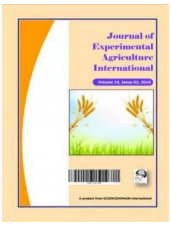

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Profitability of Yam-Maize-Soybean Enterprise among Resource Poor Farmers Using Herbicide for Weed Control in the Northern Guinea Savanna

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Authors' contributions

This work was carried out in collaboration between all authors. Authors UEU and CI designed and wrote the protocol of the study. Author AHU performed the statistical analysis and with author UEU wrote the first draft of the manuscript. Authors UEU, AHU and CI managed the analyses of the study. Authors UEU and AHU managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study examined the profitability of herbicide weed control in yam-maize-soybean enterprise, factors influencing it, as well as the problems encountered by the farmers using this weed control measures. The study was conducted in Bwari Area Council of the Federal Capital Territory (FCT) in the Northern Guinea Savanna agro-ecological zone of Nigeria, between August, 2015 and January, 2016. Data were collected from 60 randomly selected farmers using a structured questionnaire, and analyzed using descriptive statistics, net income, gross margin model and multiple regressions. Result shows that the enterprise was dominated by male farmers (97%) with 88% of them married and had an average household size of 7 persons. The respondents were educated with average

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farm size of 4 ha. The gross revenue was ₦1,062,695.08 per hectare, with net income of ₦280,118.615 and the return per naira was 1.36, implying that for every naira spent in the enterprise the farmer expects a return of ₦1.36. The gross margin ratio estimate was 1.69, and this result implied that for every ₦1 realized from the sales of yam, maize and soybean the farmer had ₦1.69 kobo left over to cover basic variable costs as well as profit. Lack of credit facilities, high cost of labour, environmental effects and high cost of herbicide were the major problems encountered by the farmers. Level of education, farm size, household size, farming experience, use of herbicide was all positively related to profit and significant at 5% probability level. Polices that would favour herbicide subsides and credit facilities for farmers in this agro-ecology zone will be a strong incentive for increased productivity and profitability.

Keywords: Profitability; yam- maize-soybean; resource poor farmers; herbicide; weed control.

1. INTRODUCTION

Effective weed control in crop production systems is a necessary requirement that will enable increased crop [1]. According to [2], manual weeding is labour intensive; and if done late sometimes may lead to severe yield losses [3]. Manual weeding has been found to be unsustainable [4] and cumbersome in terms of economies of scale [5]. The use of herbicide in weeding is a beter option to hand weeding as it is cheaper, faster, and more effective with less drudgery [6,7].

The use of herbicide for weed control is becoming popular due to increase in the opportunity cost of labour especially in developing countries [8], and this trend enables the practice of adoption of minimum-till and zero-till farming systems [9]. This may offer the advantages of saving the fragile and marginal soils of most African countries. The use of herbicides weed control may help to conserve moisture [10], and also reduces the emission of greenhouse gases from the use of tractor [11]. Herbicide weeding uses less labour which implies reduced costs of farming operation, implying higher profit [12] as opposed to 50-70% of the total labor time spent by smallholder farmers in hand weeding [13]. Manual weeding is commonly practiced in Nigeria [6] and this cannot sustain the system with the ever increasing population that must be fed. For instance, in Nigeria, it was reported that weeding once led to yield loss of about 40% when compared to farmlands where weeding was done thrice [7]. The use of herbicide for controlling weeds is an alternative to manual weeding although it is not commonly practiced by smallholder farmers [14,15]. The reason may be because of unguided perception of its effect, high initial cost of its engagement, lack of knowledge of the application and lack farmers encouragement by the way of input subsides or crerdit facilities. According to [16,17] the use of herbicide is more profitable than hand weeding and is key to sustainable crop production [18].

Different crops combinations can be grown simultaneously on a piece of land. For instance, [19] identified cassava based (cassava, maize, melon), yam based (yam, cassava, maize and melon) as well as other crops that could be in the mixture such as okra, groundnut, cocoyam, pepper, tomatoes and amaranths. This mixture helps to make up for losses arising from the other crop enterprise. The uncertainty of yield due to changing climatic conditions, contributes to farmers choice of more crop combination, the choice of four different crop mixtures has an added advantage of resource (land) utilization and higher returns on investment [20]. The herbicide may be selective herbicides or non-delective herbicide which could be pre-emergence or post emergence herbicides.

The profitability of herbicide use in crop production in the rainforest and forest savanna transition zones in Nigeria have been reported by various authors; each enumerating the benefits in comparison with hand weeding [17,21,22,23]. However, little or no attention has been given to the use of herbicides and its benefits in terms of productivity and profitability in arable crop mixture in the Northern Guinea Savanna agro ecology of Nigeria. This is the gap in research which this study intends to fill. The objectives of this study were to:

(i) Describe the socio-economic characteristics of the yam-maize-soybean crop mixture farmers in the study area
(ii) To determine the profitability of yam-maize-soybean enterprises;

(iii) Determine factors influencing the profitability of the mixture; and
(iv) To identify the problems encountered by the farmers in the use of chemical weed control measures.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Bwari Local Area Council of Federal capital territory (FCT), Abuja. It lies at latitude range of 08°.800 and 09°.315 north and longitude 007°.220 and 07°.580 east. It has a population of about 371,674 million people and a land mass of 914 km^2 [24]. The mean annual temperature is 25.3℃, mean annual rainfall of 1387 mm and relative humidity of 59 percent. Potentially Bwari is in the Guinea Savanna (GS) agro ecology of Nigeria with a fertile soil that supports predominantly farming communities [24]. The area is predominantly savannah with sparse forests in its southern parts. Major crops grown in the include millet, corn, sorghum, rice, yams, cassava, plantains, groundnuts and cowpeas.

2.2 Sampling Technique and Sample Size

The sampling frame where the sample was drawn came from the list of farmers across the communities of the Area Council. A Multi-stage sampling technique was employed in selecting the respondents. In the first stage, 10 communities were randomly selected from the communities in the study area. The selected communities include Baragoni, Gaba, Galuyi, Igu, Kawu, Kuchiku, Kuduru, Sherekoro, Kute and Sunape (though they were later aggregated into seven (7) sampling points) which include Bwari Central Market, Baragoni, Igu, Galuyi, Guto, Kawu and Zango in the study area (Fig. A). In the second stage, 6 farmers that practiced cassava/maize/soyabean crop mixture were purposively selected. The reason for the purposive selection was to get the target respondents. This gave a total of 60 farmers.

Data were obtained through primary sources by the administration of a structured questionnaire.

2.3 Data Analysis

Objectives i and iv were analyzed using descriptive statistics such as mean, percentages, frequency counts; objective ii was analyzed using Net Return and Gross margin models while objective iii was analyzed using Ordinary Least Square and Multiple Regression models.
The gross margin model is expressed mathematically as:

$$GM = QyPy - QxiPxi \quad (1)$$

Where,

GM = Gross Margin (N/ha)
Qy = Quantity of Output (Kg)
Py = Output Price (N)
Qxi = Quantity of the ith unit of input (Kg)
Pxi = Price of the ith unit of input (N)

and,

$$\text{Benefit cost Ratio} = \frac{\text{Total Benefit}}{\text{Total Cost}} \quad (2)$$

Multiple Regression Model:

Multiple regression analysis was used to establish the relationship between key factors that may likely predict the direction and magnitude of the production enterprise and it is expressed as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9 \ldots + U) \quad (3)$$

Where,

Y = Total Profit (Naira)
X_1 = Age (Years)
X_2 = Level of education (Years)
X_3 = Farm size (Hectare)
X_4 = Household size (Number)
X_5 = Farming experience (Years of farming)
X_6 = Irrigation (Dummy: 1 if farmer practices irrigation, 0 if otherwise).
X_7 = Gender (Dummy: 1= Male; 0 = Female)
X_8 =Planting materials (Kg)
X_9 = Herbicide treatment (liters)
U = Error Term
A priori that $X_2, X_3, X_4, X_5, X_6, X_7, X_9 > 0; X_1, X_8 < 0$

The relationship between the endogenous and each of the exogenous variables were tried using four functional forms such as linear, exponential, double log and semi log while the best fit functional form was selected based on econometric and statistical criteria.

Linear function:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 \quad (4)$$

Semi-log:

$$Y=b_0+b_1logX_1 + b_2logX_2 + b_3logX_3 + b_4logX_4 + b_5logX_5 + b_6logX_6 + b_7logX_7 + b_8logX_8 + \quad \dots (5)$$

Double log:

$$logY= b_0 + b_1logX_1 + b_2logX_2 + b_3logX_3 + b_4logX_4 + b_5logX_5 + b_6logX_6 + b_7logX_7 + b_8logX_8 + \quad \dots (6)$$

Exponential:

$$Y = ae^{b1^x1^{+b}2^x2} \quad (7)$$

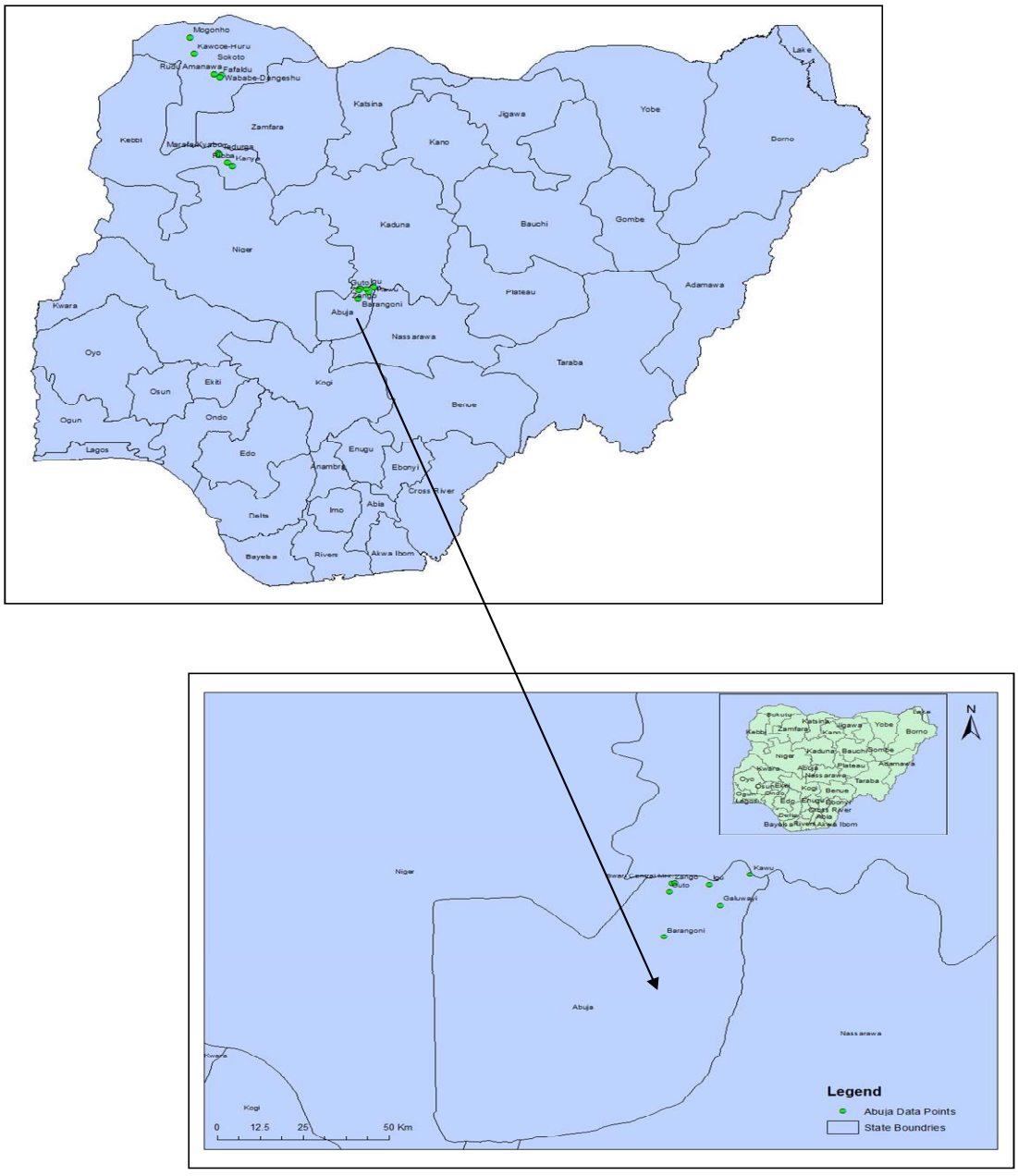

Fig. A. Nigeria map showing location of FCT and Bwari area council study site

3. RESULTS AND DISCUSSION

3.1 Socioeconomic Characteristics of Respondents

Table 1 show that the average age of the farmers who use herbicide for weed control was 52.67 years with a standard deviation of 6.83 years. This indicates a high degree of variability in the ages of the farmers. Nevertheless, they are still within the active and productive age to provide optimal performance in any form of productive labour in the farm. The result also suggests that the farmers were within the age bracket that can bear risk. This is in agreement made immediately after observation of [25] that the ability to bear risk and be innovative decreases with age, thus farmers in this study were in their youthful age. The average number of years in education was about 10 years, and this shows that farmers were reasonably educated. Although there was a wide variability in the years they spent in formal education (5.24 years). This literacy level is advantageous and has implications for exposure and adoption of innovation as evident in the use of herbicide in place of manual weeding. According to [26] and [27], educated farmers are likely to be more receptive to improved farming practices than farmers with little or no education. The mean of farm size of 4.22 hectares suggested that the farmers had small farm sizes and were categorized as small holder farmers. Small holder farmers cultivates on the average 0.1-5.99 hectares [28]. A mean household size of 7 persons is an indication of availability of farm hands. This could be attributed the tradition which allows men to marry more than one wife [29,30]. This has implication for higher profit of the enterprise. A mean farming experience of 26.27 years shows that the farmers were well experienced in farming which did not indicate experience in the use of herbicide treatment in the study area. Though farmers had little or no experience in herbicide use but having good farming experience is an advantage as this will make farmers to be more or less averse to risk involved by using herbicide. Farming experience according to [27] is an important variable that reduces the risk that may be encountered by farmers in using a new technology.

3.2 Costs and Return

Table 2 shows the cost and returns analysis of yam-maize-soybean enterprise per hectare of farmland. The total revenue was ₦1,062,695.08 per hectare. The estimated variable cost of ₦627,498.46 obtained with a gross margin of ₦435,197.615 and net farm income of ₦280,118.615. The returns per naira invested was estimated to be 1.36 which implied that for every ₦1 spent in the enterprise, the farmer made a return of ₦1.36 kobo.

The gross margin ratio was estimated to be 1.69 which implied that for every ₦1 realized from the sales of yam, maize as well as soybean; the farmer had ₦1.69 kobo left over to cover basic variable costs and profit. This suggests that yam-maize-soybean production in the savanna is profitable.

3.3 Determinants of the Profitability of Yam-Maize-Soybean Production Enterprise

The profitability of the yam-maize-soybean production with herbicide treatment was estimated using the multiple regression analysis (Table 3). Four functional forms were estimated. The semi-log functional form was the lead equation as it has the highest coefficient of multiple determination (R^2), number of t-values as well as conformity with *a priori* expectations.

The R^2 value of 0.86 indicates that the explanatory variables that were considered highly accounted for 86% of variations in the dependent variable as shown in Table 3.

Variables such as level of education (X_2), farm size(X_3), household size (X_4), farming experience (X_5), cost of planting materials (X_7), use of herbicide (X_8) were statistically significant at 5% probability level ($P < 0.05$), while use of irrigation (X_6) was statistically significant at 1% probability level ($P < 0.01$).

The significant variables accounted for 86% of the observed variation in the farmer's profit.

Level of education (X_2), farm size (X_3), farming experience (X_5), use of irrigation (X_6) and use of herbicide (X_8) were positive and statistically significant. This was in conformity with *a priori* expectation. This indicated that as farmers increase the usage of these inputs, more profit would be obtained with herbicide treatment.

Level of education was positive and significant implying that the higher the level of education, the higher the profitability of yam/maize/soybean crop mixture for farmers who use herbicide treatment.

Table 1. Distribution of respondents according to their socio-economic characteristics

Variable	Mean	Standard deviation	Range
Age (years)	56.67	6.831	28-62
Level of education (years)	10.13	5.258	0-17
Farm size	4.22	0.927	0-6.5
Household size (persons)	7.28	1.250	2-12
Farming experience	26.27	7.180	1-38

Source: Field Survey Data, (2016)

Table 2. Distribution of costs and return per hectare of yam/maize/soybean in the study area

Item	Unit	Quantity	Price	Value (₦)
Revenue				
Yam	Kg	2636.35	236.20	622,705.87
Maize	Kg	2512.20	92.13	231,448.99
Soybean	Kg	1262.35	165.20	208,540.22
Total Revenue (A)				**1,062,695.08**
Variable cost				
Tubers	Kg	10000	28.13	281,300
Maize seeds	Kg	32	152.4	4,876.80
Soybean seeds	Kg	46	162.21	7,461.66
Fertilizer	Bag (50 Kg)	16	7210	115,360
Herbicide application	Liters	43.5	2000	87,000
Land preparation	Man-day (MD)	14	3500	49,000
Planting	MD	8	1500	12,000
Fertilizer application	MD	9	2000	18,000
Weeding	MD	3	1500	4,500
Harvesting	MD	6	8000	48,000
Total Variable Cost (B)				**627,498.46**
Fixed costs				
Depreciation expenses				7,312
Rent on land				10,247
Interest				137,520
Total Fixed Cost(C)				**155,079**
Total Cost (B+C=D)				**782,577.46**
Net return(A-D=F)				**280,118.615**
Gross Margin				**435,197.615**
Benefit/cost ratio(A/D)				1.36
Gross Margin ratio(A/B)				1.69

Source: Field Survey data (2016)

Farm size was positive and significant implying that the higher the farm size, the higher the profitability of yam/maize/soybean crop mixture for farmers who use herbicide treatment.

Farming experience was positive and significant implying that the higher the farming experience, the higher the profitability of yam/maize/soybean crop mixture for farmers who use herbicide treatment.

Use of irrigation was positive and significant implying that the higher the use of irrigation in their farmers, the higher the profitability of yam/maize/soybean crop mixture for farmers who use herbicide treatment.

However, household size (X_4) and cost of planting materials (X_7) were negative and statistically significant at 5% probability level, suggesting that the higher the values of these variables, the less the amount of profit made by the farmers who used herbicide treatment. This implied that level of education (X_2), farm size(X_3), household size (X_4), farming experience (X_5), use of irrigation (X_6), cost of planting materials (X_7), use of herbicide (X_8) are determinants of profitability in the use of herbicide treatment by

farmers involved in yam-maize-soybean production in the Savanna.

Problems encountered by yam-maize-soybean farmers in the use of herbicide are presented in Fig. 1. The major problem encountered by the farmers was lack of credit facilities as it ranked first (86.66%). This suggests that the farmers did not have good access to credit facilities which likely affected their ability to purchase herbicides for the control of weeds in their farmland. Credit is an important resource to farmers.

Table 3. Regression analysis of the yam-maize-soybean enterprise with herbicide treatment

Variables	Linear	Exponential	Double log	+Semi-log
Constant	448005.570	177619.642	13.110	12.142
Age(X_1)	245.665	79748.730	-.004	.009
	(-0.233)	(-1.103)	(-1.279)	(1.120)
Education level (X_2)	3808.102	44165.746	.009	.107
	(1.551)	(1.200)	(2.598)**	(2.722)**
Farm size	37492.957	84077.154	.091	.177
(X_3)	(2.880)**	(1.617)	(2.521)*	(2.541)**
Household size (X_4)	7303.528	58367.287	.011	.094
	(-0.694)	(-1.005)	(-1.520)	(-3.361)**
Farm Experience (X_5)	3643.350	110359.399	0.009	0.233
	(-1.399)	(2.465)*	(1.520)	(2.649)**
Irrigation (X_6)	14642.964	13739.487	.060	057
	(1.255)*	(2.360)	(2.444)*	(2.523)*
Gender(X_7)	46947.687	46919.492	.069	069
	(0.733)	(0.211)	(1.518)	(1.521)
Plant Material (X_8)	-0.0407	-3389.556	-9.474E-10	0.020
	(-1.206)	(-1.738)	(-1.002)	(-3.109)**
Herbicide (X_9)	.100	16104.504	1.567E-6	110
	(2.039)*	(2.502)*	(2.837)**	(3.234)**
R^2	.067	0.76	0.81	.086
N	60	60	60	60
F-Value	12.26	18.94	22.74	27.85

*Figure in parentheses are t-ratio, * Indicates F-value significant at 5%, where * = Significant at 5%; ** = Significant at 1%, (Source: Field Survey, 2016)*

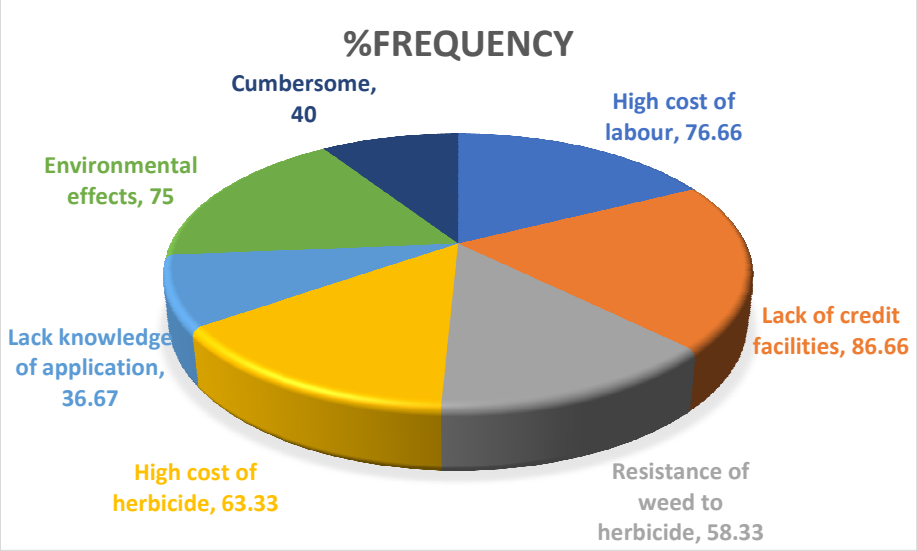

Fig. 1. Distribution of yam-maize-soybean farmers according to problems encountered in the use of herbicide treatment

Source: Field Survey, 2016

This was followed by high cost of labour (76.66%). Another major problem is environmental factors (75%). Hossain [18] observed that some important environmental factors are associated with the over use of herbicides. These include unintended damage occurring both on the sprayed site, and offsite. This corroborates the findings of [31] who observed that long-term fate of the herbicides has a negative effect on the environment through their breaking down of their products in the soil, air and groundwater. High cost of herbicide (63.33%) and resistance of some weeds to certain herbicides (58.33%) ranked 4th and 5th respectively. Several research and surveys have confirmed resistance of some weeds to herbicides [32,33] According to them; repeated use and application of any herbicide will expose weed populations to selection pressure that may lead to an increase in the number of surviving species, and of resistant individuals in the population. The least problem encountered by the farmers was lack of knowledge of application (36.67%) which was ranked 6th and the farmers who believed that the practice is cumbersome (40%) ranked 7th.

4. CONCLUSION AND RECOMMENDATIONS

The use of herbicide treatment in yam-maize-soybean enterprise in the Northern Guinea Savanna agro-ecology is profitable. The farmers were young, reasonably educated and experienced with large number of persons per household. They cultivated on small farm sizes. The study therefore concluded that yam/maize/soybean production in the savanna is a profitable enterprise.

Level of education, farm size, household size, farming experience, use of irrigation, cost of planting materials, use of herbicide are determinants of profitability in the use of herbicide treatment by farmers involved in yam-maize-soybean production in the Savanna.

Farmers in the savanna region should be encouraged to use herbicides in weeding their farms. Consistent government policies that would favour herbicide subsidization and credit facilities should be made available and implemented.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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