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AGROECONOMIC ANALYSIS OF FERTILIZER EFFECTS ON MAIZE/COWPEA INTERCROP IN ILE-IFE AND ABEOKUTA, SOUTHWESTERN NIGERIA

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ABSTRACT

Optimizing crop yield and farm income levels under continuous cropping system makes external sourcing of nutrients inevitable. The integration of leguminous plants into maize-based crop production systems have been identified as an environmentally-friendly and profitable technology for promoting food security and incomes of poor rural farming households. This paper investigates the effects of different levels of inorganic nitrogen fertilizer on DMRE-SRY cultivar of maize output, and determines the economic benefits derivable in a maize/ cowpea intercrop production system in the rain forest and derived savanna zones of southwestern Nigeria. With maize and cowpea maintained separately at a spacing of 0.90 m x 0.20 m and 0.90 m x 0.30 m, respectively, with two seeds per hill, a plant population of 111,111 and 74,074 were obtained per hectare for each crop during the 2003, 2004 and 2005 experimental periods. The two component crops were planted in strip rows of 2:2 cowpea in between maize. Data were collected on inputs and costs, as well as on crop outputs and prices. Data were analysed with descriptive statistics and budgetary technique. Results showed that maize grain yield was highly influenced by fertilizer levels. The highest grain yield of 4.07 t/ha recorded in the rain forest was significantly higher than the 2.1 t/ha obtained for the derived savanna zone at the 135 kg N/ha level of fertilizer application. The gross margin of maize increased from N31,950 at 90 kg N/ha to N52,520 at 135 kg N/ha in the forest while a reduction in loss was obtained for the savanna zone as fertilizer levels increased from 90 kg N/ha to 135 kg N/ha. The promotion of maize/ cowpea intercrop at appropriate fertilizer use levels is, therefore, a promising agronomic practice for promoting sustainable maize production in the study area.

Key words: Economic, Agronomic, Maize/cowpea Intercrop, Fertilizer, Agroecological zones.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crop in the diet and economy of Nigeria where over 50 million people consume on average 43 kg of maize per year (Olayide *et al*., 1980; Olayemi and Ikpi, 1995). Among different income groups, maize is a relatively more important source of calories for the poorer proportion of consumers (Mafongoye *et al.,* 2003). With more than 50 % of all households assigning over 50 % of their

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cereal area to maize, maize production dominates the farming system in Nigeria and hence it is of strategic importance for food security and the socio-economic stability of the country (Ogunbodede and Olakojo, 2001).

Fakorede *et al*. (2002) and Adegbite *et al.* (2002) referred to maize among the cereals as the crop with the highest yield potential, which is invaluable for the nourishment of both man and animal. Its production and utilization potentials have also increased greatly in recent times and the crop is the centre piece of green revolution (Fakorede *et al*., 2001). However, factors such as the mounting population pressure, urbanization and the competing economic uses of agricultural land have led to a reduction in land holdings and a consequent intensification of land use (Bamire and Amujoyegbe, 2004). This invariably affects the soil structure and nutrient status as well as the yield and income levels of the farming household (Juo and Lal, 1977; Bamire and Manyong, (2003). The declining yield level presents a need to develop a more sustainable production system, as the nutrient availability from organic and natural sources alone become inadequate.

According to Jones and Wild (1975) and Mafongoya and Sileshi 2003), attaining appreciable yield under the continuous cropping system and the characteristic low level of nitrogen (N) and phosphorus (P) in soils makes external nutrient addition inevitable. Soil fertility and productivity can therefore only be maintained through efficient and increasing use of land improving and yield-increasing intensification technologies such as organic and inorganic fertilizers, alley cropping and tree planting. The adoption of these technologies by farm operators is however usually met with limitations due to various reasons: while the bulkiness, scarcity and wetness of organic fertilizers make it impossible for use on large farm lands, inorganic fertilizers are either costly or unavailable when required by farmers as the reserves of fossil fuels channeled to their production are limited and non-renewable (Ogoke *et al.,* 2001). This has caused most smallholders to grow maize with lower doses of N–P–K fertilizer. On the other hand, high inorganic N fertilizer causes soil acidification and it is therefore detrimental to crop growth (Pieri, 1992; Adetunji, 1994). Alley cropping practice, introduced by the International Institute of Tropical Agriculture (IITA) has also recorded a low adoption rate among smallholders in Nigeria as non-economic benefits are associated with the alley plants such as *Gliricidia sepium and Leucaena leucocephala* (Feder *et al*., 1985; Awe, 1997; IITA, 2003). In an attempt to enhance the food security and income of poor communities in maize-based cropping systems, the use of more environmentally friendly and profitable technologies have been suggested. Adetunji (1991) and Adegbite *et al.* (2002) have identified the integration of leguminous plants into the crop production system as most appropriate. In this system, Adetunji (1991) reported that recycling of soil nutrients occur by using legumes in the intercrop as it complements inorganic fertilizer use. Exner and Cruse (1993) claimed that legumes suppress weeds while Giller *et al*. (1994) and, Giller and Cadisch (1995) reported that they fix biological N and reduce soil erosion, while providing food to humans and or livestock. The integration of small amounts of inorganic fertilizer N along with organic material and N from annual legumes offers a strategy to meet the N needs of smallholder farms (Waddington and Heisey, 1997). The introduction of N_2-fixing legumes into continuous maize cropping systems can, therefore, serve as a cheap, and renewable source of N for the non-N-fixing crops involved in such systems (Ogoke *et al.*, 2001; Cheruiyot *et al.*, 2003). In this arrangement, maize dominates the cropping system, while some grain legumes, particularly cowpea, pigeon pea (*Cajanus cajan*) and groundnut (*Arachis hypogaea* L.), are grown in loose rotations with the maize.

Among the indigenous African grain legumes in the semi-arid zone of West Africa, cowpea (*Vigna unguiculata* (L.) Walp), has been reported to be the most economically important (Bationo *et al.*, 2003; Langyintuo *et al.*, 2003). It is an important component of the predominantly cereal/legume production system in the West African Semiarid Tropics (WASAT) region (Bationo *et al.*, 2003; Carsky and Iwuafor, 1999; Cheruiyot *et al.*, 2003; Sanginga *et al.*, 2003) and is usually grown as an intercrop with the major cereals, namely maize and sorghum (*Sorghum bicolor* Moench) or with yam (*Dioscorea spp*) (Steiner, 1984) depending on the agroecological zones. However, pertinent questions that arise from the use of this agronomic practice are: what is the effect of the legume/ maize interaction on crop yield and farmers' net income? How does this vary across agroecological zones? Providing answers to these questions is important for promoting food security and incomes of the farming households. Hence, the objective of this paper is to investigate the effect of different levels of inorganic nitrogen fertilizer on DMRE-SRY cultivar of maize output, and determines the economic benefits derivable in a maize/ cowpea intercrop production system in the rain forest and derived savanna zones of southwestern Nigeria.

MATERIALS AND METHODS

The study was conducted at the Teaching and Research Farm (T&RF) of the Obafemi Awolowo University Ile-Ife (OAU), Nigeria and the T&RF, University of Agriculture, Abeokuta (UNAAB). Geographically, OAU is situated within the rain forest zone, on latitude $7^0$28'N and longitude $4^0$33'E, at about 200 m above sea level. It experiences approximately eight months (March to October) of bimodal rainfall and has about four months (November – February) of dry season each year with slight irregularity in the rainfall distribution pattern. On the other hand, UNAAB is located in the derived savannah zone on latitude $7^0$9'N and longitude $3^0$21'E. It also experiences approximately eight months (March to October) of bimodal rainfall and has about five months (November – March) of dry season each year with slight irregularity in the rainfall distribution pattern. The weather data recorded for the sites were obtained from both the meteorological stations located within the T&R farm of O.A.U., and the Ogun-Osun River Basin Development Authority located within 2 kilometers to the UNAAB experimental site. The experiment was conducted from August to December for the cowpea and late maize cropping for the 2003 to 2005 periods. The soil of the experimental plots in the rain forest is classified as Ultisol (low base status forest soils), well drained, greyish brown to brownish red while, the soil in the savanna zone is an underlain basement complex rock with quartz schist, coarse grained and fine grained granite and gneiss as parent material (Aiboni, 2001).

The experimental design was a randomized complete block design (RCBD) in a split-plot arrangement and replicated three times at each location. The main plot is five cowpea sowing dates (0, 14, 28, 42 and 56 days after maize sowing (DAP), measured 33.8m x 4m (135.2 m^2) while the sub-plots were made up of four levels of N fertilizer applied to maize: 0, 45, 90 and 135 kg N/ha with a basal dose of 26 kg P_2O_5/ha and 26 kg K_2O/ha which were incorporated into the soil by broadcasting during land preparation. The plot was 4 m x 33.8 m (135.2 m^2) and contained four different levels of fertilizer randomly distributed on an area of 4 m x 7.2 m (28.8 m^2). The maize and cowpea were planted on flat with alternate double rows with 0.90 m between rows. The maize stands were maintained at 0.20 m within rows while the cowpea was at 0.30 m with two seeds per hill, to give a plant population of 111,111 and 74,074 plants/ha respectively. An early maturing variety of maize (*DMRE-SRY*) and determinate cultivar of cowpea (*OLOYIN*) were used so as not to have overlapping effect on maize.

Data were collected on inputs and costs, as well as on maize and cowpea outputs and prices and were analysed with descriptive statistics using means and percentages to describe the variables in the study. The partial budget technique was employed to analyse and compare the costs and returns to different fertilizer levels at various treatments in each location. According to Horton (1982) and Olusi (1990), the partial budget approach is expressed as: Gross Margin (GM) = Total Revenue (TR) – Total Variable Cost (TVC); where: TR = P x Q; (P = price in naira (N); Q = quantity of output (tonnes); TVC = Total variable cost. To compare the productivity of maize and cowpea in the intercrop under different fertilizer treatments, the land equivalent ratio (LER) employed by Osiru and Willey (1972) was adapted and computed:

$LER = YI_c / YM_c$; (the relative yield), where, YI_c = yield of crop C in intercrop; YM_c = yield of crop C in monocrop; Total $LER = RY_{maize} + RY_{cowpea}$.

RESULTS AND DISCUSSION

Productivity effects of fertilizer treatments on maize output in the maize/ cowpea intercrop

The effect of different levels of fertilizer on maize productivity in the intercrop was evaluated using the indices of relative yield (RY) and total land equivalent ratio (LER). Results show that the RY and LER of maize at the different levels of fertilizer varied significantly in the two agroecological locations (Table 1).

In the rain forest zone, the RY of the crops were < 1 at 0 kg N / ha and 45 kg N / ha while, the RY of maize was the same at 90 kg N/ ha and 135 kg N/ ha. The lower RY recorded for maize at 45 kg N/ ha as compared to the 0 kg N/ ha application showed that there was competition for the little N applied to maize in intercrop. This result corroborates the observation of Bationo and Ntare (2000) that cowpea responds to applied nitrogen in form of urea at low level by promoting the fodder yield but with no effect on grain yield. The inter-competition for the applied N at 45 kg N/ha may lead to the non-availability of adequate N needed by maize for proper silking and eventual grain development. On the other hand, the RY of cowpea though < 1, increased steadily as fertilizer levels increased but not significantly different from each other in the intercrop. The high relative yield of the *DMRE-SRY* cultivar of maize used at 90 and 135 kgN/ha levels of N reveal the significant benefit it derives from the intercrop. In the derived savanna, the RY of the crops were < 1 at all the levels of fertilizer but increased steadily as N level increased. This may be due to the poor precipitation distribution during the trial period, which prevents effective utilization of the applied N. This result supports the findings of Adetiloye (2001) that adequate moisture is required for the effective utilization of applied N in soil. However, the LER at the two locations for each treatment was > 1, indicating that the crop combination had superior nutrient impact on the soil. Thus, the productivity of maize in the maize/ cowpea intercrop is enhanced while the potentials of the land resource base are maintained.

Costs and returns to maize/ cowpea intercrop under different fertilizer levels

The effects of N fertilizers on gross margin in the two agroecological zones are presented in Tables 2 and 3. For all fertilizer treatments, including 0 kg N/ ha application labour constituted the highest component of total variable cost in maize/ cowpea intercrop. For instance, at 135 kg N/ ha application, labour accounted for 29.6 % while miscellaneous expenses such as feeding, fuelling and storage (13.4 %), transportation (12 %), fertilizer purchase (9.8 %) followed in descending order of dominance. The high costs of labour were attributed to its scarcity in carrying out the various farm operations during the period of the experiment. The TVC is about 62.2 % of Gross Income in the rain forest and 109.5 % in the derived savanna zone shows that input costs are more than 50 % of gross income in the two locations. This implies that the cost incurred on inputs was too much in the savanna, and need be taken into consideration by farmers in the area.

Grain yield was highly influenced by fertilizer level. The higher the fertilizer levels the higher the grain yield of maize in the intercrop. However, a minimal level of fertilizer (> 45 kg N/ ha) is required to support higher grain yields above zero level fertilization. There was an increase of about 45 and 80 %, respectively, when 90 and 135 kg N/ha levels of fertilizer were used in the rain forest zone, while the savanna recorded an increase of 74.5 and 95.3 % respectively. This corroborates the findings of Adetunji (1996). Sanginga *et al.* (2003) had also indicated that there would be reduced competition for N due to greater N fixation efficiency and transfer of N to the non-legume component in the intercrop.

The highest total revenue of N138,320 was recorded in the rain forest zone at 135 kg N/ ha. This is significantly different at 1 % from the derived savanna estimate of N78,660 under the same fertilizer treatment, in spite of the high price associated with maize in the savanna zone. In the forest zone, a gross margin of N17,000 was recorded at 0 kg N/ ha , while a gross loss of N2,150 was obtained at 45 kg N/ ha application. This shows that some level of gross margin is expected in a maize/ cowpea intercrop even in the absence of fertilization. However, the gross margin significantly increased from N31,950 at 90 kg N/ ha to N52,520 at 135 kg N/ ha. This implies that when fertilizer is to be applied in the maize/ cowpea intercrop, the minimum quantity that will give a high level of gross margin in the rain forest zone must be greater than 45 kg N/ ha.. In the derived savanna zone, however, a gross loss of N21,720 was recorded at 0 kg N/ ha application, and this decreased steadily to N7,440 at 135 kg N/ ha. This implies that increased fertilizer application is capable of reducing the gross loss recorded at zero fertilizer level. However, the trend reveals that the quantity of fertilizer that could result into a gross margin in the derived savanna zone of this study must be greater than 135 kg N/ ha.

SUMMARY AND CONCLUSION

The paper investigated the agronomic analysis of Nitrogen fertilizer in *DMRE-SRY* cultivar of maize and *OLOYIN* cultivar of cowpea and determined the economic benefits derivable in the intercrop for the derived savanna (Abeokuta) and rain forest (Ile-Ife) zones of southwestern Nigeria.

Results showed that the RY and LER of maize varied significantly at the different levels of fertilizer in the two agroecological locations. The relative yield of maize was high in the rain forest zone which signified that significant benefit is derived from the intercrop, while this was low in the derived savanna at the various levels of fertilizer application. The superior estimate obtained for the land equivalent ratio in the two locations suggests that the productivity of maize in the maize/ cowpea intercrop is enhanced while the potential of the land resource base is also maintained. Total variable costs incurred increased with increase in the level of fertilizer application. For all fertilizer treatments, labour constituted the highest component of total variable cost in the maize/ cowpea intercrop. The high costs of labour are attributed to its scarcity in carrying out the various farm operations during the experimental period. Grain yield was highly influenced by fertilizer level. The higher the fertilizer levels the higher the grain yield of maize in the intercrop. It is important to note that lack of inorganic fertilizer could still sustain production in a maize cowpea intercrop but to a very small extent.

A gross margin of N52,520 was obtained at 135 kg N/ ha in the rain forest, while a gross loss of N7,440 was recorded in the derived savanna zone. However, the trend reveals that the quantity of fertilizer that could result into a gross margin in the derived savanna zone of this study must be greater than 135 kg N/ ha (Table 2). The application of appropriate quantities of Nitrogen fertilizer should therefore be encouraged among maize/cowpea intercrop farm operators.

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Table 1: Effect of fertilizer on relative yield (RY) and land equivalent ratio (LER) of maize and cowpea in the intercrop

Fertilizer levels (kg N/ ha)	Rain Forest			Derived Savanna		
	Maize Relative yield	Cowpea Relative yield	LER	Maize Relative yield	Cowpea Relative yield	Land equivalent ratio (LER)
0 (control)	0.93	0.51	1.44	0.50	0.67	1.17
45	0.81	0.50	1.31	0.68	0.66	1.34
90	1.35	0.47	1.82	0.88	0.70	1.58
135	1.35	0.64	1.99	0.98	0.78	1.76
SE	0.28	0.08	0.36	0.21	0.05	0.26

SE = standard error of the mean

Table 2: Effect of N fertilizer on gross margin (N /ha) of *DMRE-SRY* maize cultivar in the intercrop at the forest agroecological zone**

Item	Nitrogen levels (kgN/ha)			
Cost (N)	0 (kgN/ha)	45 (kgN/ha)	90 (kgN/ha)	135 (kgN/ha)
1. Land (rent) @ N5,000 / ha	2,500	2,500	2,500	2,500
2. Seed (100/kg for 50 kg/ha)	5,000	5,000	5,000	5,000
3. Tractorization @ N2,500 / operation/ ha for 3 operations	7,500	7,500	7,500	7,500
4. Herbicide purchase (pre - emergence and contact)	8,000	8,000	8,000	8,000
5. Fertilizer (purchase)@ N2,800 /48kgN/ ha	0000	2,800	5,600	8,400
6. Labour				
(a) Planting @500/md for 15 md /ha	7,500	7,500	7,500	7,500
(b) Fertilizer application @ N500/md for 10md /ha	0000	5,000	10,000	10,000
(c) Herbicide spraying @ N500/md for 10md /ha	5,000	5,000	5,000	5,000
(d) Harvesting @ N300/md for 10md/ha	3,000	3,000	3,000	3,000
7. Harvesting Bag @ N125 /bag for 20 bag /ha	2,500	2,500	2,500	2,500
8. Transportation.	10,000	10,100	10,200	10,300
9. Miscellaneous	11,550	11,550	11,550	11,550
10. Total Variable Cost	62,000	70,400	83,200	86,100
11. Yield/tonnes/ha	2.21	1.95	3.02	4.07
12. Price /tonne (N)	35,000	35,000	35,000	35,000
Gross income (11x12)	77,350	68,250	105,700	142,450
Gross Margin (13-10)	15,350	-2,150	22,500	56.350

** Mean across 2003 to 2005 years of experimentation

Table 3: Effect of N fertilizer on the gross margin (N /ha) of *DMRE-SRY* maize cultivar in the intercrop in the savanna agroecological zone**

Item	Nitrogen levels (kgN/ha)			
Cost (N)	0 (kgN /ha)	45 (kg N/ha)	90 (kg N/ha)	135 (kg/ ha)
1. Land (rent) @ N8,000 / ha	4,000	4,000	4,000	4,000
2. Seed (100/kg for 50 kg/ha)	5,000	5,000	5,000	5,000
3. Tractorization @ N2,500 / operation/ ha for 3 operations	7,500	7,500	7,500	7,500
4. Herbicide purchase (pre - emergence and contact)	8,000	8,000	8,000	8,000
5. Fertilizer (purchase)@ N2,800/48kgN/ha	0000	2,800	5,600	8,400
6. Labour				
(a) Planting @650/md for 15 md /ha	9,750	9,750	9,750	9,750
(b) Fertilizer application @ N600/md for 10 md /ha	0000	6,000	8,000	10,000
(c) Herbicide spraying @ N600/md for 10 md /ha	6,000	6,000	6,000	6,000
(d) Harvesting @ N500/md for 10md /ha	5,000	5,000	5,500	6,000
7. Harvesting Bag @ N125 /bag for 20 bag /ha	2,500	2,500	2,500	2,500
8. Transportation.	12,000	12,100	12,200	12,300
9. Miscellaneous	12,550	12,550	12,550	12,550
10. Total Variable Cost	72,300	81,200	86,600	92,000
11. Yield/tonnes/ha	1.06	1.43	1.85	2.37
12. Price /tonne	40,000	40,000	40,000	40,000
13. Gross income (11x12)	42,400	57,200	74,400	94,800
Gross margin (13-10)	**-29,900**	**-24,000**	**-12,200**	**2,800**

** Mean across 2003 to 2005 years of experimentation

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