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Determinants of Seed Cotton Output: Evidence from the Northern Region of Ghana

Yazeed Abdul Mumin[1]* Ditchfield Precious Kwaku Amegashie[2] Akwasi Mensah-Bonsu[2]

1. Department of Economics and Entrepreneurship Development, University for Development Studies, PO Box 520, Wa, Ghana
2. Department of Agricultural Economics and Agribusiness, University of Ghana, PO Box LG 68, Legon-Accra, Ghana

* E-mail of the corresponding author: yazeeduds@gmail.com

Abstract

This study looked at the factors influencing the output of seed cotton in the Northern region of Ghana. Basically, 200 cotton farmers were interviewed and multi-stage random sampling was used in the selection of cotton farmers. The analytical technique used in the study is the Augmented Cobb-Douglas production model. The results of the maximum likelihood estimation showed the significant determinants of seed cotton output at 10 percent to include: farmer's educational status, experience, farm size, fertilizer, seed used, labour input, location, extension contact and farmer group size with the rest being not significant. The result of the estimation also shows decreasing returns to scale of 0.824. The relevance of these inputs underscore the call on policy and cotton companies to focus on not only the quantity of these inputs but also on their quality and timely provision.

1. Introduction

The efficient and effective production of every crop requires the knowledge of the sensitive factors that influence its production. Even though several studies indicates (Nakhumwa, *et al.,* 1999; Gwimbi, 2009) that biophysical conditions which include the physical climate, physical and chemical soil characteristics, terrain, etc. are important factors affecting farm production because they determine suitability and biological potential of production activities, other studies (such as Singh, 2006) found the level of technology, production systems, farming methods, and land tenure as well as pest and disease management (see Ahmed, *et al*., 2004) as essential factors of cotton production. Various farm inputs such as education, non-farm income and expenditure on plant protection have been identified by studies (such as Kim, 2005 and Sabo, *et al.,* 2009) as relevant factors affecting farm output. Sabo, *et al.* (2009) also indicated that cotton production was gender sensitive to the male sex in Adamawa State of Nigeria. Wizarat (1981), Mahmood, *et al.* (1981), Deolalikar (1981), Yilmaz and Ozkan (2004), Goodwin, *et al.* (2004) and Kiani (2008) observed that cotton production depended on several factors (the land tenure, farm size, fertilizer, irrigation, labour, tractor, bullocks, seeds, current expenditure, cropping intensity, district dummies) which are basically man-made. Notwithstanding these studies, there still exist gap regarding knowledge on the determinants of seed cotton production in Ghana.

Cotton *(Gossypium hirsutum)* is one of the important industrial crops cultivated in the country apart from cocoa, coffee, tobacco and timber. Seed cotton is produced in the country mainly for two reasons: feeding the local textile industries and export. In Ghana, it is cultivated mainly in the Northern, Upper East and Upper West regions. This paper focuses on the Northern Region which contributes up to 50 percent of national output of cotton and also leads in terms of number of cotton growers (22 849 cotton farmers representing 48.0% of cotton producers in the three northern regions)(MOFA, 2006). Cotton is an important cash crop in this area because it contributes to increasing access to innovation, serves as a source of income and employment to farmers and their families in the area. Families of cotton farmers benefit from cotton production, making them less vulnerable to poverty (Quarshie, 2002). It also provides raw material to textile mills, ginning factories and oil expellers and as such was considered for the Presidential Special Initiative (PSI) in Northern Ghana.

In spite of this economic significance of cotton, the crop records wide fluctuations in output levels. The level of output of seed cotton in the Northern region declined from 23 369 metric tonnes in 1999/00 to 12 607.9 metric tonnes in 2007/08. This development affected lint production which also declined from 9 348 metric tonnes to 5 325.1 metric tonnes over the same period (MOFA, 2006, ICAC, 2007 and MOFA, 2008). The general ramification of this situation has been the decline in the national production levels of seed cotton from 35 503 metric tonnes in 2000 to 17 506 metric tonnes in 2001, representing a 51.0% decline in production. Although the output of seed cotton increased to 22 851 metric tonnes in 2002, it later decreased to an average of 21 000 metric tonnes from 2005 through 2007 (MOFA, 2008). This developments in the cotton sub-sector is partly attributed to cotton production in the Northern region being characterized by appreciable levels of technological limitations, uncertain quality and time of input delivery to cotton farmers, very low producer price and inadequate education and research (ICAC, 2007).

The ability of cotton farmers to stimulate cotton output and yield in the Northern Region of Ghana is mainly affected by their understanding and application of the farm level factors in production. However, the understanding and application are low due to high illiteracy rate and malpractices among farmers in the Northern Region (MOFA, 2006 and Al-Hassan, 2008). Also, in comparing Ghana and other Western and Central African countries, Ghana lies far behind all cotton producing countries although it is argued that Ghana has excellent conditions for cotton production (Hussein *et al.* 2005). For instance, Togo (which is smaller than Ghana) and Senegal (where the natural resources are far less favourable than in Ghana) produce more cotton annually than Ghana (MOFA, 2006 and ICAC, 2007). Although a variety of factors either natural or socio-economic have been identified to affect crop output Ali, (1983); Khan, *et al.* (1986); Nabi, (1991); Hassan, (1991); Ahmed and Kuhlmann, (2004); Khuda, *et al*., (2005); Singh, *et al.* (2006); Gwimbi, (2009) and Sabo, *et al.* (2009) there still exists inadequate literature regarding the factors responsible for increased cotton output and the extent of contributions made by these factors in the Northern region of Ghana.

Unlike the food crops and cocoa sectors where extensive research is being carried out, research in cotton is lagging in Ghana (MOFA, 2002 and ICAC 2007). Literature has shown that research works conducted into the cotton sector focus on the state of cotton industries in Ghana, prospects and challenges of the crop production, the impact of cotton production specifically on food security, supply response, domestic and international trade policies, profitability, price incentives and cost analysis of cotton (Yilmaz and Ozkan, 2004; Seini, 1986 and 2002; Wahab, 2006 and ICAC, 2007). These glaring problems and the need to promote cotton production called for examining the factors affecting the output of seed cotton. Therefore, the objective of the study is to determine the factors affecting the output of seed cotton in the Northern region of Ghana. The rest of the paper is organized as follows: Section (2) encapsulates the methodology of the study. Section (3) focuses on the empirical results of the study. Conclusions are presented in section (4).

2. Methodology

2.1 Theoretical Framework

Examining the factors that determine production involves the evaluation of the extent to which inputs are transformed into output. This can be attained using a production function which seeks to relate the level of output to levels of inputs available for a given technology. This study utilized the Power production function commonly known as the Cobb-Douglas production function. The Cobb-Douglas is principally a nonlinear production function and is one of the commonly used function in economic analysis (Coelli, *et al*., 2005) of issues relating to empirical estimation in agriculture (Sankhayan, 1988). The functional form of the Cobb-Douglas is given as:

$$y = a_0 \prod x_i^{\alpha i}, \qquad i = 1, 2, \dots, n. \tag{1}$$

where, y and x_i are the levels of output and inputs respectively. The constants α_0 and α_i represent the efficiency parameter and the production elasticities of the respective input variables. The estimation form of this function can be derived by taking the natural logarithms of the both sides. This will give the function as below:

$$ln\, y = ln\, a_0 + \Sigma\, a_i\, ln\, x_i\,, \qquad i = 1, 2, \dots, n. \tag{2}$$

where ln is the natural logarithm notation and the rest of the variables are as described above. It has been argued that the purpose of estimation of a production function is to derive various quantities of economic significance (see Sankhayan, 1988) such as average and marginal products, elasticity of production and returns to scale, isoquants and rates of technical substitution among others. The emphases of this work are the factor shares (total, average and marginal products) and the returns to scale. Whereas the factor shares are short run analysis, the returns to scale analysis is a long run problem and deals with what happens when all the factors of production are increased simultaneously (Sankhayan, 1988). In order to achieve the objectives of functional analysis, several theoretical deductions, made from the production function, used in this study include average product (AP), marginal product (MP), elasticity of production (EP) and returns to scale (RS). The mean values of cotton output and inputs were used in the assessment of these concepts stated.

The average product (AP) is the output (Q) produced per unit of the variable input x_i, keeping other inputs constant at some specified levels. This is used to measure the average physical product of the inputs. The AP of input x_i is:

$$AP = Q/x_i, \text{ holding } x_2, \dots, x_n \text{ constant}, \qquad i = 1, 2, \dots, n. \tag{3}$$

Thus the AP is derive by dividing the mean output (Q) for all farmers by the mean level of the given input (x_i).
Marginal product (MP) is the change in the total product due to a unit change in the input, keeping all other inputs constant at the same prescribed levels. This is deduced from the assumption of the production function

that is a single valued and continuous for which there exist first and second order partial derivatives of output with respect to each of the variable inputs. The first order partial derivative of Q with respect to x_i yields the MP as illustrated below:

$$\partial Q/\partial xi = MP_i = a_i x_i^{ai-1} a_0 x_i^{ai} x_2^{a2},\dots,x_n^{an} = 0 \quad (4)$$

$$= a_i x^{-i} Q \quad (5)$$

$$MP_i = a_i (Q/x_i) \quad , \qquad i = 1, 2, \dots, n. \quad (6)$$

The second order partial derivatives need to be negative (for output maximization) as required for its concavity (Sankhayan 1988; Coelli, et al., 2005) such that;

$$\partial^2 Q \big/ \partial x^2 < 0 \quad (7)$$

For a case of diminishing returns to input x_i; $(\partial Q^2 / \partial^2 xi) < 0$, which implies that $0 < a_i < 1$ and at the maximum of AP, MP = AP. Where: a_i is the coefficient of the x_i. The MP is assess by multiplying the coefficient (a_i) of the input by the average product (Q/x_i) as seen in equation (6). The allocations of variable inputs in a way that will engender the achievement of the objective of output maximization by a farmer require the operation at the efficient part of the production function. This efficient part is evaluated by considering the behavior of the MP in the production function. In principle the MP of a factor may assume any value, positive, zero or negative. However, according to production theory only the part of the production function, that is, on the range of output over which the MPs of the factors are positive with APs higher than MPs (Koutsoyiannis, 2003) are considered efficient (see Bishop and Taussaint, 1958; Chisholm and McCarty, 1981; Adegeye and Dittoh, 1985) and these can be found in the second stage of the typical production function.

Elasticity of production (EP) is the percentage change in the quantity of output (Q) due to one percent change in the quantity of a given input (x_i) while keeping all the other inputs constant at some prespecified levels. Elasticity of production (Q) w.r.t. input x_i can be obtained as:

$$EP = \partial Q/\partial x_i \,.\, x_i/Q \text{ thus}, \qquad i = 1, 2, \dots, n. \quad (8)$$

$$EP = (a_i Q/x_i)/(x_i/Q) \quad (9)$$

$$EP = a_i \quad (10)$$

Thus, for the Cobb-Douglas production function the power of the respective input variable directly give the elasticity of production with respect to it. The elasticity of production of an input can be less than, equal to or greater than unity as its MP is respectively less than, equal to or greater than its AP. It will be positive if both AP and MP are positive.

Returns to scale (RS) is a technical property of production function used to describe the relationship between scale and efficiency (Frank and Bemanke, 2000). This tells what happens to output when all inputs are increased by exactly the same proportion. This can be estimated as:

$$RS = \sum_i^n (\partial Q/\partial x_i)(x_i/Q) \quad , \qquad i = 1, 2,\dots,n \quad (11)$$

Thus the summation of all the powers of the input variables provides directly a ready estimate of the returns to scale. Returns to scale can be decreasing, constant or increasing depending on whether a_i is less than, equal to or greater than one.

2.2 Model Selection

Recent literature presents various models for explaining the relationship between output and inputs in the various branches of economics. Sabo *et al.,* (2009) used varied production functions to test which one best describes cotton production in Adamawa State. This approach is what this work adopts. The algebraic forms of the linear, log-linear and Cobb-Douglas specifications are respectively as follows:

$$y = a_0 + \Sigma\, a_i x_i + e \quad (12)$$

$$\ln y = a_0 + \Sigma\, a_i\, x_i + e \quad (13)$$

$$\ln y = \ln a_0 + \Sigma\, a_i \ln x_i + u \quad (14)$$

Where y is the level of output, x_i is the ith input used, a_0 is the constant and a_is, are the parameter estimates, ln is natural logarithm and, e and u are the stochastic error terms assumed to be normally distributed as [e and u $\sim N(0, \sigma_e^2$ and $\sigma_u^2)$]. These three models as specified above were ran and the best model was adopted on the basis of the RESET test, the Akaike (AIC) and Bayesian (BIC) Information criteria. These provided a basis for determining model adequacy and if these parameters are reasonably good for a model, then that model can be accepted as a fair representation of reality (Gujarati, 2006). The Ramsey RESET test was used to test for model specification. This was done by testing whether introducing values of the predicted dependent variable (cotton output) as additional explanatory variables in the models will lead to a statistically significant increase in the R-squared (for a model misspecified), on the basis of the f-test.

Table 1: Model Selection Statistics

Description	AIC	BIC	Ramsey RESET: F-value (prob.)
Cobb-Douglas	132.71	182.03	2.01 (0.114)
Log-linear	136.61	186.08	1.89 (0.134)
Linear-linear	3045.46	3094.93	24.39 (0.000)***

Source: Field survey, 2010.

Table 1 shows that the Cobb-Douglas and the Log-linear functions were not statistically significant as indicated by the F-values of the RESET test whereas the Linear-linear function is significant at 1%. This makes the former functions superior to the Linear-linear function. However, the least Akaike (AIC) and Bayesian (BIC) criteria values in Table 1 suggests that the Cobb-Douglas is relatively superior to the Log-linear and as such adopted. As a result, the study employed the Augmented (Note 1) Cobb-Douglas Production function in the estimation. Another advantage of the Cobb-Douglas production function is that it gives direct measures of elasticity. The Augmented Cobb-Douglas model used is specified as follows:

$$\ln Q = \ln \beta_0 + \beta_1 \ln Lab + \beta_2 \ln Fsize + \beta_3 \ln Fert + \beta_4 \ln Edu + \beta_5 \ln Ext + \beta_6 \ln Exp + \beta_7 \ln Sd + \beta_8 \ln Fagp + \beta_9 \ln Spray + \beta_{10} Ldo + \beta_{11} Mkt + \beta_{12} Loc + \beta_{13} Gend + \beta_{14} Bon + u \quad (14)$$

Where: β_0 is the intercept and β_1 to β_{14} (Note 2) represents the parameter estimates and u is the stochastic disturbance term assumed to be normally distributed ($u \sim N(0, \sigma_u^2)$). The rest of the variables are as defined in Table 2 below. The statistical significance of the various coefficients of the model was tested by the following hypothesis stated below with H_0 and H_1, representing the null and alternate hypotheses respectively.

H_0: There is no relationship between the explanatory variables and the dependent variable ($\beta_i = 0$)

H_1: There is a positive relationship between the explanatory variables and the dependent variable ($\beta_i > 0$)

In an attempt to maximize the reliability of the estimates and conclusions, it was deemed imperative to test the fitness of the model. This indicates the extent to which variations in the dependent variable is jointly explained by variations in the independent variables. The F-test was used to achieve this requirement. The goodness of the model was also assessed by using the R-squared. The model was estimated using the Maximum Likelihood Estimation (MLE).

2.3 Data

Cross-sectional data were collected from 200 cotton farmers in two main producing districts (90 farmers from the Savelugu/Nanton District and 110 farmers from the West Mamprusi District) in the Northern region of Ghana using multi-stage random sampling technique. The selection of the districts was done using purposive sampling because these districts represented the districts with the largest number of farmers (GCCL, 2009) and selection of farmers was done randomly. Data were obtained on farmer-issues including socio-demographic characteristics, cotton production (output and conventional inputs) and marketing, land tenure and other inputs as well as equipment, using structured questionnaire. However, the effects of climatic factors, time and soil quality were not captured in the model mainly because the study dealt with only cross-sectional data. Also, the problem of endogenous bias could not have been discounted for interviewing only cotton farmers but the focus of the study was not on binary choice where the views of non-cotton farmers would have been very necessary.

3. Empirical results

Table 2 presents the basic statistics of the various variables used in the model. The key statistics presented are the means and standard deviations. The average number of years spent in formal education is 1.79 years which is far less than the national average on 10 years (Al-hassan, 2008). This indicates a high illiteracy rate among cotton farmers in the area. However, these farmers have an appreciable level of experience in cotton farming because farmers have at least 11 years, on the average, of experience in cotton farming.

Table 2: Name, Description and Summary statistics of variables used in the model

Variable	Name and description	Mean (STD)
Q (DV)	Cotton output (kilograms)	1 236.94(951.73)
Edu	Level of education (No. of years spent in formal education)	1.79(3.59)
Exp	Level of experience (No. of years in cotton farming)	11.89(7.47)
Fsize	Cotton farm size (Hectares)	2.15(1.42)
Sd	Quantity of seeds used (kilograms)	1.45(1.11)
Spray	Volume of chemical spray used (Litres)	8.63(5.72)
Fert	Quantity of chemical fertilizer used (kilograms)	5.75(3.92)
Ext	Extension contact (No. of contacts with extension officer/season)	3.91(2.13)
Fagp	Farmer group size (No. of farmers in the group)	6.49(1.90)
Lab	Labour used on the cotton farm (man-days)	40.73(19.05)
Loc	Farmers location (Dummy: 1=Savelugu/Nanton district and 0=West Mamprusi district)	0.50(0.50)
Gend	Gender of farmer (Dummy: 1=Male and 0=Female)	0.89(0.31)
Mkt	Market availability (Dummy: 1=When farmer takes part in negotiating prices, have early sales and receives instant payment and 0=Otherwise)	0.58(0.49)
Ldo	Land ownership (Dummy: 1=Owner of cotton farmland and 0=Otherwise)	0.91(0.29)
Bon	Motivation package (Dummy: 1=received bonus & 0=Otherwise)	0.39(0.49)

Note: DV=Dependent variable
Source: Field survey, 2010.

The average cotton farm size is 2.15ha which is quite small compared with the average of 2.8ha for other crops cultivated in the area. The average quantities of other conventional inputs (seed, spray, fertilizer and labour) are 1.45kgs, 8.63litres, 5.75kgs and 40.73 man-days respectively. The spray is made up of insecticides and weedicides. The insecticides were applied five times in each cropping season by almost all farmers because these were provided by cotton companies whereas the weedicides were applied by few farmers who could afford to buy them on their own. The average number of contacts with extension officers is at least 3 times per season. Discussion with cotton farmers suggests that this is relatively good when compared with their contacts with extension officers on other crops because they indicated that the cotton companies make sure the Cotton Production Assistants visit the farmers. Farmer group is a requirement for cotton production in the area and the average number of people in the group is at least 6 people. Cotton farmers are predominantly males (89%) and landowners (constituting 91%) in the area.

Table 3 presents the model diagnostic statistics on the basis of the three functional forms. From Table 3, the R-squared is 75.4% (for the Cobb-Douglas) suggesting that at least 75% of variation in seed cotton output in the Northern region is explain by the variables included in the model. Also, the probability of the F-statistic is 0.000 suggesting that the R-squared is significant and that the explanatory variables of the model (farm size, experience, quantity of seed, spray, fertilizer, contact with extension agents, farmer group, labour, location, gender, education, market, land ownership and bonus) collectively and significantly explained the quantity of seed cotton produced in the area.

Table 3: Model Diagnostic Statistics for the Three Functional Forms

Description	Cobb-Douglas	Log-Linear	Linear-linear
R-squared	75.4	75.0	77.1
Adjusted R-squared	73.5	73.0	75.3
F-statistic	59.09	60.640	25.350
F-Probability	0.000	0.000	0.000

Source: Field survey, 2010.

Table 4 presents the parameter estimates of the determinants of cotton output using the three functional forms and the discussion focuses on the adopted one which is the Augmented Cobb-Douglas function. Table 4 also shows the average products (AP) and marginal products (MP) of the inputs. Education is a variable that has a positive and significant relationship, at 10 percent, with cotton output in the area. This has an elasticity of 0.099 indicating that, *ceteris paribus*, a 1% increase in a farmer's schooling year adds up to 0.099% increase (68.41kgs in terms of marginal product) to the farmer's output of seed cotton because farmers with appreciable levels of education were able to manage their inputs and farms quite well. Experience of the farmer was positive and statistically significant, at 5 percent, suggesting that farmers who stayed longer in cotton production obtained higher output of cotton *ceteris paribus*. This had an elasticity of 0.077 and a marginal product of 8.01kgs. Discussions with the farmers suggest that experience is a crucial factor because it aids them in the use of inputs and risk and uncertainty evaluation and control.

The estimate of farm size has an elasticity of 0.241 and is positively significant at the 5 percent level suggesting a 0.241% (138.65kgs of marginal product) increase in output of seed cotton given a percentage (a unit) increase in the hectors of land used. The more land allocated to cotton enable farmers to either vary land as an input or practice land rotation although this practice might not necessarily guarantee efficiency. Seed quantity was another variable with a positive relationship with output and statistically significant at 10 percent. Thus farmers who used more quantity of cotton seed, with the appropriate combinations and levels of other inputs had more cotton plants per farm and hence, higher levels of cotton output than those who used less quantity of cotton seeds as was also argued earlier by Sabo, *et al.* (2009) and Yilmaz and Ozkan (2004). This has an elasticity of 0.089. The fertilizer input had an elasticity of 0.184 suggesting that a 1% increase in the kilograms of chemical fertilizer used increases cotton output by 0.184%. Indeed fertilizer was considered as an important input by farmers because of its role in increasing cotton output in the area. Extension services enhanced farmers' access to modern agricultural technology, especially input varieties and use as well as pests and disease control and had an elasticity of 0.219% increase in cotton output given a percentage increase in contacts. Despite the relevance of extension services farmers were reported to have had inadequate contact with extension agents. The reasons were mainly due to limited logistic support to visit all farmers by an agent and also other farmers were avoiding the agents when they failed to comply with prescribed advice and practices.

The estimate for labour used is positive and significant at 1 percent level of significance and had an elasticity of 0.272 suggesting that, holding other factors constant, a percentage increase in labour used contributed up to 0.272% increase in the level of cotton output. Discussions revealed that labour was required to carry out cotton activities timely; particularly weeding and harvesting (since harvesting in particular is labour intensive and farmers used an average of 53 man-days).

Table 4: Parameter estimates (based on Cobb-Douglas, Log-linear and Linear-linear models) of the determinants of cotton output.

Variable	Cobb-Douglas		Log-linear		Linear –linear		Cobb-Douglas	
	Elasticities	t-value	Elasticities	t-value	Elasticities	t-value	AP	MP
lnEdu	0.099 (0.051)*	1.92	0.073 (0.029)**	2.51	109.21 (52.84)**	2.07	691.02	68.41
lnExp	0.077 (0.376)**	2.26	0.005 (0.005)*	1.79	-2.41 (5.59)	-0.43	104.03	8.01
lnFsize	0.241 (0.102)**	2.36	0.057 (0.038)	1.48	87.82 (62.12)	1.41	575.32	138.65
lnSd	0.089 (0.053)*	1.66	0.080 (0.027)***	2.97	190.11 (78.61)**	2.42	853.06	75.92
lnSpray	-0.017 (0.087)	-0.33	0.004 (0.006)	0.75	6.42 (14.95)	0.43	143.33	-2.44
lnFert	0.184 (0.052)**	2.11	0.026 (0.014)*	1.77	81.11 (25.09)***	3.23	215.12	39.58
lnExt	0.219 (0.052)***	4.23	0.064 (0.016)***	3.97	74.28 (21.65)***	3.43	316.35	69.28
lnFagp	-0.693 (0.107)***	-6.46	-0.126(0.017)***	-7.58	-129.44(23.34)***	-5.55	190.59	-132.08
lnLab	0.272 (0.082)***	3.30	0.005 (0.002)***	2.73	3.40 (2.33)	1.46	30.37	8.26
Loc	0.277 (0.066)***	4.20	0.238 (0.070)***	3.41	340.45 (94.89)***	3.59		
Gend	-0.025 (0.072)	-0.35	0.058 (0.074)	0.79	-160.54(117.71)	-1.36		
Mkt	0.024 (0.051)	0.47	0.044 (0.051)	0.88	60.09 (67.76)	0.89		
Ldo	0.118 (0.077)	1.53	0.136 (0.075)*	1.80	42.24 (145.43)	0.29		
Bon	-0.041 (0.063)	-0.65	-0.027 (0.064)	-0.43	-16.38 (104.00)	-0.16		
Constant	6.076 (0.034)***	16.18	6.368 (0.205)***	31.13	441.46 (278.65)	1.58		

Note: Values in parenthesis = robust standard errors; ***, **, * significant at P</=0.01, 0.05 and 0.10 respectively and ln = natural logarithm, AP =Average product and MP = Marginal product. Return to scale (RS) = 0.824

Location is a district dummy and has a positive effect and significant at 1%. This has an elasticity of 0.277

implying that, *ceteris paribus*, the output of cotton for farmers in the Savelugu/Nanton District is 31.917% (Note 3) higher than the output of farmers in the West Mamprusi District. This development was mainly explained by the use of herbicides/weedicides in the Savelugu/Nanton District and the gradual replacement of cotton with watermelon in the West Mamprusi District. Farmer group size had a negative relationship (and did not meet the apriori expectation because large group size was expected as a means of social capital) with cotton output and significant at 1%. The elasticity of farmer group size implied that a percentage increase in the size of farmer group leads to 0.693% decrease in output of seed cotton in the area. This was so because farmer group is a pre-requisite for cotton production and also a hedge to remedy defaults in nonpayment of outstanding debts by farmers. The estimation revealed that market availability and land ownership have positive correlation with the level of seed cotton output whereas gender and bonus have negative relationship. These variables were, however, not significant. Spray used and farmer group size are within the ranges of output for which the MPs are negative (-2.44 and -132.08, Table 4). This is the stage 3 of the production function and represents an inefficient stage. Spray had a negative elasticity of 0.017 but not statistically significant. The sprays used did not meet the expected sign because it was said to have been less effective and contributed to withering of the cotton plant and this was attributed to expired sprays supplied to farmers by cotton companies. However, it still remained the lead pests and disease management strategy in the area.

The relationship between the marginal product (MP) and average product (AP) for all the other inputs in Table 4 suggests that farmers in the area are operating at the efficient part of their production. This was evident in the fact that the APs for these inputs were higher than the MPs and also fall under the efficient range of output over which the MPs are positive placing the range of operation in the second stage of production. This shows that the outputs of these inputs are in the range where the MPs are decreasing and suggests the existence of diminishing returns to these individual input variables, under usual conditions, since the APs were higher than the MPs. This was a typical characteristic of the stage 2 of the production function where the MPs are not only positive and falling but also lower than the APs for each of these variables. Hence, farmers need to operate within this range for these resources since any addition will lead to increase in their TP, *ceteris paribus,* and cut down the use of the spray provided as well as the farmer group size. The result of the estimation showed returns to scale of 0.824 suggesting that 1% increase in all factors employed in cotton production by the same proportion in the area, given their present state of technical abilities, leads to 0.824% increase in the output of seed cotton in the long run. This is a situation of decreasing returns to scale and was partly attributed to diseconomies creeping in because of the decreasing ability of the Ghana Cotton Company Ltd and other companies to efficiently co-ordinate the activities of cotton farmers in the area.

4. Conclusions

This study employed the Augmented Cobb-Douglas production function to estimate the determinants of seed cotton output. The findings are that: experience and educational level of the farmer positively and significantly influence the output of cotton because of the implication of these factors on input use and dealing with risk and uncertainty. The quantities of seed and fertilizer used are significant inputs affecting the output of seed cotton. Labour employed also significantly influences seed cotton output. This suggests that the key conventional farm inputs in the area play crucial roles in augmenting cotton output. Contact with extension agents is a means of imbibing farming skills and motivation for farmers to comply with good farming practices and as such has a significant effect on output. The existence of other cash crops serves as a threat to cotton production in the area since the location difference in output of the farmers in the two districts is partly due to the production of watermelon in the West Mamprusi district. Although farmer group is a hedge against farmers default, larger farmer groups adversely affect cotton output. The other factors although crucial but do not significantly affect the output of seed cotton. Cotton farmers in the area are operating within the efficient range of input application for most inputs suggested by the higher AP over MP for these inputs and the positive values of MP. The result of the estimation shows returns to scale of 0.824 which is decreasing returns to scale.

With the high level of illiteracy and the importance of experience in cotton farming among sampled farmers, the implementation of educational and mentorship programming is recommended to improve farmers' skills and performance. Thus policy and cotton companies need to focus on timely delivery of good quality cotton seed and fertilizer in the right amount as well as supply of unexpired and familiar weedicides and pesticides. Also, further investigation into the sources of these sprays, reasons for their supplies and their effects on the cotton plant is expedient. Contact with extension services should be deepened by increasing the knowledge and logistic base of the Cotton Production Assistants to offer the relevant services and advice needed by farmers. Farmers should at least operate within this current range for the resources employed at their efficient levels since any addition will lead to increase in their output, ceteris paribus.

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Notes

Note 1: Augmented because the model specified is not the conventional Cobb-Douglas function.

Note 2: The derivation of the coefficients of the dummy variables for a natural logarithm function is given as $(e^{\beta d} - 1) *100$, where: e is a mathematical constant and it is given as 2.71828, β_d is the value of the estimated coefficient in the production model.

Note 3: Natural log of the dummy variable was derived from working out the relation $[(e^{0.277} - 1)100] = 31.917$. Where: e = 2.71828 and 0.277 is the coefficient of the dummy variable.