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Nimoh, F. (Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana)

Asuming-Brempong, S. (Department of Agricultural Economics and Agribusiness, University of Ghana, Accra, Ghana)

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Author (s)

Nimoh, F. †
Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
Email: frediemoh@yahoo.com

Asuming-Brempong, S.
Department of Agricultural Economics and Agribusiness, University of Ghana, Accra, Ghana

Abstract

Cowpeas have been identified as one of the crops with the highest and cheapest source of protein which can be relied on to help curb malnutrition problem in most developing countries. Farmers in most farming communities in Ghana, such as Akatsi in the Volta region, still practice the 'tradition bound' agriculture. The returns from such production system are estimated to be below potential levels. Assessment of the productivity of major inputs employed in the production of cowpeas in the study area indicates that outputs are below maximum potentials. The level of inputs such as farm size, labour, pesticide, and ploughing (land preparation) were found to be positively related to output, while quantity of seed was negatively related to output. The marginal value products (MVPs) of the inputs were lower than their unit costs. It is anticipated that farmers could increase production beyond current levels, if the resources employed are utilized efficiently. Among the problems identified to affecting the production of cowpeas in the study area include: unfavorable climate, incidence of pests and diseases, land tenure problem, lack of credit for operation, lack of storage facility, transportation and lack of ready market for the produce. To help improve the production, and hence farmers' income and their living standards, there is the need for an accelerated education programme to provide information on the appropriate methods of production, especially on how inputs could be allocated by the resource-poor farmers.

Keywords: Cowpeas, Resource use, Allocative efficiency

Introduction

Cowpeas have been identified as containing adequate levels of protein to help curb protein malnutrition. Cowpeas are the second most important food grain legume crops in tropical Africa (Onwueme and Sinha, 1991). The protein content of cowpeas is estimated to be 23.4% when dry and 3.4% when green or fresh. In developing countries, such as Ghana, the cultivation of cowpea is envisaged to be the best and quickest way to augment the production of food protein. Because of the high levels of protein and calories, cowpeas have been identified as good vehicle for combating protein calorie malnutrition in Ghana (Sefa-Dedeh, 1993).

The ability of cowpeas to produce a few 100kg of grain when pearl millet and peanut have failed to produce any grain has earned the crop the name "Crop of Security" for farmers in Northern Senegal (Menyonga *et al.*, 1987). The production of cowpeas provides a major source of income for farmers in most farming communities. It is also a major and cheapest source of protein for many consumers.

In the study area and other parts of Ghana, the production of cowpeas is mainly on small-scale and many farmers use rudimentary production methods. The output of the smallholder farmer has been found to be seasonally variable, not much because of variation in climatic, but mainly because of how the various inputs are combined in the production of cowpeas. Inappropriate use of the available resources leads to low returns to farmers.

Efficient production, and hence high output and maximum profit, is what every farmer expects to achieve. Efficiency in general refers to a ratio of what is produced to input used (Makehalm and Malcom, 1986). The concept of efficiency may either relate to economic efficiency (thus, allocative or price efficiency) and technical efficiency. Technical efficiency refers to the ability to obtain the highest amount of output with given amount of factor inputs, and allocative efficiency is the concept of efficiency in which resources are allocated in the "Pareto" sense (optimum output) so that marginal value product (MVP) of resources are equal to their amount prices (Onyenweaku, 1991). According to Henderson and Poole (1991), technical efficiency refers to the ability to produce a given level of output with a minimum quantity of inputs under certain technology. Technical efficiency is an operating characteristic of the firm for any combination of inputs where maximal output results.

† Corresponding author

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Optimizing output results in economic efficiency. The efficiency use and productivity of any single resource depends on the equity of other resources it combines with (Heady and Jensen, 1954). With the increasing cost of agricultural inputs, such as labour, improved seeds, pesticides, fertilizer, etc., it is important that small-scale farmers use the available resources at their disposal efficiently in a way that will ensure increased output. Efficient use of resources will help increase production, hence food security. This will also help improve and increase farmers' income, diets of the people and ultimately raise their standard of living.

Following the principles of production economics exemplified in the theory of the firm, maximizing profit has been regarded as the primary objective of farm management to arrive at the particular output that gives greater profit than any other level of output. Similarly, Drucker (1968) stated that management must, in every decision and action, always put economic performance first. The above statements are in line with the theory of the firm, which implies that a farm is performing well if it organizes resources in such a way that it maximizes profit.

To help increase the production of cowpeas to meet the nutritional needs of the growing population, as well as to provide adequate and compensatory returns to farmers, it is imperative to assess the production practices used by farmers, and then make appropriate policy recommendations on measures that will ensure maximum output from economically combined inputs. This study therefore sought to look at the ways in which resources for cowpeas production could be efficiently utilized to ensure maximum output at reduced costs.

The main objective of the study was to evaluate resource use efficiency for cowpeas production in the Akatsi district in the Volta Region of Ghana. The specific objectives were to: examine the demographic features of cowpeas farmers in the study area, evaluate the profitability of cowpeas production in the study area, evaluate the productivity of key production factors the farmer use in the production of cowpeas, and identify the major production and marketing problems faced by farmers in the study area.

Methodology

Study area

The study was conducted in the Akatsi district, located in the South-Eastern part in the Volta Region of Ghana. The choice of the study area was based primarily on the fact that, the Bean/Cowpea Collaborative Research Support Project (CRSP), of which the study was part, undertook some preliminary area, and additional economic information was needed for further studies in the area. The district is located between latitudes 6°S and 7°N and longitude 0°W and 1°E. It is a low-lying coastal plain with flatland in the south and rolling plain to the north. The topography of the district is generally a gentle undulating land averaging 10-50 meters above sea level. The vegetation is of the coastal savanna in the south and savanna woodland to the north. The district falls within the coastal savanna equatorial climate regime, and it is characterized by high temperatures (min. 21°C and max. 34.5°C), high relative humidity (85%) and moderately low regime rainfall (1,084mm) with wet and dry seasons of about equal lengths. The rainfall pattern is bimodal. The economy is a rural one. Agriculture, on subsistence basis, is the leading employer of the district's workforce, and it accounts for about 75.5% of the labour force. The district has a vast cultivatable land area but less than 40% is cultivated.

Type and source of data

The main data that was used for the study was primary data. This was obtained by using a structured questionnaire. Using the simple random sampling technique, a total of 152 cowpea farmers from nine (9) communities/villages were interviewed. The communities/villages are Atidzive, Agoveme, Avenopedo, Monome, Tsakpe, Anyidzim, Tsifakofe, Tsiati, and Akatsi.

Analytical methods

Descriptive statistics such as frequency tables and percentages were used to present information on the demographic features of the farmers interviewed. The profitability of cowpea farming was evaluated using economic analysis to estimate farmers' net returns from production. The net return from operation per farmer per production season was computed as follows:

$$NR = TR - TC \qquad \text{…………………} (1)$$

$TR = Q_i P_i$ and $TC = \sum X_i P_{xi}$,where, TR, is total revenue per season; Qi, is total output (in *olonka* = bowl of cowpea of approximately 3kg weight) per season; P_i, is price of an *olonka* of cowpea received by the *ith* farmer; TC, is total cost of production; X_i, quantity of the *ith* input used for production per season; Px_i, the price of the *ith* input; and NR, is the net return.

The debate regarding the best method to measure farm performance and resource-use efficiency predates the subjects of farm management and agricultural economics as it is known today (Phiri, 1991). In measuring technical and allocative inefficiencies, previous studies by Kalirajan (1981), and Adesina and Djato (1996) used the dual approaches involving the use of profit or cost functions. Other approach based on the profit maximizing assumption used extensively to determine resource use efficiency is the unit profit function approach. Lau and Yotopoulos (1972), Sidhu (1974) and Yotopoulos and Lan (1976) have used the unit profit function approach in assessing resource use efficiency. The use of the unit profit function to determine resource use efficiency has its limitations. The unit profit function is most appropriate for determining relative efficiencies of large and small farms of different technologies and of different scales of operation. Where the profit maximizing and household objectives approaches have been applied to small-scale agriculture, the results have almost been at odds with others (Phiri, 1991). Despite criticisms leveled against the profit maximizing approach of assessing resource use efficiency, many studies have used the approach.

With resource-use efficiency, the farmer is considered to be a rational producer and that s/he allocates resources in a way to maximize profit. A rigorous comparison of the allocative efficiencies of any groups of farms requires that the farms be; (i) characterized by constant returns to scale, (ii) that the farms be represented by the same production function, and (iii) that the farms face the same configuration of input and output prices (Onyenweaku, 1991). To determine the allocative efficiency, a production function is estimated, which is assumed to satisfy the condition that the marginal physical product of any input is positive and should be declining. It is also assumed that all inputs can be divided into two categories, fixed and variable, where in the short-run the inputs are fixed and in the long-run they are variable.

In this study, four different production functions, namely; linear, semi-log, double log (Cobb Douglas) and translog were employed to evaluate the productivity of key production factors for cowpeas production in the study area, and the one produced the best fit was chosen. The double-log function (Cobb-Douglas) provided the best fit and was therefore chosen for the study (Hopper, 1965; Olomla, 1991; Mbata and Matewa, 1983; Sankhayan, 1983).

Using the ordinary least square (OLS) estimator, the production response function model was expressed implicitly as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, Ui) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where Y = Value of output (cowpea) in Cedi, X_1 = Land (farm size in acres), X_2 = Labour (person-days), X_3 = Value of chemical pesticide in Cedi, X_4 = Value of seed, X_5 = Value of ploughing (land preparation) in Cedi, and Ui = error term.

The functional form of the double-log function was expressed as follows:

$$InY = b_0 + b_1 InX_1 + b_2 InX_2 + \ldots\ldots\ldots + b_5 InX_5 + e \quad \ldots\ldots (3)$$

The marginal physical product (MPP) and elasticity were given by:

$$MPP = b * y/x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$Elasticity = b \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where y is the mean output and x is the mean of factor inputs, and bo and bi are the constant and regression coefficients, respectively.

The marginal physical product (MPP) for the factor inputs was computed as follows:

$$MPP_{ij} = \bar{Y}_i \big/ \bar{X}_{ij} * E_{ij} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where, $\bar{Y}$ and $\bar{X}$ represent the means (log) of crop (cowpea) output of the ith farm and the jth input for the jth farm, respectively, and the E_{ij} is the factor elasticity of the ith output of jth input.

Using the above specifications and the output and input prices, the marginal value products (MVPs) and allocative efficiency ratios (F) were computed as follows:

$$MVP_i = MPP_{ij} * P_y \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$F_i = \frac{MVP_{ij}}{P_x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where, P_y and P_x are the unit prices of output and factor input (MFC), respectively. The decision of whether a resource is used efficiently or not, thus allocative efficiency, is based on the value of F_i. If F_i is equal to one ($F_i = 1$), then the factor input is efficiently utilized, hence the farmer is considered allocative efficient (Hopper, 1965). The factor input is over-utilized if F_i is less than 1 ($F_i < 1$) and under-utilized if F_i is greater than unity ($F_i > 1$). The significance of each explanatory variable was determined using the t-test. The overall significance was determined by the F-ratio.

Results and discussion

Table 1 presents information on the demographic characteristics of cowpea farmers in the study area. Of the total number of farmers interviewed, about 68% were males and 32% were females. Most of the farmers were aged between 26 and 45 years, and majority of them (87.4%) were married. Information gathered indicated that some of the male farmers were in polygamous marriage. It was also mentioned that the status as a married farmer was very important, as spouses contributed significantly to the production of cowpea in the study area. Majority (44.8%) of the farmers had family size between 5 and 7 individuals. Most of the farmers (43%) had junior/middle school education, and their major occupation was farming.

Table 1: Demographic Characteristics of Cowpea Farmers in Akatsi District

Gender Distribution			
	Male	Female	Total
Freq.	103	49	152
Valid %	67.8	32.2	100.0

Age (Years) Distribution							
	15-25	26-35	36-45	46-55	56-65	66 and above	Total
Freq.	8	37	50	30	18	9	152
Valid %	5.3	24.3	32.9	19.7	11.8	5.9	100.0

Marital Status					
	Married	Single	Widowed	Separated	Total
Freq.	132	11	5	3	151
Valid %	87.4	7.3	3.3	2.0	100.0

Household Size					
	1-4	5-7	8-10	11-17	Total
Freq.	44	68	32	8	152
Valid %	29.0	44.8	21.1	5.4	100.0

Education							
	JSS/ Middle	No Educ.	Primary	Sec. / SSS	Non-Formal	Tertiary	Total
Freq.	64	33	26	15	7	5	150
Valid %	42.7	22.0	17.3	10.0	4.7	3.3	100.0

Principal Occupation							
	Farmer	Self Employed	Trader	Wage Employee	Food Processor	Student	Total
Freq.	130	9	7	3	2	1	152
Valid %	85.5	6.0	4.6	2.0	1.3	0.7	100.0

Source: Field Survey, 2004

Table 2 presents the information on farm size, variety of cowpea cultivated, and the farmer's experience in cowpea farming. The farm (cowpea) size of majority (29.6%) of the farmers was between 1 and 2.9 acres. The main cowpea variety cultivated was *tsenabawo*. This variety was found to be high yielding, had high demand and better priced, and over 61% of the farmers were cultivating it. The farm experience (cowpea farming) of the farmers ranged between 1 and 50 years. However, majority (34%) of them was found to be in cowpea farming for a period of 6 to 10 years.

Table 2: Farm size, variety of cowpea cultivated and farm experience

Farm Size (Acres)									
	< 1	1-1.9	2-2.9	3-3.9	4-4.9	5	6-9	> 10	Total
Freq.	7	45	45	24	16	6	4	5	152
Valid %	4.6	29.6	29.6	15.8	10.6	3.9	2.6	3.4	100.0

Variety of Cowpea Cultivated								
	Tsenabawo	Vakle	Japango	Tsenabawo & Japango	Tsenabawo & Vakle	Tsenabawo, Japango & Vakle	Asetenapa	Total
Freq.	92	27	15	11	4	2	1	152
Valid%	60.5	17.8	9.9	7.3	2.6	1.3	0.7	100.0

Experience in Cowpea Farming (Number of Years in Farming)									
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	46-50	Total
Freq.	47	51	19	11	7	10	1	1	3	150
Valid %	31.3	34.0	12.7	7.3	4.7	6.7	0.7	0.7	2.0	100.0

Source: Field Survey, 2004

The results of the assessment of the profitability of cowpea production in the district showed that all the cowpea farmers in the various communities/villages obtained positive margins in the previous year's (2003) production (Table 3). The average net return for farmers in the season was about ¢1,158,398.00. There were however variations in the margins for farmers in the different communities. This was due to differences in farm sizes and management practices used by the farmers. It was mentioned that the margins for the past years' production were not all that variable.

Table 3: Profitability of cowpea farming (per Season)

Village	TR (¢)	TC (¢)	NR (¢)
Avenorpedo	3,252,144	948,435	2,303,708
Monome	2,872,136	1,182,091	1,690,045
Tsiati	2,699,000	1,240,800	1,458,200
Tsifakofe	2,475,000	1,286,000	1,189,000
Tsakpe	2,197,429	1,107,964	1,089,464
Akatsi	1,700,000	833,750	866,250
Atidzive	2,180,576	1,369,852	810,724
Agoveme-abor	1,887,850	1,149,662	738,187
Anyidzim	600,000	320,000	280,000

Source: Field Survey, 2004
Note: TR = Total Revenue, TC = Total Cost, NR = Net Returns
Exchange rate: 1 US Dollar = 9,225.00 Ghanaian Cedi

Using the Cobb Douglas production function to evaluate the productivity of key production factors for cowpea production in the study area, results of the ordinary least square (OLS) estimates of the parameters for the sampled farms showed that output (cowpea) was positively related to land (farm size), labour, chemical pesticide, and ploughing (land preparation), but was negatively related to quantity of seed sowed (Table 4). This implies that output increased with quantities of land (farm size), labour, chemical pesticide, and ploughing, but decreased with increased quantity of seed. The result of the estimate showed that land was significant at 1%, and labour and ploughing were both significant at 5%, at R^2 of 42.34% and F-ratio of 23.18.

Table 4: OLS estimates of coefficients: Cobb-Douglas (Double log)

Input	Estimated Coefficients	Standard Error
Constant	1.36	(1.034665)
Land	0.43***	(0.116392)
Labour	0.21**	(0.100490)
Chemical Pesticide	0.09	(0.082422)
Seed	-0.02	(0.100002)
Ploughing	0.22**	(0.084946)
R^2 42.34 F-ratio 23.18	N 152	

Note: ***, ** and * represent levels of significance at 1%, 5% and 10 %, respectively

The effect of changes in output with respect to changes in the factor inputs was determined by evaluating the marginal physical products (MPPs) and elasticities (ϵ) of the various factor inputs (Table 5). The results of the evaluation showed that the marginal productivities (MPs) of land, labour, chemical pesticide and ploughing were positive, while that for seed was negative. Thus, a unit increase in any of the inputs, holding the others constant, caused a change (increase or decrease) in output by an amount corresponding to the respective values of the individual factor inputs. Land and chemical pesticide were more productive than the other inputs. The production elasticity of each input was found to be less than unity, indicating that the relationship between the inputs and output was inelastic. Also the coefficient of returns to scale was 0.93, indicating decreasing returns. Thus, the farmers were operating at the region of the production function where output was increasing less than proportionate with the increase in the factor inputs.

Table 5: Marginal physical products (MPPs) and elasticity (ϵ)

Input	MP	ϵ
Land	3.34***	0.43
Labor	0.44**	0.21
Chemical Pesticide	2.21	0.09
Seed	-0.05	-0.02
Ploughing	0.09*	0.22

Note: Mean of Land (farm size) = 0.63, Mean of Labour = 2.35, Mean of Chem. Pesticide = 0.20, Mean of Seed = 1.82, Mean of Ploughing = 12.64. ***, **, and * represent levels of significance at 1%, 5% and 10%, respectively

To assess the efficient use of resources, the allocative efficiencies (*Fi*) of the various factor inputs were computed using their marginal value products (MVPs) and marginal factor costs (MFCs). The results of the computation showed that, with the exception of seed input, a unit increase in any of the other inputs, holding the others constant, positively changed the monetary returns by a value corresponding to the marginal value product of that input. The marginal value products (MVPs) of all the inputs were lower than their unit costs (Table 6).

The relative allocative efficiency of the cowpea farmers was based on the non-classical requirement that each factor be paid equal to its marginal value product. In the sense, the ratios of marginal value products (MVPs) to marginal factor costs (MFC or unit acquisition cost) were computed and the values obtained were: 0.90, 0.10, 0.27, -0.02 and 0.01 for land, labour, chemical pesticide, seed and ploughing, respectively (Table 6). Studies have shown that maximum or absolute allocative efficiency for a particular resource is confirmed if efficiency ratio (F) is equal to unity (i.e. $F = 1$). But if efficiency ratio is greater than unity ($F > 1$), it means less than the profit maximizing level of the input is in used, and if $F < 1$, it means more than the profit maximizing level of that particular resource is in used (Onyenweaku and Fabiyi, 1991). From the results of the study, it is evident that the efficiency ratios of the inputs were less than unity ($F < 1$) for all the factor inputs, indicating that more than the profit maximizing level of all the resources were employed by the farmers in the Akatsi District. Thus, all the resources were inefficiently allocated and were over utilized above their economic optimum levels (Sankhayan, 1983; Mbata and Matewa, 1983).

Table 6: Marginal value products (MVPs), marginal factor costs (MFCs) and allocative efficiency (F) of factor inputs

Input	MVP (¢)	MFC (¢)	F = MVP / MFC
Land	43,086.87	47,985.58	0.90
Labor	5,676.11	56,799.18	0.10
Chemical Pesticide	28,509.57	104,973.30	0.27
Seed	-645.01	27,850.96	-0.02
Ploughing	1,161.02	201,646.50	0.01

Source: Field Survey, 2004. Exchange rate: 1 US Dollar = 9,225.00 Ghanaian Cedit

Cowpea farmers in the Akatsi district face various production constraints/problems in their operation. Among the constraints/problems identified include: unfavorable climate, incidence of pests and diseases, land tenure problem, lack of credit for operation, lack of storage facility, transportation and lack of ready market for the produce.

Conclusion and recommendations

Based on the results of the study, it can be concluded that cowpeas production in the Akatsi district of Ghana is basically subsistence. However, production in the various communities are relatively profitable. Nevertheless, the farmers are operating at the region of the production function where output is increasing less than proportionate with the increase in the factor inputs used. More than the profit maximizing levels of resources are employed by the farmers in the district. Thus, all the resources are over utilized above their economic optimum levels, and hence inefficiently allocated. Key problems affecting production include both field/farm and post production factors, such as pests and diseases, land tenure problem, lack of credit for operation, lack of storage facilities, transportation and lack of ready market for the produce.

The findings from the study have vital policy implications for enhancing, revitalizing and improving the production of cowpeas in the study area. To help improve the production, and hence farmers' income and their living standards, there is the need for an accelerated education programme to provide information on the appropriate methods of production, especially on how inputs could be allocated by the resource-poor farmers. This information could be made available to the farmers through extension officers. During the survey, it was also observed that many farmers hardly get information from the extension officers due to the high extension to farmer ratio in the district. Efforts by the government through the Ministry of Food and Agriculture (MoFA) should be made to increase and improve extension delivery to the district, and in other parts of the country. A response to this would help increase the production of the cowpeas and crop production in general to help meet the food deficit (quality and quantity) gap in the country. It can also help address the food insecurity problem.

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