THE ECONOMICS OF MAIZE PRODUCTION UNDER DIFFERENT COWPEA-BASED GREEN MANURE PRACTICES IN THE DERIVED SAVANNA ZONE OF NIGERIA

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Abstract

There is a challenge in Nigeria of how to sustainably increase land productivity in the face of land pressures, un-availability and/or high cost of fertilizers, and reduced fallow periods. The present study analyzed the economic potential of producing maize under different regimes of cowpea green manure cropping. Two different field experiments were carried out in the derived savannah zone (part of the grain belt) in Nigeria in the 2009 and 2010 planting season. The first trial evaluated the performance of succeeding maize crops grown after the application of two varieties of cowpea green manure (Drum and Oloyin), grown at different population rates. The second trial involved the agronomic and economic evaluation of succeeding maize yield using three populations of the green manure from the Oloyin under in situ mulch or tilled-in. The field experiments were simultaneously conducted under standardized growth conditions. Production data (input used and output), yield characteristics, and implicit and explicit cost data were collected. The data were analyzed using descriptive statistics and budgetary analysis. The results show that maize grain yield was significantly enhanced ($p \leq 0.05$) by using cowpea green manure. Compared to the controlled plot (no green manure) yields, the net yield was 49% and 75% higher in Experiment I, and by 65% and 69% higher in Experiment 2, in the years 2009 and 2010 respectively. A dense green manure population in the preceding year (>80,000 plants/ha) raised both yield (3,630kg) and profit (N.145,620)[1] of maize per hectare in Experiment I. The study concludes that the use of cowpea as green manure raises the economic profits from maize production. The net profit realized was found to be significantly greater ($P \leq 0.05$) than the reported mean profit (N.113,660) from the use of chemical fertilizer in the location. The study recommends that manuring maize plots with Drum variety at a minimum population of 80,000 plants/ha is the most economically profitable in maize production system that can be used by small farmers to sustainably raise income and promote soil health as an alternative to chemical fertilizers.

Keywords: Green manure, cowpea, derived savannah, gross margin.

[1] Nigerian currency: naira (NGN); NGN1000 = €5.00 = US$6.35, www.coinmill.com, October 2012.

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Introduction

Agricultural production is the mainstay of the Nigerian economy. Agriculture is the single largest contributor to the well-being of the rural poor in Nigeria, sustaining about 86 percent of rural households in the country. The sector provides employment for over 70% of the economically active population (NBS 2006), it is the major source of domestic food consumed, and it contributes about 46% to the Gross Domestic Product (Idachab 1998; NBS 2006; Agbonlahor 2010; Sanyal & Babu 2010). Because agriculture is the largest employer of all sectors (accounting for 70 percent of the work force) and labor is the main (and sometimes only) asset for the poor (Agenor et al., 2003), the agricultural sector has the greatest potential for reducing poverty in Nigeria. Improved agricultural development and growth can offer a pathway out of poverty. In the light of this view, the government (Federal, State and Local) now promotes the agricultural sector as an essential driver of economic growth and ingredient for the country's development strategy. This trust is built on the country's rich, favorable agro-ecological conditions, and the fact that most of the population live in rural areas.

A series of strategies has recently been designed that aim to accelerate agricultural growth, strengthen food security, and reduce poverty. The agricultural production landscape is dominated by resource poor farmers who cultivate food crops (intercrop) in small (< 1ha) land holdings with little or no use of purchased inputs. The dismal performance of the agricultural sector in terms of its contribution to Nigeria's yearly total revenue in the last three decades prompted the government to initiate several agricultural schemes and programs to enhance agricultural productivity in Nigeria, which include the following: the River Basin Development Authorities, the National Accelerated Food Production Project, the Agricultural Development Project, Operation Feed the Nation, the Green Revolution, the National Directorate of Food, Roads and Rural Infrastructure, the Agricultural Credit Guarantee Scheme Fund, the National Special Programme for Food Security, Root and Tuber Expansion Project, and the National Fadama program. With a burgeoning population, estimated at about 150 million, and an annual growth rate of 4.1% which increasingly limit access to natural resources, the need to shift toward an environmentally responsible and 'greener' economy has become increasingly apparent.

Maize is a dominant component of the crop production system in the derived savanna zone2. The bulk of cereal production in Nigeria is located in the derived savanna zone hence the name 'the grain belt' of the country (Ismaila et al., 2010; Kudi et al., 2011). The importance of maize is tied to its use both as a basic staple food and its use as major source of energy feedstuff in livestock feed.

Cowpea is the most popular edible legume cultivated in Nigeria. It is used as the base ingredient in the preparation of a wide range of food recipes. The agronomic potential as soil nitrogen fixer has not been fully exploited in the savanna zone.

A major limitation to maize production in Nigeria is the declining soil fertility which is exacerbated by the high cost and/or unavailability of chemical fertilizer (Ismaila et al., 2010). Achieving sustainable food security for the burgeoning population can only be achieved through the intensification of food production on existing crop land using

[2] The derived savanna zone is a transition zone between the southern forest and northern savanna zones. It is characterized by a vegetation type composed of tall shrubby grasses and sparse hard woods.

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enhanced soil nutrient, input and recycling methods (Hossner & Juo, 1999). Efforts directed towards ameliorating soil fertility problems include use of fallow land, however where fallow periods have been shortened below a critical level, the system can no longer sustain crop yield. Chemical fertilizer has also been used but it is often scarce and expensive especially at the peak demand periods (Hossner & Juo, 1999).

Green manuring is the practice of enriching the soil fertility by turning under, un-decomposed plant materials (other than crop residues), either at the location (in situ) or brought in from a different location (Pieters, 1927). Green manure is an age long practice in African, especially among farmers in Egypt and South Africa (Pieters, 1927). Research has shown that green manure can substitute for up to 60-100 kg fertilizer N/ha in the production of cereals (Ozowa, 1995). Green manure has also been found to enhance the availability of native phosphorous and other micronutrients to crops as well as improving soil aeration and organic matter (Abrol and Palaniappan, 1988; Maobe et at., 2011).

Despite these well reported benefits, green manuring is not a common soil improvement practice use by peasant farmers in Nigeria. Both economic and technical factors are responsible for this low rate of adoption. The economic factors are the more limiting. The costs of labour for establishment, maintenance and incorporation, the, seemingly zero output value, the time and land value to cultivate the manure crops are all disincentives to adoption. As opined by Agbonlahor et al., (2007), no farmer will adopt a soil amendment scheme, no matter how novel or innovative, if the economic benefits cannot be ascertained.

The present study seeks to explore the economics of producing maize under different cowpea green manure trials in derived savanna zone of Nigeria, specifically, the study objectives were to:

1. Determine the optimal cowpea variety and population density that when used as green manure will give the highest yield of maize
2. Determine the relative yield level and profitability of cultivated maize crops under green manuring.
3. Determine the significant differences in maize yield from different cowpea-based green manure schemes.

Materials and Methods

Two field trials were carried out at the Teaching Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria; Latitude 7º10'N and longitude 3º26'E, between May and September 2009 and repeated March to August 2010. In experiment I, two brown cowpea varieties that are popular in the zone (Oloyin and Drum[3]) were planted at three different planting densities, each in two consecutive years, in a 2 x 3 factorial combinations arranged in a Randomized Complete Block Design (RCBD). The control plot was left uncultivated (without green manure crop). The population densities for the Drum variety in 2009 were 26,666, 40,000 and 80,000 this was doubled in 2010 by reducing the intra-row spacing. Thus the planting densities for 2010 for Drum were 53,333 (75cm x 25cm), 80,000 (50cm x 25cm), and 160,000 (25cm x 25cm)plants per hectare. Population

3 Drum is the brown big bean creeping variety while Oloyin is erect and the bean size is smaller than Drum.

densities for Oloyin were kept constant for both years at 55,555 (60cm x 30cm), 111,111 (30cm x 30cm) and 222,222 (30cm x 15cm) plants per hectare. In the second experiment, three different population densities of Oloyin variety 55,555 (60cm x 30cm), 111,111 (30cm x 30cm) and 222,222 (30cm x 15cm) plants per hectare were used in the trial. The green manure was either left as mulch materials or uprooted and incorporated in situ as green manure after six weeks of planting to take advantage of the optimum vegetative growth.

A week after application of the cowpea green manure, open pollinated maize Suwan-1-Y was planted in each of the six green manure plots per block and the control plot which serve as the seventh treatment in each of the two experiments. Both yield and economic data (prices and labour use) were collected. The yield data was analyzed using analysis of variance (ANOVA) using GenStat Discovery (edition 3). The economic data were analyzed using gross margin analysis and inferential statistics.

Results and Discussion

The results show that maize grain yield was significantly enhanced ($p < 0.05$) by using cowpea green manure. Compared to the controlled plot (no green manure) yields, the net yield was increased 49% and 75% in Experiment I and by 65% and 69% in Experiment 2, in years 2009 and 2010 respectively. The economic benefit from using different populations of two cowpea varieties as green manure in maize production is shown in Tables 1 and 2. The partial budgetary technique reveals that the Drum variety of cowpea is economically more profitable as green manure material in maize production compared to the Oloyin variety.

The second experiment analyzed the economics of the incorporation method of the manure. The cost of green manure incorporation has been reported as a major constraint to adoption as it represents a major cost item (about 13%) of the variable cost in maize production. It was therefore necessary to analyze the economic benefits under different incorporation methods. The tilled-in method and the open mulch methods were assessed (Table 3 & 4). The tilled-in method is *in situ* manual turning-in of the entire above ground parts of the green manure materials. The evaluation of the performance of the succeeding maize plant, based on method of green manure incorporation shows that tilled-in green manure plots had higher yields compared to the mulched plots. As shown in Table 5, the in situ tilled-in green manure plots resulted in a 26% increase in the gross profits from maize compared to the mulch plots. Although tilled-in and mulch incorporation of green manure yielded a positive rate of return on investment, the tilled-in incorporation gave about 2.6 times more economic return compared to the mulch incorporated plots for every naira invested.

It was observed that maize grain yield in 2009 was generally lower compared to the succeeding year (2010) in Experiment I, and across all treatments, except in the control plots. This may be due to the yield enhancing effects of the accumulated organic matter and nitrogen in the soil after the initial treatment in 2009 as well as the increase in the planting density of the Drum variety in 2010. In 2009, the Drum variety had not achieved complete ground cover at the time of incorporation. Sullivan (2003) identified late planting, poor stand establishment, and water stress as factors that limit the growth of legumes.

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Table 1: Cost and Returns Analysis for maize production using two varieties of cowpea green manure and three planting densities (Nigerian naira) (Year 2009).

Item	*Drum plots*			*Oloyin plots*			*Control*
Plot	**P1**	**P2**	**P3**	**P1**	**P2**	**P3**	**P0**
Cowpea population	26,666	40,000	80,000	55,555	111,111	222,222	
Maize yield (kg/ha)	1,031	1,240	1,075	1,487	1,370	1,357	752
Gross returns (N/ha)	72,170	86,800	75,250	104,090	95,900	94,990	52,640
Cost (N/ha)							
Land preparation (N/ha)	18,000	18,000	18,000	18,000	18,000	18,000	18000
Cowpea seeds(N/ha)	1,120	1,680	3,360	3,733	7,466	14,932	
Planting cowpea	9,000	9,000	9,000	9,000	9,000	9,000	
Incorporation	18,000	18,000	18,000	18,000	18,000	18,000	
Maize seed	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Planting of maize	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Weeding	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Harvesting of maize	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Total variable cost	102,880	103,440	105,120	105,493	109,226	116,692	74,760
Gross Margin	-30,710	-16,640	-29,870	-1,403	-13,326	-21,702	-22,120

Table 2: Cost and Returns Analysis for maize production using two varieties of cowpea green manure and three planting densities (Nigerian naira) (Year 2010).

Item	*Drum plots*			*Oloyin plots*			*Control*
Plot	**P1**	**P2**	**P3**	**P1**	**P2**	**P3**	**P0**
Cowpea population	53,333	80,000	160,000	55,555	111,111	222,222	
Maize yield (kg/ha)	2,780	3,590	3,630	1,541	1,402	1,332	721
Gross returns (N/ha)	194,600	251,300	254,100	107,870	98,140	93,240	50,470
Cost (N/ha)							
Land preparation (N/ha)	18,000	18,000	18,000	18,000	18,000	18,000	18,000
Cowpea seeds(N/ha)	2,240	3,360	6,720	3,733	7,466	14,932	
Planting cowpea	9,000	9,000	9,000	9,000	9,000	9,000	
Incorporation	18,000	18,000	18,000	18,000	18,000	18,000	
Maize seed	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Planting of maize	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Weeding	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Harvesting of maize	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Total variable cost	104,000	105,120	108,480	105,493	109,226	116,692	74,760
Gross Margin	90,600	146,180	145,620	2,377	-11,086	-23,452	-24,290

Table 3: Cost and Returns Analysis for maize production using cowpea green manure (Oloyin), three planting densities and two different incorporation methods (Nigerian naira) (Year 2009).

Plot & treatment	P1 Tilled-in	P2 Tilled-in	P3 Tilled-in	P1 Mulch	P2 Mulch	P3 Mulch	Control
Maize grain yield(Kg/ha)	2,140	2,490	2,260	1,730	1,680	1,760	1,710
Gross returns at N. 70/Kg of grain	149,800	174,300	158,200	121,100	117,600	123,200	119,700
Variable costs							
Land preparation 20 WD/ha	18,000	18,000	18,000	18,000	18,000	18,000	18,000
Cowpea seed 20 Kg at N.100 or N. 160 per Kg	3,733	7,466	14,932	3,733	7,466	14,932	
Planting of cowpea 10 WD	9,000	9,000	9,000	9,000	9,000	9,000	
Incorporation of green manure 20 WD	18,000	18,000	18,000	9,000	9,000	9,000	
Maize seed 23 Kg at N.120/Kg	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Planting of maize 10 WD	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Weeding 1st and 2nd 40 WD	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Harvesting of maize 10 WD	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Total variable cost	105,493	109,226	116,692	96,493	100,226	107,692	74,760
Gross margin/ha	44,307	65,704	41,508	24,607	17,374	15,508	44,940

(WD = work day (N.900); P1=55,555, P2=111,111, P3=222,222 plants/ha)

The early planting of green manure in March 2010 before the rain stabilized, compared to the May planting in 2009, may account for the difference in the vegetative yield of the cowpea variety between the period. There is the need to balance the trade-off between the peak vegetative growth period and the yield of the succeeding maize plant from tilled-in manure. The buildup of organic matter was higher in the tilled-in plots than in the mulched plots. It is not unlikely that mineralization of the mulched cowpea manure would have been negatively affected by the harsh weather elements prevalent in the derived savanna (Babalola 1988; Kudi et al., 2011).

The significant difference obtained in the results of the test of differences in the succeeding maize yield between the treatments suggest that the use of the creeping and highly vegetative (high biomass yield) Drum variety can be recommended for green manure. Also, in situ tilled-in incorporation of the green manure gave a higher gross profit (N.73,287/ha) from maize than in the mulched plots (N.25,662/ha) (Table 6).

Grain yield of maize from the control plots in the experiments were generally low (mean 134.7 kg/ha) (Tables 3 & 4). Low grain yield of maize is typical on farmers' field in tropical soils due to the limiting soil nitrogen and phosphorous (Ismaila et al., 2010). This contributes to the poor and unsustainable yields associated with maize production in the derived savanna in the absence of soil amendments. The assessment of the succeeding maize performance, with different cowpea green manure variety, suggests that the use of the Drum variety (mean 2,780 kg/ha) was found to be the better legume manure material,

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due to agronomic and economic considerations, to adopt in the derived savanna rather than the Oloyin variety (mean yield 1540 kg/ha) (Tables 1 & 2).

Table 4: Cost and Returns Analysis for maize production using cowpea green manure (Oloyin), three planting densities and two different incorporation methods (Nigerian naira) (Year 2010).

Plot & treatment	P1 Tilled-in	P2 Tilled-in	P3 Tilled-in	P1 Mulch	P2 Mulch	P3 Mulch	Control
Maize grain yield(Kg/ha)	1,780	1,690	1,970	1,790	1,700	2,080	1,340
Gross returns at N.70/Kg of grain	124,600	118,300	137,900	125,300	119,000	145,600	93,800
Variable costs							
Land preparation 20 WD/ha	18,000	18,000	18,000	18,000	18,000	18,000	18,000
Cowpea seed 20 Kg at N.100 or N. 160 per Kg	3,733	7,466	14,932	3,733	7,466	14,932	
Planting of cowpea 10 WD	9,000	9,000	9,000	9,000	9,000	9,000	
Incorporation of green manure 20 WD	18,000	18,000	18,000	9,000	9,000	9,000	
Maize seed 23 Kg at N.120/Kg	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Planting of maize 10 WD	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Weeding 1st and 2nd 40 WD	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Harvesting of maize 10 WD	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Total variable cost	105,493	109,226	116,692	96,493	100,226	107,692	74,760
Gross margin/ha	19,107	9,074	21,208	28,807	18,774	37,908	19,040

(WD = work day (N.900); P1=55,555, P2=111,111, P3=222,222 plants/ha)

Table 5: Cost and Returns Analysis for different methods of green manure incorporation (Nigerian naira) (Drum variety).

Year	2009		2010	
Treatment	Tilled-in	Mulch	Tilled-in	Mulch
Cowpea density, Plants/ha	80000	80000	80000	80000
Maize grain yield	2580	1760	2855	2001
Revenue (Naira/ha)	180600	123200	199850	140070
Total variable cost (N/ha)	116210	98601	122042	113022
Gross margin (N/ha)	64390	24599	77808	32048
Returns on investment (%)	55.4	24.9	63.8	32.0

The Drum variety yielded more biomass of applied green manure than the Oloyin variety (Tables 1 & 2). A constraint to the adoption of green manure technology by resource-poor farmers, is the associated sacrifice (loss) of farm resources use in the cultivation and incorporation of the manure. With the Drum variety of cowpea, the economically recommended plant population is a minimum of 80,000 plants/ha. Cowpea population

less than 80,000 plants/ha can be expected be suboptimal for the derived savanna zone, as the associated variable costs will far exceed the extra revenue from the succeeding (i.e. second year) maize cultivation. The test of difference of means (Table 6) shows that there was a significant ($p < 0.05$) difference in the gross margin of the succeeding maize plant based on cowpea variety ($t = 4.03$) and the method of incorporation of manure ($t = 3.22$).

Table 6: Test of mean difference in maize yield by treatment

Treatment	Mean Gross margin (N/ha)	t-value	Decision
Variety			
Oloyin	13,421	4.03	Reject H_o
Drum	64,922		
Method of incorporation			
Tilled-in	73,288	3.22	Reject H_o
mulch	25,662		

Summary and Conclusions

Maize grain yield was found to be enhanced by using cowpea green manure. The results of this study show that the economic benefits associated with cowpea green manuring, evident in the yield of the succeeding maize crop, far outweighs the cost of cultivating and incorporating the manure. Against the backdrop of high cost and or unavailability of inorganic fertilizer, this holds huge promise for sustaining the cropping system in the derived savannah and for promoting rural growth and development. The associated economic benefits suggest that cowpea green manure can be adopted by maize farmers to enhance yield and incomes. Planting Drum cowpea variety, at a minimum population of 80,000 plants/ha was superior in terms of financial returns to maize production. The superiority of Drum variety as a green manure crop for the cultivation of maize is greatly enhanced when established either very early before the rains stabilize or a little further into the rainy season. Given an adequate growing environment for the green manure, tilled-in incorporation of the generated biomass will result in better yield of maize crops.

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