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Economic Evaluation of Grain Amaranth Production in Kamuli District, Uganda

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Abstract: In Uganda, grain amaranth is relatively new and has generally not been considered as an important crop compared to other grain crops and legumes. This study was therefore conducted to determine factors affecting adoption of grain amaranth growing, factors affecting production, and economic returns on investment of its production. The study was carried out in Kamuli district where a total of 174 grain amaranth farmers and 90 non-grain amaranth farmers were randomly selected and interviewed. Using descriptive statistics, regression analysis (logit model and a Cobb-Douglas type production function) and profitability ratios, it was found that grain amaranth is produced on a small scale and yields are low. Farmer adoption of the crop was favoured by age, gender (female), education of the farmer, and source of income. The output was positively affected by the amount of labour and manure used in production, while a negative relationship existed between output and male farmers. The crop was most viable under small acreages (0.02-0.04 ha) with positive returns to investment of 0.016. Its production should therefore be encouraged because of its income generation potential and since it requires small land.

Key words: Adoption, grain amaranth, logit model, return on investment, Uganda.

1. Introduction

Grain amaranth (*Amaranth* sp.) is an industrial and food crop in many parts of the world. It is popularly known as "super grain" because of its amazing properties that are nutritional, medicinal and industrial [1, 2]. It belongs to the family *Amaranthaceae*. There are about 60 amaranth species in this family but the commonly grown species are *Amaranthus hypochondriacus* (commonly called "pig weed"), *A. cruentus, A. edulis* and *A. caudatus*. There are also many varieties within these three species which are easily distinguished by their seed colours: white, yellow or pink [2]. Grain amaranth develops brilliant coloured grain heads. Countries that grow it in significant quantities include Mexico, Russia, China, India, Nepal, Argentina, Peru and Kenya [2]. In Uganda, two varieties, the golden and the white varieties, have been identified and seeds have been given to farmers.

Grain amaranth is a very fast maturing crop. It grows very rapidly especially under conditions of high temperatures, bright light and dry soil thereby tolerating dry conditions [3]. Its tolerance to the dry conditions is particularly important for semi-arid areas because a good harvest is possible even with limited rain. It has very tiny seeds (about 2 million seeds per kilogram) and at present, no seed planter has been designed to plant them. This has limited its cultivation

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on large acreages.

Grain amaranth is more popular because of its high nutritional value than its commercial potential. It was found that with as little as 12.7% by weight (20% of protein) of added amaranth flour, maize meal would satisfy the protein and lipid needs of young children as long as the maize meal supplies approximately 90% of the diet energy [4]. It reportedly contains twice the level of calcium in milk, five times the level of iron in wheat, higher potassium, phosphorus and vitamins A, E, C and folic acid than cereal grains [5]. Its potential in making several commercial products like snacks, breakfast cereal, bread, and paste is very high. It can be popped and mixed with groundnuts before ground/milled. The un-popped grain can be ground and mixed with other cereals such as maize and millet and consumed as porridge. It can be used to spread on bread instead of butter and on cassava or sweet potatoes. The most common commercial use of grain amaranth is as a snack. Flour is the next common use [6].

In Uganda, grain amaranth is known as a vegetable crop but it has generally not been considered as an important crop by farmers compared to other grain crops or legumes. Its production and consumption is relatively new and is limited to a few areas around the Lake Victoria basin in the districts of Iganga, Kamuli, Bududa and Nakasongola. It was introduced in Uganda in 2005 through the efforts of Volunteer Efforts for Development Concerns (VEDCO), a non-governmental organization that implements food and nutrition security program. Various studies including Svirskis et al. [2, 7-9] have studied agro-climatic conditions and agronomic practices to maximize amaranth leaf production, grain composition and nutrition. However, there is scanty empirical work done on economics of grain amaranth production including returns to the farm resources invested. Factors that drive adoption of grain amaranth growing by some farmers and not others in these areas are also not empirically known. A study was, therefore, conducted to determine factors affecting adoption of grain amaranth growing, determine the factors affecting production of the crop, and determine the economic returns on investment of its production. This was to contribute knowledge on the scanty literature on production of grain amaranth in Uganda. This information is useful in promoting the production of the crop by both the relevant government agencies and NGOs. Once production is increased, farmers will benefit from the nutritional value of the crop, and the crop may be a potential source of income.

2. Materials and Methods

2.1 The Study Area and Sample Selection

This study was carried out in Kamuli district, one of the major growers of grain amaranth in Uganda. The district is located in eastern Uganda, in the Lake Victoria basin. Farmers who participated in the study were sampled from three sub-counties of Namasagali, Butansi and Bugulubya. These sub-counties were purposively selected based on their popularity in amaranth production. They are part of the areas where VEDCO has been supporting grain amaranth production and utilisation. The sub-counties are also categorised differently basing on the notable climatic differences between the areas. Generally, Bugulubya is considered drier whereas Butasi is considered wet. Namasagali is considered moderately wet and dry. In each sub-county, four parishes were randomly selected and a sample of respondents was obtained from the farmer groups in these parishes. In each farmer group, a list of farmers, who had grown grain amaranth for at least one year before this study was carried out was compiled with the help of VEDCO staff and local extension workers. In addition, a list of farmers who did not grow grain amaranth but were within the communities where the farmer groups operated was obtained. From the lists, farmers were selected by systematic sampling using a random start. A total of 174 grain amaranth farmers and 90 non-grain amaranth farmers were selected.

2.2 Data Collection and Analysis

A structured questionnaire was administered to capture information on socio-economic characteristics of the farmers, production aspects of grain amaranth, input and equipment use, extension and financial services, post-harvest handling and marketing. Data obtained were checked to correct any errors and to standardize some measurements to the acceptable measurement units. The data were entered in Microsoft Access and cleaned before analysing using the STATA package to get descriptive and econometric statistics.

Analytical methods used included descriptive statistics, regression analysis using a logit model and a Cobb-Douglas type production function, and the returns on investment analysis. To determine factors which influenced the adoption of grain amaranth, a logit model was used. This is a binary choice model, like the probit model, which is appropriate to model between adopters and non-adopters of a technology. The dependent variable in these models is dichotomous and the use of Ordinary Least Squares (OLS) can cause the predicted values to fall outside the range of 0 and 1 probability values [10]. Farmers who had adopted grain amaranth were assigned a value of 1, while the non-growers were assigned 0. The logit model was particularly selected over the probit model because it is well suited for observational data whereas the probit model is well suited for experimental data [11].

The logit model is based on the cumulative logistic probability function stated as:

$$Ln(P_i) = \frac{p_i}{(1-p_i} = b_0 + b_1x_1 + b_2x_2 + \cdots + b_f + \varepsilon \quad (1)$$

Where:

$Ln[\frac{p}{(1-p)}]$ = log of the odds that a certain choice will be made,

i = the i^{th} observation in the sample,

P = the probability of the outcome,

b_0= the intercept,

$b_1, b_2, \ldots, b_f$ = the coefficients associated with each explanatory variable,

$x_1, x_2, \ldots, x_f$ = explanatory variables.

The reduced form of a logit model can be expressed as

$$Y = \alpha + \beta_i + x_i + \varepsilon \quad (2)$$

Where,

Y = dependent variable (adoption of grain amaranth production by farmers in Kamuli)

α = Constant,

X_i = Explanatory variables,

β_i = Vector of explanatory variables,

ε = Error term.

The explanatory variables which were included in the model and their hypothesized effects are summarised in Table 1.

To determine the factors influencing the production of grain amaranth, a Cobb-Douglas type of production function was used. The Cobb-Douglas production function is convenient because it is linear in logarithms; it generates elasticities, permits the calculation of return to scale and it is easy to estimate. It is also commonly used in analysing survey data where a number of variable inputs are considered. Elasticities of production to be estimated express input-output relations in a power (Cobb-Douglas) type of function [12].

The general Cobb-Douglas equation can be expressed as:

Table 1 Hypothesized effects of explanatory variables on the adoption of grain amaranth production by farmers.

Variable	Definition	Mean	Hypothesized effect
Age	Age (years) of the farmer	40	+
Sex	Sex of the farmer (0 = female; 1 = male)		_
Education	Education (years spent in school)	6	_
Source of income	Source of income of the farmer (1 = farming; 0 = elsewhere)		+
Total land under crop	Total land (ha) under crop	1.9	+
Income category	1 = lowest income category; 6 = highest income category		_

$$Y_i = \alpha X_{1i}\beta_1 X_{2i}\beta_2 \ldots \ldots X_{ki}\beta_k exp\ (\varepsilon_i) \qquad (3)$$

This can be transformed in the log-linear function expressed as:

$$LogY_i = log\alpha + \beta_1 logX_{1i} + \beta_2 logX_{2i} \ldots . \beta_k logX_{ki} + \varepsilon_i$$

Where:

Y_i is the dependent variable (Output),

α is the intercept,

$X_i \cdots X_k$ are independent variables,

$\beta_i \cdots \beta_k$ are elasticities to be estimated,

ε_i is the random error.

Grain amaranth production was assumed to depend on the available direct inputs and other factors which may not be direct inputs but affect production. Inputs which were hypothesised to be most important in grain amaranth were labour and manure. Other factors which were hypothesised to affect grain amaranth yield were the socio-demographic factors (age, gender, education, income levels of farmers), extension services, the level to which farmers adhere to the most important agronomic practices in grain amaranth production and weather farmers produced solely for home consumption or for both consumption and sale. These variables are hypothesised to affect yield basing on economic theory, wide range of literature and the summary statistics as obtained from the study area.

The relationship between the dependent variable (output) of grain amaranth and the independent variables was specified as:

$$lnY_i = lnA + \alpha_1 lnlandama + \alpha_2 lnlabor + \alpha_3 lnmanure + \alpha_4 var_i + \ldots + \varepsilon_i \qquad (4)$$

Where:

Y = output of grain amaranth (in kg) harvested by a farmer,

$landama$ = land under grain amaranth in hectares,

$labor$ = labour used in grain amaranth production in man-days,

$manure$ = quantity of manure applied in grain amaranth gardens,

var_i =other non direct inputs which affect grain amaranth output,

ε_i = the random error.

α_1, α_2 and α_3 are coefficients for land under amaranth, labour, and manure respectively, and α_4 represents coefficients for other non-physical quantity inputs.

The dummy variables and socio-demographic characteristics do not represent the physical quantities of inputs but are used to establish the effect of factors that are not easily measured. These variables are therefore not transformed into natural logarithms and are represented as a set of variables, var_i. Included var_i are age of the farmer, gender of the farmer, education of the farmer, income level of the farmer, agronomic practices in grain amaranth production, extension services and if farmers produce for both sale and consumption. Definitions of the variables in the model and their hypothesized effects are presented in Table 2.

In estimating the economic returns for grain amaranth production, different ways can be used. Some researchers have used cash measures of income, such as net income, gross margin analysis, net present

Table 2 Hypothesized effects of the factors that influence the output of grain amaranth in Kamuli district.

Variable	Definition	Mean	Hypothesized effect
Labour	Amount of labour (man days) per ha used in amaranth production	345.79	+
Manure	Amount of manure (basins) per ha used in amaranth production	22.28	+
Age	Age (years) of the farmer	40.00	+
Sex	Sex of the farmer (0 = female; 1 = male)		–
Education	Education (years spent in school)	5.64	–
Main income source	(1 = farming, 0 = other sources)		–
Extension services	Number of extension services received in a season	2.00	+
Agronomic practices	Total summation of the number of times agronomic practices (weeding, thinning and pruning) are carried out in a season	6.25	+
Sell amaranth	1 = If a farmer sells grain amaranth, 0= if a farmer does not sell grain amaranth		+

worth and returns to labour and management [13]. Others used ratios of income to some measure of asset [14]. In this study the simple measure of profitability was adopted. An enterprise is profitable if the gross revenue is greater than the total variable cost, that is, if gross margin is positive. The total variable costs (TVC) that relate to production of a given level of output are computed as:

$$TVC = \sum_{i=1}^{n} W_i X_i; for\ i = 1,2,3,\ldots,n \quad (5)$$

Where W_i is the unit cost of a given input, and X_i is level of input use.

The return per Uganda shilling invested was used to assess the viability of an enterprise [15]. This was determined as the ratio of gross margin to total variable costs. It shows how much a farmer gains by investing a shilling in the enterprise. Operating expenses in the production of grain amaranth were cost of seed, manure, value of family labour and hired labour. Variations in labour quality are put into consideration. Since there are always variations in labour, an arbitrary scale was adopted. In this case, children (7-17 years) were given a value of 0.5 man-days and women labour was considered equivalent to men labour (one man-day) and thus gender variations are ignored. Gender variations in labour quality are crop specific and for grain amaranth women are considered to give in the same labour quality as the men.

3. Results and Discussion

3.1 Major Crops Commonly Grown in Kamuli District

In Kamuli, maize was the major crop that is commonly grown as reported by 77% of the farmers (Fig. 1). Very few farmers (7%) indicated cassava as the major crop next to maize. Other reported common crops were coffee, sweet potatoes, beans, rice and millet. Grain amaranth was not mentioned by any farmer as a major crop. This is because it was relatively new in the area and farmers had not yet realized fully its economic value.

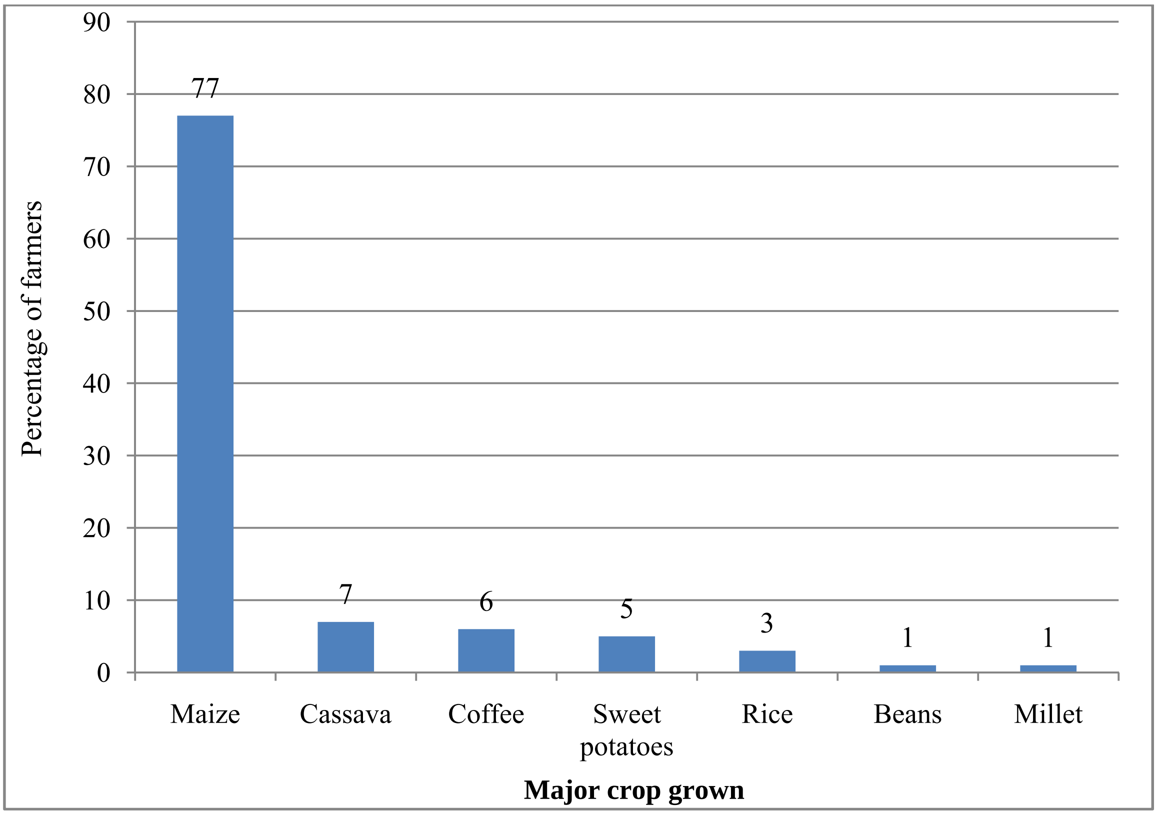

Fig. 1 Major crops grown by farmers in Kamuli.

Most of the farmers (84%) in Kamuli have knowledge about grain amaranth (Table 3). The majority (77%) of the farmers reported to have obtained information through NGOs particularly VEDCO. The crop has been known and grown in Kamuli for more than 3 years but most farmers (55.2%) reported to have grown it for the past 3 years. The crop is therefore relatively established in the area. Farmers receive adequate extension services concerning grain amaranth production. At least 81% of the farmers reported to have received extension services. They received at least two extension visits in a season. Commitment of extension workers in providing services is expected to boost production of the crop [16].

The major reason of farmers growing amaranth is that the crop is liked by family members as a food because of its taste. The crop also performs well in the area as reported by 28.8% of farmers. Only 15.7% mentioned that it is not labour intensive (Table 3). This is because the crop is grown on a very small scale, implying that labour demands are proportionately low.

3.2 Grain Amaranth Production in Kamuli District

Farmers in Kamuli have on average 1.61 ha of land under crops (Table 4) of which a very small portion (0.07 ha) is used for amaranth production. Survey results show that on average 42% of the total crop land (0.68 ha) was allocated to maize production, the major crop in the area. Results indicated no correlation between the total land farmers put to crop production and the land under amaranth production. Land under amaranth is independent of the land owned by the farmers, indicating that land per se is not a constraint to amaranth production. In comparison with maize, the major crop in the area, the results show a strongly positive correlation (significant at 1%) between land under maize and the total cropped land.

Most farmers have two seasons of amaranth crop in a year although some have as many as four seasons. This is because the crop has a very short maturity

Table 3 Availability of information on grain amaranth production.

Characteristic	Category	Percentage of farmers (multiple responses)
Knowledge about grain amaranth (n = 264)	Yes	84.0
	No	16.0
Source of information about grain amaranth (n = 264)	NGO	77.7
	Fellow farmers	22.3
Percentage of farmers who grow the crop (n = 264)		68.6
Years spent growing amaranth (n = 174)	One year	4.6
	Two years	28.7
	Three years	55.2
	More than 3 years	11.5
Why amaranth is grown (n = 153)	Liked by family members	37.3
	Performs well	28.8
	Not labour intensive	15.7
	Fast maturing	8.5
	Other reasons	9.9

Table 4 Other production information on grain amaranth.

Characteristic	Mean	Std.	Min	Max
Number of times grain amaranth is grown in a year	2.0	0.4	1.0	4.0
Maturity period for the gold variety (n = 112)	68.5	13.0	44.0	90.0
Maturity period for the cream variety (n = 55)	68.9	14.8	45.0	90.0
Land under crop in ha (n = 258)	1.6	5.3	0.2	1.1
Land under amaranth in ha (n = 173)	0.1	0.9	0.04	0.12
Land (ha) under crop for amaranth growers (n = 171)	1.6	5.3	0.2	1.1
Land (ha) under crop for non amaranth growers (n = 58)	1.6	4.9	0.2	1.1
Land under maize in ha (n = 90)	1.7	7.0	0.3	1.3

period of about 70 days. There are two varieties of amaranth grown, the golden and the cream varieties but most farmers (71.3%) grow the gold variety. The major inputs used in production are labour (Table 5), seed and manure. The crop requires at least 194 man-days per hectare per season. Most of this labour is provided by the family with limited hired labour, with a larger proportion contributed by females. Fig. 2 shows that male labour is allocated more to maize than grain amaranth.

Another key input was the seeds. Most farmers (88%) save the seed for the next planting with few getting them from other farmers, NGOs or purchasing from shops. This shows that there is little expenditure on the purchase of seed. The study found that only 4.4% of the farmers bought seed. The cost of seed by the time of study was thus not a constraint in amaranth production. The few farmers who bought seed paid Ush1,000[1] (about US$0.44) per kilogram.

Manure was another important input in amaranth production. However, results from the survey showed that only 45% of the grain amaranth farmers used manure. Animal manure in form of cow dung, goat and poultry droppings was commonly used. On average, farmers applied about 1,000 basins (about 125 kg) of manure per hectare in a season. The manure was not bought but gathered by farmers from their animals. The crop requires enough nutrients for efficient utilization of available sunlight, water and nutrient absorption given its vegetative and broad leaved nature [17]. It was reported that low use of organic manure exposes the crop with high weed pressure and water stress hence reducing the overall yield [17].

Estimates indicate that the highest yield was obtained when acreages were small, between 0.02 and 0.04 ha from which a yield of 7.82 kg was obtained. This translates to approximately 173.8-347.6 kg ha^{-1}. This is far less than the potential yield of 3,000 kg ha^{-1} that can be attained at research stations [18]. Whereas

[1]The exchange rate at the time of the survey was US$1 = 2,300 Uganda shillings (USh).

Table 5 Labour use in grain amaranth production (for area of 0.05 to 0.1 acres).

Activity	Average labour (man-days)	Std. Dev.	Min.	Max.
Ploughing	2.17	1.23	0	5
Planting	1.78	0.83	0	4
Weeding	2.16	1.29	0	5
Thinning	2.28	1.90	0	5
Chemical application	0.09	0.29	0	1
Manure application	0.77	0.97	0	5
Heaping	1.18	0.76	0	2
Harvesting	1.43	0.67	0	2
Amaranth total labour	11.06	4.51	0	19
Maize total labour per acre	66.4	53.3	3	229.0

it is documented that for many crops, farmers achieve between 13%-33% of the yields attainable at research stations [19], grain amaranth farmers in Uganda attain 10% of the potential yield. Much effort is therefore required to improve on the current level of production. A few farmers sell amaranth, only 21.7% of the harvested is sold (Fig. 3). The low level of commercialization was attributed to limited markets.

3.3 Factors Which Determine Adoption of Grain Amaranth Production

Results in Table 6 show age of the farmer, gender, source of income and education as the key determinants of farmers' probability to adopt grain amaranth production. Farmer's age was found to significantly ($P < 0.05$) increase the probability of grain amaranth adoption, implying that as a farmer grows older the likelihood to grow the crop increases. In amaranth production, the older members of the community may be motivated to grow the crop because of its nutritional benefits for their households; and because it is not yet considered a commercial crop, the younger farmers tend to engage more in income generating activities. Age has been found in most studies to increase probability of adoption. In most of these studies, age has been explained as a proxy for farming experience. Older farmers also tend to have the ability to own more resources and authority in decision making which makes it easier for them to try out new technologies [20].

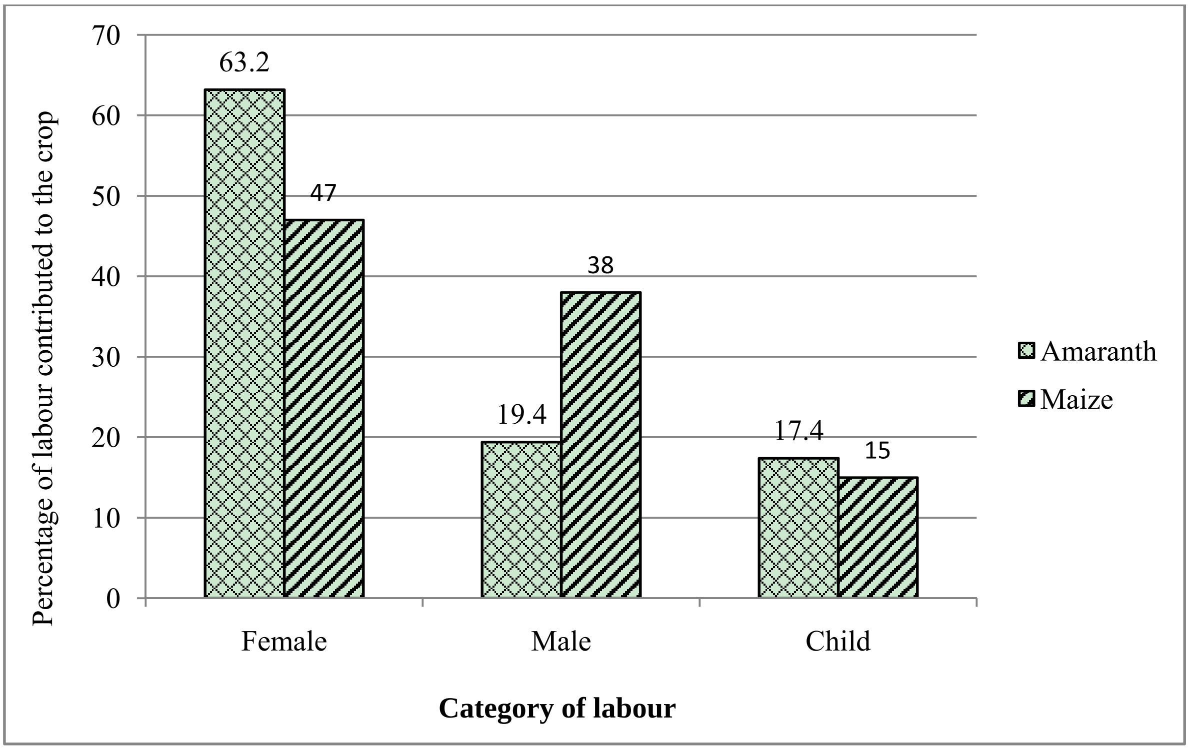

Fig. 2 Proportion of labour (%) contributed by family members to amaranth and maize production.

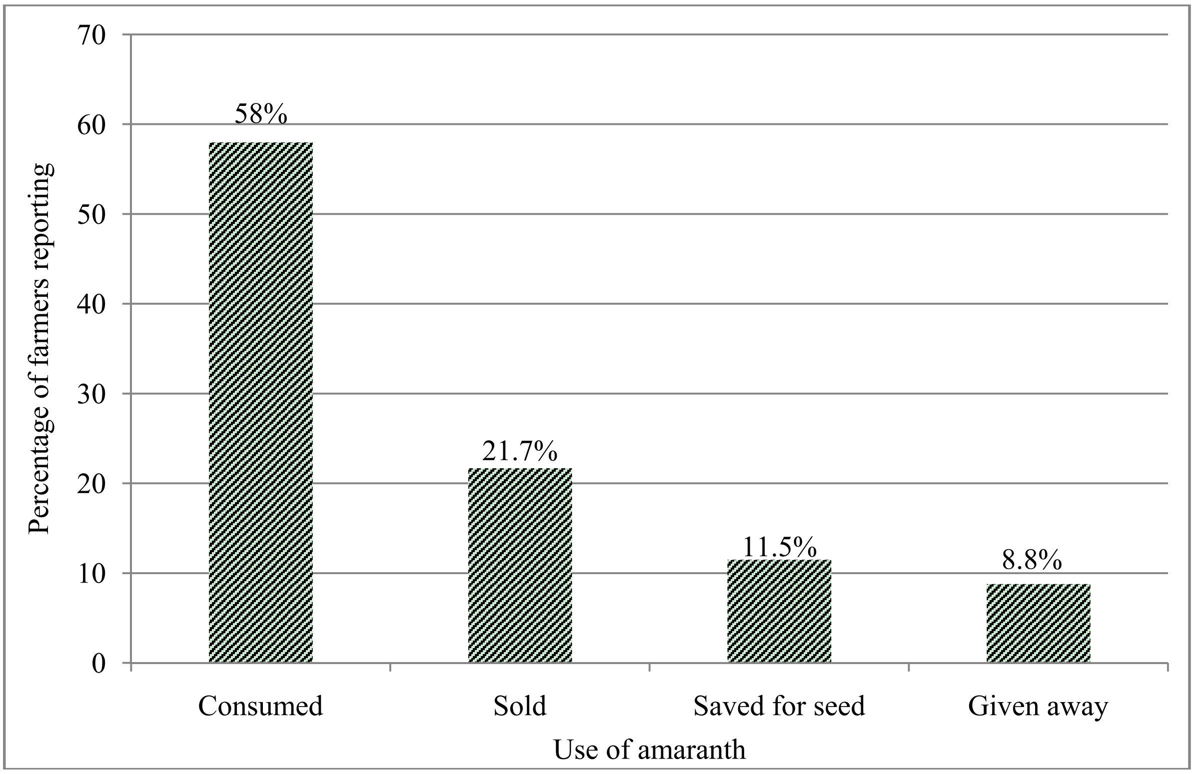

Fig. 3 Utilization of grain amaranth by Kamuli farmers.

Gender of the farmer was also found significantly ($P < 0.01$) important in influencing the adoption of grain amaranth production. From the model, the likelihood for women farmers to adopt was much

Table 6 Logistic regression results for the factors which affect adoption of grain amaranth production.

Dependent variable: If the farmer grows grain amaranth			
Independent variables	Odds ratio	Z value	$P > (z)$
Age of a farmer	1.030	2.27	0.023
Gender (male = 1)	0.338	-3.29	0.001
Education of farmer	1.078	1.71	0.086
Source of income (farming = 1)	0.421	2.99	0.003
Total land under crop	0.963	-1.29	0.196
Income category of the farmer	0.897	-0.92	0.356

No. observations = 261; LRchi2 (6) = 28.3; Prob > chi2 = 0.001; Pseudo R^2 = 0.0848, Log likelihood = -153.28.

higher than that for male counterparts. This gender difference is similarly explained by the economic nature of the amaranth, being more of substance (household consumption) than commercial. Women tend to concentrate on farm enterprises which meet consumption needs of their households, while males tend to involve themselves in the more income generating activities [21]. Currently, grain amaranth production in Kamuli is not perceived as income generating compared to other crops such as maize and cassava.

Results further show the level of farmer education as a significant factor ($P < 0.10$) in influencing the probability to adopt amaranth grain production. The probability that the more educated farmers will adopt grain amaranth production is significantly higher than for the less educated ones (Table 7). Similar observations were made in related studies such as Mugisha et al. [16, 22, 23], where results suggested that the more educated farmers, the more likely to adopt because they can better process information more rapidly. Education has been associated with the willingness to attend community meetings, participation in group meetings and it enables individuals to appreciate and understand new technologies [24, 25]. Since amaranth growing was relatively new in the area and most farmers had been met in the farm groups by the promoting NGOs (VEDCO), farmers with some level of education were able to take up the new technology than the less educated farmers or those who had no education.

Table 7 Factors affecting grain amaranth output.

Dependent variable: Grain amaranth output			
Variables	Coefficient	*t*-value	*P*-value
Amount of labour	0.57	5.63	0.000
Amount of manure	0.01	3.07	0.003
Age (years) of the farmer	-0.12	-1.16	0.25
Sex of the farmer (male = 1)	-0.56	-2.02	0.05
Education of the farmer	0.01	-0.46	0.65
Source of income (farming = 1)	0.05	0.23	0.82
Level of carrying out agronomic practices	-0.06	-0.49	0.63
Extension services	0.15	0.50	0.62
If farmer sells amaranth	0.35	1.43	0.16
Constant	1.137	1.18	0.24

$N = 70$; $F = 9.30$; Prob > $F = 0.000$; $R^2 = 0.582$; Adj. $R^2 = 0.520$; Root MSE = 0.825.

Another significant factor was the main source of farmers' income. Farmers whose major source of income was farming were found to increasingly adopt grain amaranth production than those who derive much of their livelihood from other activities other than farming. Although the income levels of farmers were not significant in influencing adoption of grain amaranth production, the direction of the sign indicates that higher income farmers were not motivated to amaranth production. Similarly, the probability of farmers with more land under crop to adopt amaranth production was lower.

3.4 Factors Which Influence Production of Grain Amaranth

The regression results presented in Table 7 summarize the factors which influence the production of grain amaranth in Kamuli district. The *F*-value is significant at 1% level. This implies that the selected independent variables significantly explain the grain amaranth output obtained across farmers in Kamuli. The R^2 value of 0.58 implies that 58% of the variation in the dependent variable is explained by the fitted model. Results indicate a significant positive relationship with amount of labour and manure used in grain production. Negative relationships exist between output and male farmers.

As expected, labour has a positive and significant

($P < 0.01$) influence on amaranth output. Farmers who have productive family members or who can afford to hire extra labour are able to timely meet the labour requirements not only in amaranth production but also in other farming enterprises [26]. This translates into higher output. The results in Table 8 show that for every increase in one man-day, the output of grain amaranth increases by 0.57 kg. The elasticity of 0.57 indicates that labour is inelastic implying that it requires a significant input of labour to increase the yield. As previously seen, more labour is required for grain amaranth production than for most other crops grown in Kamuli.

The results also show that manure is an important input in grain amaranth production. Every unit (a basin of manure) increase in the amount of manure used increases the output of amaranth by 0.01 kg. As observed in labour, manure application is inelastic, and therefore more manure is required to make a significant increase in yield. This is in agreement with Kauffman et al. [3] that for a good output to be obtained from grain amaranth, manure needs to be applied. It is a common observation in Kamuli and elsewhere that grain amaranth grows naturally on manure heaps. It was further found that being a female farmer had positive and significant effect ($P < 0.10$) on amaranth output. This confirms the role of women in farming. They provide the bulk of the labour especially to activities like weeding, thinning which men seldom do [19]. Other farmers' socio-demographic characteristics do not influence grain amaranth production. Every category of the farmer can produce satisfactorily grain amaranth. The young and the old, the educated and the non-educated can be involved in the production of the crop. This is largely because production of grain amaranth does not require so many inputs and is generally grown on small scale.

What also emerged from the study is that there is a weak negative relationship between the level of carrying out agronomic practices and grain amaranth yield. This was contrary to *a priori* expectations. This may be because the practices may not be done as well as expected such that although they may be done so many times, the effect is not reflected in the output. In relation to this finding, the study indicates that the number of extension visits made by the extension agents have not had a significant effect on amaranth production. Its sign is, however, positive. This implies that a better strategy needs to be devised in extending services to farmers since (from descriptive statistics) data indicates a satisfactory number of visits which have been made by extension workers. There is a positive, although not significant, indication that farmers whose among their objective is to sell a proportion of grain amaranth obtain higher yields. This implies that encouraging production for both consumption and sell may boost production.

3.5 Economic Returns on Grain Amaranth Production

Grain amaranth production is known to be on small acreages even in countries that have grown it for a relatively long time. In most of the countries that grow it, the nutritional importance surpasses the profit maximisation. There is, however, an increasing trend that the crop is getting commercial as its nutritional value is getting better known even to the non-traditional amaranth growing countries.

Similarly in Uganda, data obtained indicate that grain amaranth is grown on very small acreages. Farmers who grew the crop on bigger acreages obtained less yields. The relationship between land size and the quantity of grain amaranth harvested is demonstrated by the scatter plot (Fig. 4). The result show a negative relationship, with yields decreasing as more acreage is put to production. This result is supported by the correlation between grain amaranth yield and acreage which is strong but negative (-0.62).

Gross margin was computed considering farmers who had acreages between 0.02-0.04 ha since this was the most viable acreage for grain amaranth farmers in the study area. For comparison purposes, the return on investment for maize was also computed (Table 8).

Table 8 Profitability of grain amaranth and maize at the prevailing production costs.

Item	Grain amaranth	Maize
	Output and inputs for acreage between 0.02 and 0.04 ha	Output and inputs for one ha
Output (kg)	8	1,156
B. Selling price (Ush kg^{-1})	1,500	349
C. Total value product (A*B)	12,000	403,444
Costs (Ushs)		
D. Production costs (seed, manure)	0	0
E. Post-harvest expenses	0	0
Labour costs		
F. Total family labour (man-days)	11	164
G. Total hired labour (man-days)	0	10
H. Value of family labour/man day*	1,073	2,147
Value of family labour per season	11,807	352,108
Value of hired labour	0	21,470
Total cost of production	11,807	373,578
Gross margin (Ush) (C-K)	193	29,866
Cost of producing one kg of amaranth	1,476	323
Return per shilling invested (L/K)	0.016	0.080

*This analysis considers a person-day as equivalent to 3 hours for grain amaranth as obtained in the descriptive statistics. The cost of family labour was imputed using the prevailing mean wage rate of Ush 2,147 per 6 hours (one man-day is equivalent to 6 hours).

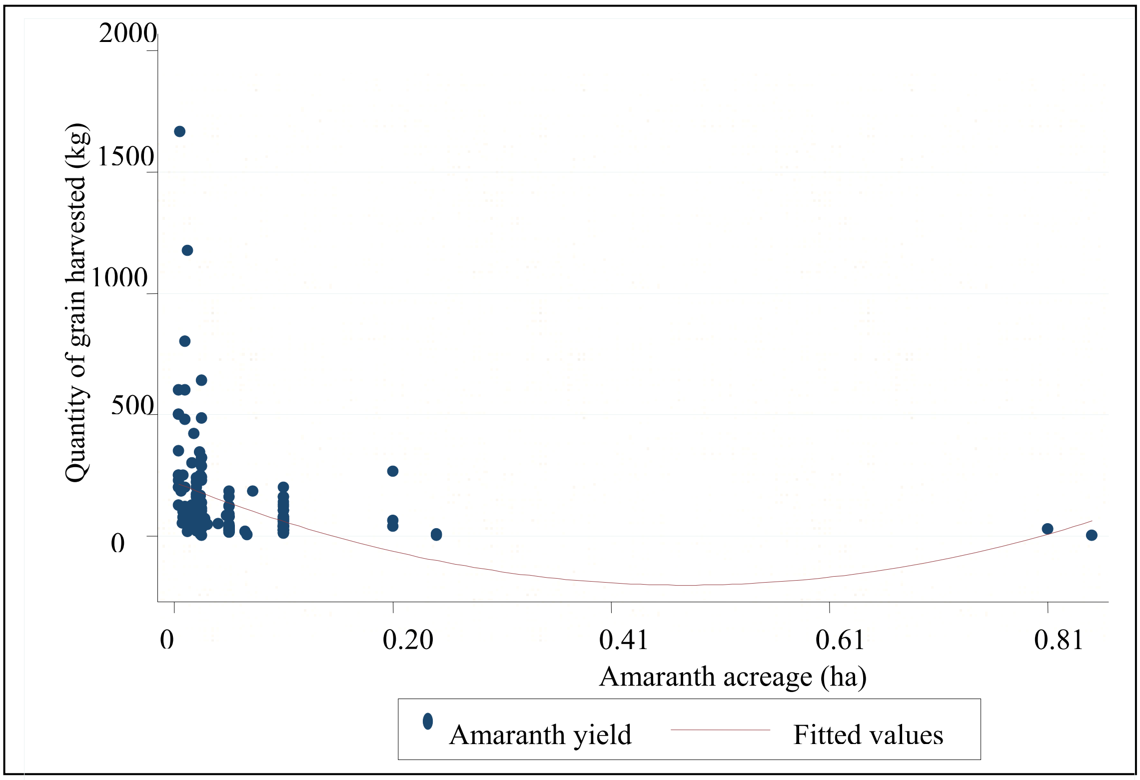

Fig. 4 Relationship between land size and the quantity of grain amaranth harvested.

The cost of producing one kilogram of grain amaranth was almost the same as the selling price of amaranth. The gross margin was therefore small but breaking even, implying that grain amaranth is profitable at the current production state. It had a low but positive return per shilling invested (0.016). Every 100 Uganda shilling invested in grain amaranth production generated 1.6 shillings. This was lower than if it was invested in maize (return of 8 shillings for every 100 shilling invested). This difference is attributed to two main factors: the small scale of production hence not benefiting from economies of scale in comparison to maize, and the low commercial level of grain amaranth whose market was still very limited. The crop is still categorized as a subsistence crop while maize is a commercial crop.

4. Conclusions and Recommendations

Grain amaranth production in Uganda is relatively new. It has been promoted mainly by VEDCO which gives farmers seeds and regular extension advisory services. The production of the crop has, however, attracted female farmers more than the males and the youths. Two varieties, the cream and gold variety are grown although farmers prefer the gold variety. The most important inputs in amaranth production are labour (mainly family labour) and manure. Land was not a constraint because the crop was grown on very small pieces of land compared to the total land owned by farmers. It was estimated that the acreage of 0.02-0.04 ha gave the highest yields. From the study it was found that the likelihood to adopt grain amaranth growing increased with age of the farmer. Female farmers were also more likely to adopt the production compared to their male counterparts. Similarly, farmers who derived their income through farming had a higher likelihood to adopt. Estimation of returns on investment of grain amaranth indicated that its production was profitable although the return per shilling invested was low.

It is therefore recommended that production of grain amaranth is encouraged by both the relevant government and non-government organizations because of its income generation potential. It also requires less land, implying that the landless can also afford to grow it and benefit from the nutrition and also earn some income.

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