below one would indicate a monoculture advantage. Thus, the problem with LER is that it does not capture the economic return of the farming system (Vandameer, 1989).

The solution to this problem is provided by calculating the Relative Value Total (RVT) of the crop mixtures. Such calculation is relevant for farmers who have monetary value as his farming goal (13). However, RVT is given as

$$RVT = \frac{aP_1 + bP_2}{aM_i} \quad \ldots \quad (2)$$

Where P_1, P_2, M_i are as defined in equation (1), a and b are the market prices of crop 1(maize) and 2 (pigeon pea) respectively.

A slightly more complex but a better measure of economic advantage of intercropping or mixed cropping was given by Moseley (1994), termed Replacement Value of Intercropping (RVI). RVI is superior to RVT because it accounts for variable cost during the production process.

Thus, RVI is computed as

$$RVI = \frac{aP_1 + bP_2}{aM_i - C} \quad \ldots (3)$$

Where a, b, P_1, P_2 and $_I$ are as defined previously.

C is the variable costs associated with monocropping. The variables costs (C) in this experiment are labour cost, cost of planting materials and fertilizer. However, labour cost is treated to be constant in this study because almost equal amount of time was spent on each of the treatment. The amount of hours spent on clearing, weeding, fertilizer applications were assumed to be equal in all the experiment. Therefore, equations 1, 2 and 3 were used to analyse the relevant data.

Results

Soil Analysis

The soil pH ranges from 5.6 to 6.5. However, it indicated an increase near neutral and there was a significant ($p \leq 0.05$) increase in organic carbon. Organic carbon increased from 14.9 g kg^{-1} to 31.1 g kg^{-1} in 2008, and then to 35.6 g kg^{-1} in 2009. There was mark progressive increase in nutrient elements (N, P, K, Ca, Mg) from below critical value to above critical value. Effective cation exchange ranged from 1.71 to 6.47 and there was also an increase in the base saturation. Thus, the textural class of the soil was loamy sand (Table 2).

Table 2: Soil chemical and physical properties analytical results

Parameters	Ekpoma	Ekpoma	Ekpoma
	2007	2008	2009
pH(water)	5.56	6.30	6.50
Organic Carbon (g/kg)	14.90	31.10	35.60
Nitrogen (g/kg)	3.60	7.60	8.70
Phosphorus (mg/g)	6.75	7.30	8.04
Potassium (cmol/kg)	0.08	0.11	0.64
Magnesium (cmol/kg)	0.36	1.13	1.81
Calcium (cmol/kg)	0.57	1.50	3.40
Sodium (cmol/kg)	0.10	0.37	0.38

Exchangeable acidity	0.30	0.80	0.60
ECEC	1.71	3.88	6.47
Base saturation	64.91	79.38	90.73
Particle Size Analysis (g/kg)			
Sand	832	834	844
Silt	114	104	74
Clay	54	62	82
Textural Class	Loamy sand	Loamy sand	Loamy sand

Organomineral Fertilizer

Organomineral fertilizer which is a product of compost market waste fortified with mineral fertilizer and its nutrients content is shown below (Table 3).

Table 3: Nutrient content of organomineral fertilizer grade A

Elements	values
total Nitrogen (g/kg)	44.00
Available phosphorus (mg/kg)	11.00
Exchangeable Bases (cmol/kg)	
K	6.80
Na	0.80
Mg	10.80
Ca	6.80
Extractable micronutrients (mg/kg)	
Mn	558.30
Fe	8153.40
Cu	247.40
Zn	712.70

Source: Pace setter organomineral fertilizer plant, Ibadan.

Varietal Growth of *Canajus Cajan*

The height of IAR & T 50 and TCC 6A varieties of pigeon pea were significantly ($p \leq 0.05$) higher compared to IAR & T 16B and TCC 8127C (Table 4). The combined application of OMF and mycorrhizal inoculum has significantly ($p \leq 0.05$) increased the height of IAR & T 50 and TCC 6A compared to other treatments. However, IAR&T 50 and TCC6A varieties of pigeon pea showed a significant response to the combined application of mycorrhiza and OMF at twelve, sixteen and twenty weeks after planting. The stem girth of IAR&T 50 and TCC 6A were significantly ($P \leq 0.05$) influenced by the application of OMF and mycorrhiza than other varieties at twelve, sixteen and twenty weeks after planting. Thus, the number of leaves of IAR&T 50 was higher than other varieties throughout the growth period under the inoculation of mycorrhiza and OMF (Table 4).

Yield and Yield Component

It was observed that the application of OMF and mycorrhizal inoculum either separately or combined, significantly ($p \leq 0.05$) increased the grain yield of pigeon pea compared to the pigeon pea without OMF and mycorrhiza. Thus, this was mostly evidenced in IAR&T 50 and TCC 6A varieties of pigeon pea (Table 5). The grain yield of IAR&T 50 was significantly higher compared to other varieties of pigeon pea with and without the application of fertilizer. In addition, the above ground biomass of the four varieties of pigeon pea investigated was in the following order of significance: IAR&T 50 > IAR&T 16B > TCC6A > TCC 8127C. Hence, there was a significant interaction between varieties, OMF and mycorrhizal inoculation (Table 5).

Growth of Maize Intercropped with Pigeon Pea

The height of maize was positively influenced in intercrop with pigeon pea (TCC 8127C variety), and this could be as a result of its dwarf nature. There was no difference in the stem girth and the number of leaves of maize interplanted with varieties of pigeon pea (Table 6). The leaf area of maize was higher when interplanted with IAR&T 50 at four and six weeks after planting. However, at eight week after planting, the leaf area of maize was highest in maize interplanted with IAR&T 16B compared to other varieties of pigeon pea (Table 6).

Table 4: Growth of Pigeon pea (height(cm), stem girth (cm) and number of leaves) as affected by mycorrhiza inoculum and organomineral fertilizer application at twelve and sixteen week after planting in 2007.

Varieties	Mycorrhiza	OMF	Height(cm)		Stem girth(cm)		
			number of leaves				
inoculation	application	12	16	12	16	12	16
IAR&T16B	With	With	89.33b	129.67a	4.00b	4.63b	203.00b	296.00e
“	with	without	99.00b	134.00b	3.93b	5.00b	154.00c	292.00e
“	without	without	84.38b	114.00c	3.33c	4.03c	181.00c	245.00e
“	without	with	95.67b	117.50c	3.73b	4.20c	131.00c	276.00e
IAR&T50	with	with	125.23a	164.97a	4.50a	6.77a	431.00a	2345.00a
“	with	without	110.40a	144.10b	5.00a	6.63a	412.00a	1754.00b
“	without	without	125.10a	140.07b	3.70b	4.57b	260.00b	1233.00b
,,	without	with	120.03a	152.37a	3.93b	5.43b	438.00a	2148.00a
TCC6A	with	with	121.27a	152.93a	4.63a	6.73a	570.00a	1800.00b
“	with	without	115.33a	146.00b	3.17b	4.63b	458.00a	723.00c
“	without	without	104.15a	119.67c	3.20c	3.77d	249.00b	693.00c
“	without	with	123.48a	128.33c	3.87b	6.18a	453.00b	1594.00b
TCC8127C	with	with	96.20b	109.50c	3.40c	4.47c	209.00b	444.00d
“	with	without	98.00b	116.43c	3.13c	3.70d	199.00c	413.00d
“	without	without	83.86b	102.83c	3.17c	3.47d	128.00d	311.00e
“	without	with	81.10b	108.67c	3.40c	3.93d	214.00b	444.00d

Mean values with the same letter in the vertical column are not significantly different at P ≤ 0.05 according to Duncan's multiple range tests. .OMF = organomineral fertilizer

Table 5: Grain yield, dry matter yield and Nitrogen fixation as affected by mycorrhizal inculum and organomineral fertilizer application in 2007

Varieties inoculation	Mycorrhizal application of shoot(tons/ha)	OMF Dry matter yield leaves (tons/ha)	Dry matter yield of (tons/ha)		Grain yield
IAR&T16B	With	With	7.28a	2.42a	0.95d
"	with	without	5.11b	1.70b	0.86d
"	without	without	4.05c	1.32b	0.64e
"	without	with	5.09b	1.72b	0.82d
IAR&T50	with	with	8.88a	2.87a	1.66a
"	with	without	8.32a	2.77a	1.29b
"	without	without	4.53c	1.45b	0.83d
,,	without	with	5.53b	1.90b	1.57a
TCC6A	with	with	2.28d	0.8.0c	1.60a
"	with	without	1.16d	0.4.0d	1.08c
"	without	without	5.94e	2.01d	0.82d
"	without	with	1.11d	0.38d	1.44b
TCC8127C	with	with	1.057d	0.36d	1.02c
"	with	without	1.16d	0.40d	1.03c
"	without	without	4.39e	1.56d	0.48e
"	without	with	1.10d	0.37d	1.14c

Mean values with the same letter in the vertical column are not significantly different at P ≤ 0.05 according to Duncan's multiple range tests. OMF = organomineral fertilizer.

Table 6: Growth of maize intercropped in four varieties of pigeon pea: height (cm), stem girth (cm) and number of leaves) at four, six and eight weeks after planting 2007.

Height(cm)			Stem girth (cm)				Leaf area (cm^2)			Number of leaves		
				Cropping								
System	4	6	8	4	6	8	4	6	8	4	6	
Sole maize	19.00a	26.93b	47.80b	5.00a	5.40a	5.60a	138.34b	225.89	351.73a	8.00	10.00	12.00
Intercropping												
Maize in IAR&T 16B	20.00a	27.00b	46.60b	4.10a	5.00a	5.20a	141.75b	165.00b	270.40b	8.00	10.00	12.00
Maize in IAR&T 50	23.10a	30.10b	35.64c	4.60a	5.20a	6.00a	206.40a	213.67a	288.43b	8.00	10.00	12.00
Maize in TCC 6A	24.60a	30.10b	35.10c	4.60a	5.00a	5.10a	150.10b	206.23b	216.54c	8.00	10.00	12.00
Maize in TCC8127C	28.10a	42.10a	58.23a	4.40a NS	4.60a NS	5.20a NS	181.50b	206.50b	261.00b	8.00 NS	10.00 NS	12.00 NS

Mean values with the same letter in the vertical column are not significantly different at P ≤ 0.05 according to Duncan's multiple range tests.

Yield of M**aize – Pigeon Pea Intercrop**

The grain and dry matter yield of maize intercropped with IAR&T 50 were 1.55 and 1.96 tonnes per hectare respectively and were significantly ($p< 0.05$) higher compared to other varieties. The least grain and dry matter yield was obtained from TCC8127C with the average values of 1.30 and 1.58 tonnes per hectare respectively (Table 7).

Growth of M**aize – Pigeon Pea Intercrop under OMF and Mycorrhiza**

The height of maize was significantly ($p\leq 0.05$) reduced in intercrop without the application of OMF and mycorrhiza at eight week after planting in 2008 (Table 8). Therefore, it was observed that maize intercrop with pigeon pea were taller, had larger stem girth and leaf area compared to sole maize (Table 8). In 2009, the residual effect of mycorrhiza and organomineral fertilizer on maize increased their height when intercropped with pigeon pea. There was no difference in the stem girth of maize with or without application of fertilizer. However, the leaf area of maize either sole or intercrop were significantly ($p \leq 0.05$) increased by mycorrhiza and organomineral fertilizer (Table 8).

Table 7: Yields of maize intercropped in four varieties of pigeon pea in 2007 (tonnes per hectares).

Cropping system	Grain yield (Tons/ ha)	Dry matter weight (Tons/ ha)
Monocrop	1.39c	1.78b
Intercrop		
Maize in IAR&T 16B	1.36c	1.73b
Maize in IAR&T 50	1.55a	1.96a
Maize in TCC6A	1.42b	1.63c
Maize in TCC8127C	1.30c	1.58c

Mean values with the same letter in the vertical column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range tests.

Effect of OMF and Mycorrhiza on the Yield of M**aize – Pigeon Pea Intercrop**

Monoculture maize under the combined application of OMF and mycorrhiza had significant ($p \leq 0.05$) higher yield, with an average yield of 2.15 tonnes per hectare compared to other treatments (Table 9). The inclusion of mycorrhiza and OMF application has also significantly improved the yield of intercrop maize compared to other treatments without fertilizer application. The application of OMF and mycorrhiza increased the yield of pigeon pea by 108 % and 97 % respectively than monoculture pigeon pea without OMF and mycorrhiza. The highest yield was obtained in monocrop maize and pigeon pea with the application of OMF and mycorrhiza. In the residual experiment, there was no significant difference in

the yield of maize among treatments except for control and monoculture with mycorrhiza. Also, the lowest yield was recorded in monoculture and intercrop pigeon pea without OMF and mycorrhiza. However, intercrop maize was 60 % higher in yield than monoculture maize (Table 9)

Table 8: Growth of maize and pigeon pea as affected by OMF and mycorrhiza in maize – pigeon pea intercrop under field conditions at Ekpoma in 2008 and 2009 at eight and twenty week after planting respectively.

Treatments	height (cm) maize		stem girth (cm) maize		Leaf area (cm^2)		Height (cm) pigeon pea		stem girth (cm) pigeon pea	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
AM +OMF +Sole P							218.30a	239.54a	7.75a	7.87a
AM +OMF –Sole P							200.97a	214.63a	7.27a	7.27a
AM - OMF +Sole P							217.28a	229.30a	7.48a	8.22a
AM - OMF –Sole P							185.42b	218.09a	6.42ab	7.38a
AM+OMF +MP Intercrop	70.20a	94.00a	6.20a	6.16a	553.81a	460.24a	211.63a	233.47a	7.75a	7.47a
AM +OMF– MP Intercrop	72.38a	80.81b	6.27a	6.20a	490.32b	440.38a	185.32b	220.62a	6.83ab	7.76a
AM – OMF+MP Intercrop	72.93a	69.11c	5.90ab	5.96a	520.27a	400.26a	228.67a	235.46a	7.12a	7.82a
AM - OMF– MP Intercrop	62.37b	68.26c	5.20ab	5.60a	411.21b	377.79b	172.40b	218.22a	6.30ab	7.02a
AM +OMF +Sole M	75.00a	75.00b	6.98a	6.35a	493.74b	417.05a				
AM +OMF - Sole M	70.02a	70.02b	6.43a	5.87a	452.15b	354.17b				

Mean values with the same letter in the vertical column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range tests. AM- = without mycorrhizal inoculum; OMF+= with OMF; OMF- = without OMF; intercrop MP= intercrop maize – pigeon pea; sole maize; sole p= sole pigeon pea

Table 9: Experimental yields of maize and pigeon peas intercrop in tonnes per hectares

	Maize	Pigeon Pea	Maize	Pigeon Pea
	Experiment (2008)		Experiment (2009)	
Monocrop	1.41d	0.84c	1.25b	1.51b
Intercrop	1.20d	0.86c	2.00a	1.30b
Monocrop +Organomineral Fertilizer	1.75b	1.92a	2.69a	2.70a
Intercrop + Organomineral Fertilizer	1.78b	1.94a	2.18a	1.83b
Monocrop + Mycorrhiza	1.65c	1.65b	1.70b	2.79a
Intercrop + Mycorrhiza	1.98b	1.64b	2.11a	2.64a
Monocrop+Mycorrhiza+ Organomineral Fertilizer	2.15a	1.97a	2.74a	3.08a
Intercrop + Organomineral Fertilizer	1.74b	1.57b	2.43a	2.96a

Source: Experimental Data (2008 and 2009)

Land Equivalent Ratio and Economic Yield Advantage

Land Equivalent Ratio (LER) for control experiment was 2.10 (monocrops and intercrops of maize and pigeon pea without inclusion of organomineral fertilizer and mycorrhiza). Therefore, this means that 210% of the yield of maize and pigeon pea on intercrops is monocrops. The inoculation of mycorrhiza had the highest Land Equivalent ratio of 2.79 than other treatments (Table 10).

Relative Value Total (RVT) for control experiment is 1.88 (monocrops and intercrops of maize and pigeon pea without inclusion of organomineral fertilizer and mycorrhiza) (Table 10). It indicated that the farmers that practice intercropping of maize and pigeon pea will be making 188% of the income of the farmers who are involved in maize and pigeon monocropping. The inoculation of mycorrhiza had the highest RVT of 3.29. Therefore, this means that more income will be realized by the farmers by including mycorrhiza in the intercrops of maize and pigeon peas than with or without organomineral fertilizer.

The Replacement Value of Intercropping (RVI) for control experiment is 1.81 (monocrops and intercrops of maize and pigeon pea without organomineral fertilizer and mycorrhiza) (Table 10). Thus, this signifies that the farmers that practice intercropping of maize and pigeon pea will be making 81% profit more than the farmers who are involved in maize and pigeon monocropping. However, the profit (gain) of the farmers

involved in the intercrops is possible due to reduction in the cost of production as an economic advantage of intercropping.

Table 10: LER, RVT and RVI of maize and pigeon peas in monocropping and intercrops in the study area

Treatment	Land Equivalent Ratio (LER)	Relative Value Total (RVT)	Replacement Value of intercropping (RVI)
Monocrop Intercrop	2.10	1.88	1.81
Monocrop +Organomineral Fertilizer Intercrop + Organomineral Fertilizer	1.66	1.49	1.09
Monocrop + Mycorrhiza Intercrop + Mycorrhiza	2.79	3.29	3.27
Monocrop+Mycorrhiza+ Organomineral Fertilizer Intercrop + Organomineral Fertilizer	1.75	1.56	1.51

Source: Computed from the Experimental Data

Discussion

Integrated Nutrient Management is the management that combines organic and mineral methods of soil fertilization with physical and biological measures for soil and water conservation. Combine application of OMF and mycorrhizal inoculum had the potential to improve soil nutrient content and the yield of maize and pigeon pea.

However, the pH of the soil increased to near neutral due to the cultivation of pigeon pea and the application of OMF fertilizer. It was earlier reported that the cultivation of pigeon pea, inclusion of mycorrhiza and OMF application increased soil pH toward neutral (Heichel et al. 1991; Makinde et al. 2007). Also, the cultivation of pigeon pea and the application of fertilizer on the soil increased the mineral nutrient status (nitrogen, phosphorus, potassium, magnesium) and organic matter above critical values (Enwenzor et al. 1989). Adetunji and Okeleye (2001) reported that incorporation of legume pruning increased soil organic matter and plant growth, while mycorrhizal inoculation have been known to improve crop yield (Dare et al. 2008). Moreover, Ledgard and Giller (1995) reported that the benefits of intercrop are attributed to subsequent crops as the main transfer pathway is by the root and nodule senescence and fallen leaves. Also, Ogazi and Omueti, (2000) reported that the application of organomineral fertilizer improves the physical, chemical and microbiological properties of the soil and also supply micronutrient, high amount of calcium and magnesium

which reduces the hazard from the use of liming material. The decomposition of the residues of pigeon pea increased the organic matter of the soil, and this confirmed the work done by Hayat et al. (2008). Thus, the soil cultivated with pigeon pea had higher phosphorus content, and this also conformed to the work of Vesterager et al., 2006.

The combined application of OMF and mycorrhizal inoculum significantly improved the growth and yield of pigeon pea. However, this was earlier reported that the combined application of organic base fertilizer and mycorrhiza improved the growth and yield of crops such as maize, yam and cassava (Ortas et al. 2005; Shibata and Yano, 2003).

It was also observed that inoculation of mycorrhizal fungi significantly ($p \leq 0.05$) increased the yield of maize and pigeon pea under mono and intercropping system. This has also been reported by Ogungbe and Fagbola (2008) that mycorrhiza enhanced the growth and yield of maize.

The residual effect of organomineral fertilizer and mycorrhiza on the yield of maize and pigeon pea was significantly high and these confirmed the earlier work of Chung et al. (2000). The residual effect of OMF on the yield of maize and pigeon pea were highly significant and this was in agreement with the earlier work done by Makinde (2007). Ayoola and Makinde, (2009) reported significant increase of maize yield under the application of organic base fertilizer and this was confirmed by the result of this experiment. Also, the residual effect of mycorrhizal inoculum was also significantly higher in miaze and pigeon pea compared to treatment without mycorrhiza. In addition, Plenchett et al. (1983), reported that the wide spread of the fungi network through its filaments gives the plant-root mycorrhizae access to a much larger volume of soil than the root system itself which necessitated a higher nutrient uptake by plants and which eventually resulted to higher yield.

Land Equivalent Ratio (LER) for monocrops and intercrops of maize and pigeon pea without inclusion of organomineral fertilizer and mycorrhiza was 2.10. It means that 210% of the yield of maize and pigeon pea on intercrops is monocrops. In other words, the farmers will be using more than twice of the land in intercrops of maize or pigeon pea to produce the same quantity of maize and pigeon pea if they are planted singly. Therefore, this implies that more land will be saved and more yields will be obtained if these crops are in intercrops than monocrops. Remison, (1980) has alluded to increased yield as an intercropping advantage of maize intercrops in Nigeria. EDIS (2009) have also documented the importance of mycorrhiza in increasing the crop yields. Since all the treatments have LER that is greater than one, it means that it may be more advantageous to plant maize and pigeon peas in intercrops than in monocrops. Farmers practicing intercropping of maize and pigeon pea made 81% profit more than those

farmers who are involved in maize and pigeon monocropping. The profit (gain) of the farmers involved in the intercrops was possible due to the reduction in the cost of production as an economic advantage of intercropping. The man-days in weeding of intercrops were reduced as a result of the ability of the companion crops to suppress the obnoxious weeds. Also, the ability of companion crops to reduce spread of weeds has been observed by Alabi and Onolemhemhen (2001). The cost of fertilizer will also be reduced in inter-cropping due to the ability of companion crops to reduce the impact of rainfall and erosion, thereby reducing the nutrient depletion of the soil (Alabi and Esobhawan, 2006).

Moreover, inoculation of mycorrhiza can significantly increase the profit of the farmers who are involved in the planting of maize and pigeon pea intercrops. However, the RVI for the treatment with the inclusion mycorrhiza is 3.27. This means that inoculation of mycorrhiza may double the profit of the farmer. Hence, this is evident when we compared the RVI of the treatment with mycorrhiza (RVI=3.27) with control experiment (RVI= 1.81). Thus, the result corroborate with the report of EDIS (2009) and Plant Health Care (2007).

Conclusion and Recommendations

The effects of organic base fertilizer application on the yield and economic advantage of maize – pigeon pea intercrop was investigated;

Integration of mycorrhiza and OMF significantly ($p< 0.05$) increased the growth and yield of maize and pigeon pea in both cropping system.

The Land Equivalent Ratio (LER) shows that 210% of the yield of maize and pigeon pea intercrops is monocrops. The farmer will have higher yield for intercrop compared to monocrop using the same hectrage. The Relative Value Total (RVT) indicates that the farmers that practice intercropping of maize and pigeon pea will be making 188% of the income of the farmers who are involved in maize and pigeon pea monocrops. Likewise, the Replacement Value of Intercropping (RVI) reveals that the farmers that practice intercrop of maize and pigeon pea will be making 81% profit more than the farmers who are involved in maize and pigeon pea monocrops. Moreover, the study further revealed that inoculation of mycorrhiza in maize-pigeon pea intercrop can significantly increase the profit of the farmers who are involved in the planting of maize and pigeon pea intercrops, as the RVI for the treatment with the inoculation of mycorrhiza is 3.27. In conclusion, maize-pigeon pea intercrop has relative economic advantage over their monocrops and this relative advantage can be enhanced by the inoculation of mycorrhiza. Therefore, farmers are encouraged to practice intercropping system mostly with legumes and

cereals. Also, the soil and yield can be enhanced with mycorrhizal inoculation.

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