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Are Farmers Surviving the Level of Seasonal Cultivation of Tomatoes in Ghana? A Tobit Regression Analysis

Caleb Attoh[1]Edward Martey[2*] Kwame Annin[3]Alexander N. Wiredu[2]Roland Quaye[4]
1. Audit Service, Cape-Coast, Ghana
2. CSIR-Savanna Agricultural Research Institute, Ghana P.O. Box TL 52, Tamale, Ghana
3. Mathematics and Statistics Department, Kumasi Polytechnic, Ghana P. O. Box 854, Kumasi, Ghana
4. Meridian Seeds Ghana Ltd, Achimota, Ghana
*E-mail of the corresponding author:marteywayo@yahoo.com/eddiemartey@gmail.com

Abstract
Tomato is an important vegetable in the cultivation and diet of Ghanaians. However, statistics have shown that domestic production of fresh tomato is on the decline. As an important traded commodity, the research wonders if the decline is due to lower farm land devoted to its cultivation.The paper therefore, seeks to identify factors that influence the seasonal farm size devoted to tomato cultivation. A total of 159 farmers in three regions in Ghana were purposively and randomly sampled and interviewed. Results from thetobitregression model suggests that approaching the dry season, farmers using any irrigation technology tend to allocate smaller proportion of farmland to tomato. It was also realised that as farmers acquire additional farmland for crop production, they are likely to reduce the level of tomato cultivation. This could mean that farmers are only surviving the cultivation of tomato as they are unlikely to increase its cultivation. Strategies that reduce the cost of irrigation especially in the drier seasons and enhance access is critical for increasing tomato production in Ghana. Training of farmers must target good storage and use of seeds from formal sources.
Key words: Seasonal, Tomato, Cultivation, Tobit Model, Ghana

1.0 INTRODUCTION

1.1 Background and Problem Statement

The crops sub-sector is a major component in the Ghanaian agricultural sector. It contributed about 61.8 percent to the agricultural GDP (MoFA, 2010). This sub-sector includes tomato(*Lycopersicon spp.*) production. As an agricultural venture, tomato production has a great potential for growth and employment generation for the rural folks (Clotte*yet al.*, 2009). This is because it is an important vegetable, a condiment in the diet of Ghanaians and is easy to grow.Tomato is used in many dishes in Ghana in its raw or processed form. It grows very well in the tropical climate, which also makes it highly perishable. When picked ripped, they tend to rot within few days and create problems for farmers in times of seasonal glut when they are unable to sell immediately. Its seasonality therefore, remains the hindrance to increases in the volumes of production. Processing appears to be the main solution to perennial gluts in the tomato sector (Robinson and Kolavalli, 2010).

Cultivation of tomato follows differences in rainfall patterns and access to water. As a result farmers have become increasingly dependent on rain water for tomato production. On the other hand, seasonality has becomes a major constraint to its domestic production because of the availability of water due to the unreliable rainfall pattern. This is a source of risk for farmers. Also, the dependence on rain water has led to rather varying degrees of production among seasons but there is scanty research on the factors affecting seasonal cultivation of tomato.In these conditions, the opportunity to increase the land size of tomato production under appropriate conditions could be seen as important to secure increased income for farmersespecially when water is available all year round. However, Statistics indicate that there is a declining trend in domestic production of fresh tomato (FAOSTAT, 2011; Attoh, 2011). Being a traded commodity, the research wonders if the decline is due to lower farm land devoted to its production. The main objective of this paper is to identify factors that affect the seasonal size of farm land devoted to tomato cultivation.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study targets the three main tomato producing districts in three regions of Ghana namely Upper East, BrongAhafo and Ashanti Regions. The three districts are described below:

Wenchi District: This district, now a municipality is located in the western part of the BrongAhafo Region. It is

situated in the northwest part of Sunyani, the regional capital. The major economic activities in the municipality are agriculture and forestry. Most farmers acquire land through inheritance or work on family lands. The major crops grown are maize, yam, tomatoes, cassava and plantain. Hired labour is the dominant source of labour(ghanadistricts.com, 2011). Communities involved in tomato production in the district are Nkonsia, Awisa and Asubinja.

Offinso North District: It is located in the North-Western part of the Ashanti region. It is bordered by the BrongAhafo Region in the north and west. The district experiences semi-equatorial conventional climate. Soils are suitable for the cultivation of crops such as yam, cassava, maize and vegetables (for example tomatoes). Agriculture is the main economic activity in the district (ghanadistricts.com, 2011). Communities involved in tomato production in the district are Akomadan and Afrancho.

KasenaNankana East District: It is a newly created district that falls within the savannah vegetation belt. Rainfall is modest and only one rainy season. This allow for the cultivation of cereals, legumes and vegetable for own consumption and for the market only in a season without the use of irrigation (ghanadistricts.com, 2011). Communities involved in tomato production in the district are Tono, Doba, Mingu, PunguBavugenia and Nyangua.

2.2 Sampling Techniqueand Data Collection

Farmers were selected based on a multistage sampling technique. Firstly, three regions were purposively selected namely Upper East, BrongAhafo and Ashanti Regions. These are well known as areas for commercial tomato production in Ghana. The second stage involves purposive selection of one district from each region namely KasenaNankana East (Upper East Region), Wenchi (BrongAhafo Region) and Offinso North (Ashanti Region) Districts with the help of the officials at the Ministry of Food and Agriculture (MoFA). Finally, the farmers were randomly selected from the list of tomato producing households in each of the identified districts. In summary, 159 farmers (60 respondents from Akomadan, 52 from KasenaNankana East and 47 from Wenchi) were sampled and interviewed.

Data for the study was collected based on the number of times each farmer was involved in producing tomato during the 2010/2011 production year (i.e. seasons of production). The questions werethen repeated for the number of seasons identified for each farmer during the production year. Three seasons were categorized representing seasons in which farmers produced tomato.Primary data captured include demographic, socio-economic and institutional factors. Secondary data source was also used to augment the primary data. A total of 215 data points weretherefore, collected and used for the analysis.

2.2 Method of Analysis

2.2.1 Tobit Model Analysis

The tobit model is used to quantify determinants of the factors influencing the area of farmland cultivated to tomato by a farmer. The model supposes that there is a latent unobservable variable Y_i^* which depends linearly on $X_i$through β_i vector parameters. There is a normally distributed error term e_i to capture random influence. The dependent variable $Y_i$is defined as the latent variable whenever the latent variable is above zero and zero otherwise (Chebil *et al.*, 2009; Sindi, 2008).The Tobit model used in the study measures not only probability of seasonal cultivation but the degree of cultivation.The standard Tobit model is summed as:

$$Y_i^* = X_i'\beta_i + e_i\,, \qquad e_i = N(0,\sigma^2) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$Y_i = X_i\beta_i + e \qquad if \quad X_i\beta_i + e > 0$$

$$Y_i = 0 \qquad if \quad X_i\beta_i + e \leq 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where Y_i^* is the latent dependent variable, Y_i is the observed dependent variable, X_i is the vector of independent variable, β_i is the vector of maximum likelihood estimated coefficients and e_i's are assumed to be independently normally distributed.Appendix 1 shows the list of explanatory variables,X_i, that are expected to potentially affect the extent of tomato cultivation of by farmers in Ghana.

The dependent variable in this model is the proportion of farm size of tomato cultivated in each season to the

total size of farm land available for crop production in each season in the 2010/2011 tomato production year.The model parameters rather give the direction of the effect. According to Greene, (2003), the marginal effect of the changes in an explanatory variable on the intensity of area under tomato cultivationper seasonis given below:

$$\frac{\partial E[Y_i/X_i]}{\partial X_i} = \beta \emptyset \left[\frac{\beta' X_i}{\sigma}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

2.3 Description of Explanatory Variables

The explanatory variables used in the model includes farmer education and experience, whether the farmer has off-farm income, use of seeds from formal sources, the number of other crops other than tomato grown by the farmer, access to credit, number of extension visits, being a member of a farmer association, tomato price and size of farm land available to the farmer for crop production.Farmer experience (used as a proxy for age) is hypothesized to influence the farm size to tomato cultivation. Older and more experiences farmers are able to take better cultivation decisions and have better contacts possibly at lower costs. However, younger farmers with their youthful exuberance have longer planning horizon, take long term measures, become more dynamic and would want to increase cultivation (Hassan and Nhemachena, 2008; Marteyet *al.*,2012). The level of farmer education is hypothesized to positively affect farmland cultivation.A farmer with off-farm income is expected to positively influence farm land cultivation. It would reduce the perception of risk and increase the likelihood to increase farm size for cultivation (Shapiro and Brorsen, 1988; Chebil*et al.*,2009). A farmer who uses seeds from formal sources is posited to have a positive relationship with choice of farm size for cultivation (Joshi and Bauer, 2009).

The number of other crops grown is expected to have a negative effect on the farm size under tomato cultivation.It is a diversification strategy to the farmer against the risk involved in agriculture. Farm size available to the farmer is hypothesized to increase the area under tomato production. It is expected that, when the land available for different cultivations is large, farmers would want to cultivate more tomatoes.Tomato price is used as a proxy for the negotiating ability of farmers. If farmers anticipate a higher price for tomato, they tend to increase their farm size to tomato production. Access to credit is hypothesized to increase farmer's choice of farm size for cultivation. Credit can be used to acquire more land and other inputs. The number of extension contact is expected to influence the farmer to increase their cultivation activity. They generate the confidence that they would receive help on the farm when the need arises. Finally, member of a farmer association is positively associated to farm size decisions. This is because farmers have access to training and information which they benefit from collective investment of such associations (Chebil*et al.*,2009).

Some interaction terms were also used. Seasonality, used as a dummy, is interacted withthe use of any type of irrigation facility.Location of the farmer, used as a dummy, was also interacted with output levels of the farmer. The weighted average price of tomato was interacted with the use of any type of irrigation facility and farmer education, experience were interacted with farm size available to the farmer for crop cultivation.

3.0 RESULTS AND DISCUSSION

3.1 Descriptive Results

The average area farmers are willing to cultivate tomato is about 0.8 hectares (0.59 hectares for Wenchi, 1.3 hectares for Akomadan and 0.2 for KasenaNankana East). Farm size cultivated to tomato varies between 0.1 and 8 hectares. Seasonality is categorized into three, season one, season two and season three which represents harvesting periods between April to July, August to November and December to March respectively. Season one and season two can be observed as the major and minor rainy season for Akomadan and Wenchi. Season two can be observed as the modest single rainy season for KasenaNankana East but season three is the dry season for all locations. Relatively, from the sample, the main tomato producing season for Akomadan, Wenchi and KasenaNankana East are season one, season two and season three respectively. These recorded a higher proportion of cultivation by tomato farmers in these seasons during the 2010/2011 production year. This is presented in appendix two.

Of the 215 responses or data points in the sample, 32.56 percent came from Wenchi in the BrongAhafo Region (45.71 percent for season one, 48.57 percent for season two and 5.71 percent for season three), 41.86 percent from Akomadan in the Ashanti Region (51.09 percent for season one, 31.52 percent for season two and 17.39

percent for season three) and 24.65 percent came from KasenaNankana East in the Upper East Region (none for season one, 1.89 percent for season two and 98.11 percent for season three).

3.2 Tobit Estimates of Intensity of Area under Tomato Cultivation

The tobit model was used to estimate coefficients of the determinants of the extent of areaunder tomato cultivation by farmers in Ghana. The estimates of the model are shown in appendix 3. The STATA 11 software was used to estimate these parameters and their marginal effects. The model has explanatory power with Log Pseudolikelihood of 82.3634 and the F test value of 21.31, significant at 1 percent confidence level.The estimated marginal effects are presented in Table 1. These parameters provide direction and intensity of cultivation by tomato farmers. The empirical results of the Tobit model show that ten out to the thirteen used variables were significant. From the results, the interaction term of seasonality and use of any irrigation technology is significant in the model. This means that as the season progresses and rainfall decrease towards the dry season,a farmer who uses any irrigation technology would want to cultivate less of tomato. This could be due to the extra cost of using an irrigation technology as the season enters the dry season.The interaction term of use of any irrigation technology and weighted average price of tomato is also significant which means that for farmers who use any irrigation technology and can bargain for a good and higher price for their crate of tomato have a higher likelihood of cultivating higher hectares of farm land to tomato. The extent of increase in tomato cultivation is by 2.99 percent.

From the results, the intensity of tomato cultivation is significantly determined by farm size that is available to farmers for crop cultivation. The negative effect means that the more farm lands become available to farmers for cultivation, the less the farmers decide to cultivate tomato. An additional farm land acquired by a farmer for crop cultivation is likely to result in a 1.18 percent decrease in the extent of tomato cultivation. This result indicates that farmers are only surviving their tomato production and are unlikely to increase its cultivation for an additional farm land they acquire. Use of seeds from formal sources has a significant association with the level of cultivation of tomato. Farmers who use seeds form formal sources are likely to intensify their cultivation of tomato by 5.89 percent. These seeds do not contain impurities as compared with the recycled seeds of farmers.

The number of other crops other than tomato grown by the farmer has a significant relationship with the extent of tomato cultivation. The negative association means that, the more number of other crops other than tomato grown by the farmers, the less the likelihood of the farmer to intensify cultivation of tomato. The extent of reduction in the level of tomato cultivation is by 2.74 percent for an additional other crop grown by the farmer.Agriculture in Africa is associated with high level of riskand farmers will want to management these risks against uncertainties by diversifying. Farmers with off-farm income had a negative relationship with the level of tomato cultivation. This means that farmers who see agriculture as their sole occupation are likely to increase the intensity of their tomato cultivation by 1.88 percent. These farmers tend to give more time and attention to the cultivation of tomato.

Finally, the interaction term of farmer education, experience and farm size available for crop cultivation to the farmer is a significant variable in determining the extent of tomato cultivation. This means that educated and experienced farmers who have access to large farmland for cultivation are more likely to increase their intensity of tomato cultivation. This is because they are able to take better cultivation decisions with better ways of reducing cost (Marteyet *al.*, 2012).

Table 1: Marginal Effect of the Tobit Model on the Level of Tomato Cultivation

Variable	Marginal Effect
Farmer Location*Farmer Output	$1.47*10^{4}$*
Seasonality*Access to any irrigation technology	-0.0346***
Farmer education	-0.0038***
Farmer experience	-0.0019***
Off-farm income sources	-0.0188**
Source of Seed	0.0589***
Number of other crops other than tomato grown by farmers	-0.0274***
Farm land available to farmers for crop cultivation	-0.0118***
Access to any irrigation technology*Weighted seasonal average tomato price of a crate	0.0299**
Farm land available to farmers for crop cultivation* Farmer education* Farmer experience	$3*10^{5}$***

Source: Regression Estimation from Author's Tomato Farmer Survey Data (2011)

***p < 0.01, **p < 0.05 and *p < 0.10

4.0 CONCLUSION

The Tobit model shows that, in Ghana, tomato cultivation is seen to be surviving because even in the face of increased farm land acquisition by borrowing, inheritance or renting farmers are unlikely to increase the cultivation of tomato but probably decide to increase the level of cultivation of other crops.Also as the season for its cultivation progresses and entering the dry season, farm size cultivated to tomato reduces due to lower rainfall experienced and possibly higher cost of irrigation technology. In this situation bargaining for a good price for tomato when a farmer uses any irrigation technology is important and tomato price can be high due to tomato shortage in the dry season.Factors like use of seeds from formal sources, farmers who see tomato production (or agriculture) as their sole occupationand farmers with any irrigation technology and can bargain for a good tomato price are more likely to influencethe extent of tomato cultivation. Strategies to help farmers reduce the cost of irrigation (which include cost sharing) are fundamental for improving the level of cultivation of tomato all year round and thereby increase in incomes and welfare of farmers. Farmers must be supported with credit to buy farm lands located near dams or acquire irrigation technology when their farmlands are located far away from such dams.A processing programme that can guarantee a minimum higher negotiating price is also recommended. It is also recommended that agricultural development organizations educate farmers on the appropriate storage and use of seeds obtained from formal sources. This will not only increase the proportion of such seeds used by farmers but also the number of farmers who use such seeds for tomato cultivation. There is therefore, need to strengthen tomato farmer networks that disseminate useful information to market women, processors and producers as well on the improved varieties they cultivate.

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Appendices

Appendix 1: Explanatory Variables for the Tobit Model

No	Variable	Measurement	Expected Sign
1	Location of Farmer	0 if KasenaNankana East, 1 if Wenchi and 2 if Akomadan Districts	+/-
2	Seasonality	0 if season one, 1 if season two and 2 if season three	+/-
3	Farmer education	Number of years of formal education	+
4	Farmer experience	Number of years in tomato farming	+/-
5	Off farm income source	Dummy: 1=Agric and any off-farm income activity, 0=only Agric	+
6	Source of Seed	Dummy: 1=from formal sources like Agric Shop/NGOs, 0=prepared by farmer/friends	+
7	Farm land available to farmers for crop cultivation	Hectare	+
8	Number of other crops other than tomato grown by farmers	Number	–
9	2011tomato harvested /area in season	Crate (52kg)	+
10	Weighted seasonal average price of tomato	Ghana cedis	+
11	No. of expected Extension visits	Number of visits in season lagged by one year	+
12	Farmer association	Dummy: 1=member of any farmer association, 0=otherwise	+
13	Access to credit	Dummy: 1=if received credit, 0=otherwise	+
14	Irrigation	Dummy: 1=if used any irrigation system, 0=otherwise	+
	Interaction terms		
15	Location of farmer and Farmer Output	Farmer Location*Farmer Output	+/-
16	Seasonality and Access to any irrigation technology	Seasonality*Access to any irrigation technology	+/-
17	Access to any irrigation technologyand Weighted average price	Access to any irrigation technology*Seasonal Weighted average price	+
18	Farm land available to farmers for crop cultivation and Farmer education and Farmer experience	Farm land available to farmers for crop cultivation* Farmer education* Farmer experience	+

Appendix 2: Location of Farmers and Seasonality of tomato production in the Three Districts

Seasonality(percentage)	Location of Farmer (percentage)		
	Wenchi (N=70)	Akomadan (N=92)	K. NankanaEast (N=53)
Season one(N=79)	45.71	51.09	0.00
Season two(N=64)	48.57	31.52	1.89
Season three(N=72)	5.71	17.39	98.11

Appendix 3: Tobit Results on the Level of Tomato Cultivation

Variable	**Coefficient**	**Standard Error**
Farmer Location*Farmer Output	0.0004*	0.0002
Seasonality*Access to any irrigation technology	-0.1029***	0.0277
Farmer education	-0.0114***	0.0041
Farmer experience	-0.0055***	0.0014
Off farm income source	-0.5596**	0.0265
Source of Seed	0.1751***	0.0327
Farm land available to farmers for crop cultivation	-0.0352***	0.0050
Number of other crops other than tomato grown by farmers	-0.0814***	0.0107
No. of expected Extension visits	-0.0005	0.0036
Farmer association	-0.0417	0.0297
Access to credit	0.0316	0.0589
Access to any irrigation technology*Weighted average price	0.0890**	0.0406
Farm land available to farmers for crop cultivation* Farmer education* Farmer experience	$8.8*10^{5}$***	$1.79*10^{5}$

Source: Regression Estimation from Author's Tomato Farmer Survey Data (2011)

***p < 0.01, **p < 0.05 and *p < 0.10

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