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Adoption of Dry Season Vegetable Farming and its Effects on Income at Golinga and Botanga Irrigation Sites, Northern Ghana

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Abstract

The study examined the factors influencing the adoption of dry season vegetable farming and its effect on income in the Golinga and Bontanga irrigation sites in the Northern Region of Ghana. It involved 240 farmers selected through multi stage sampling procedure and the data analyzed using a switching regression and treatment effect models that corrected for sample selection bias. Farmers who had higher probability of going into dry season vegetable production were the younger farmers, farmers who had been cultivating vegetables for several years, farmers who had been in farmer groups for several years, farmers who had more contacts with extension officers and farmers who had accessed credit. While more labour, seed, fertilizer and insecticides were needed to increase income under irrigation farming, more labour and fertilizer as well as greater farm size were required to raise rain fed crop value. From the treatment effect model, dry season farming was found to have a positive effect on crop value. Other significant variables were farm size, seed, labour and insecticides. The study recommends that credit facilities should be made more available and accessible to the vegetable farmers to enhance their participation in irrigation farming, group formation should be promoted while extension service delivery should be enhanced.

Keywords: *Adoption, Dry season farming, Irrigation, Switching Regression, Treatment Effect model, Northern Ghana*

INTRODUCTION

Kyei-Baffour *et al.* (2005) defined vegetable as an edible plant or portion of an herbaceous annual or perennial crop which could either be served raw (green/fresh) or after a little cooking. Vegetable production is one of the global activities practiced in every economy since it forms a major component of human diet. According to Amoah *et al*. (2014), not only is the global vegetable production increased by 100% over the past quarter century but also, its trade value has exceeded that of cereals. Vegetable production provides a source of livelihood for not only the growers but also the traders and the processors. Thus, it provides an excellent source of employment for both rural and urban dwellers as it is grown in many rural areas through truck farming and in the outskirts of towns and cities as market gardening and backyard gardening to be supplied fresh to the urban markets (Owusu and Amuzu, 2013).

Irrigation is defined as the supplementation of precipitation by storage and transportation of water to the fields for the proper growth of agricultural crops (Dahigaonkar, 2008). According to Dittoh *et al.* (2013), irrigation farming is the means to reduce the risks in farming, ensure high yields as well as make production possible throughout the year. Irrigation water could be gotten from surface water or groundwater. The origin of surface water is ponds, lakes, rivers and seas while groundwater is derived underground in liquid or vapour state (Dupriez and De Leener, 2002).

Irrigation is classified into two main types, informal and formal (also called large scale commercial) irrigation; depending on the degree of government involvement in its establishment and management (MoFA, 2007). In most cases, when government establishes large scale irrigation projects, they are categorized as formal while private small scale projects such as dug outs, wells and sprinklers are categorized as informal.

Irrigation farming as a concept is one of the most important rural development investments that can have both direct and indirect impacts on poverty and food security in semi-arid tropical countries (IFPRI, 2002; Bhattarai and Narayanamoorthy, 2004). It is often the recommended strategy to reduce risks associated with rainfall variability and increase yields of food crops (Pinstrup-Andersen and Pandya-Lorch, 2001). Irrigation farming has become a relief to the poor and disadvantaged especially in the developing countries (Chazovachii, 2012). Irrigation nurtures the cultivation of early maturing vegetables and so is regarded as a welfare-enhancing agent. Likewise, a reliable and suitable source of water supply for agriculture results in tremendous improvements in agricultural production and guarantees economic returns to the grower (Walker, 2003). Todd (2015) and Domenech (2015) stressed that when farmers have access to reliable source of water, it encourages them to adopt new technologies and intensify cultivation, with its resultant increase in productivity, total production being higher, and returns from farming being great. This opens up employment avenues in the agricultural sector, both on-farm and off-farm levels, leading to improvement in incomes, livelihoods, and better life in rural areas.

Africa's use of irrigation falls far below that of Asia and the rest of the world, and far below the continent's irrigation potential. Moreover, the rate of expansion has slowed significantly since 2000 (Svendsen *et al.,* 2008). Between 2000 and 2003, the rate of expansion in irrigation was only about a third of the longer-term rate (0.5 percent), suggesting a slow rate of irrigation development.

The African continent has ample water resources overall; however, they are spread unevenly over a wide range of agro ecological zones. Efforts to manage water and to make it available where it is most needed are hampered by the undeveloped state of institutions for irrigation (and water-resource management more generally) and by the prevalence of subsistence farming. In most parts of the continent, ample groundwater resources remain largely untapped (Namara *et al.*, 2011). Compared with the global average, Africans withdraw only a quarter as much water for human use as does the world as a whole and the irrigated share of their cropland is less than one-fourth of the world average (Svendsen and Msangi, 2009).

In West Africa, irrigation accounts for a very small part of crop production. For instance, production from irrigated farms contributed only 0.9% of the total production of vegetables in 2004 in Nigeria where the area of land under irrigation is more than 58% (FAO/ENPLAN Group, 2004), though the contribution of the smaller countries especially in the Sahel countries is on the higher side (Dittoh *et al.,* 2013).

In Ghana, government's intervention has been to establish irrigation dams in specific locations where vegetables and other crops can be cultivated. Two of such locations are the Golinga and Bontaga micro dams in the Northern Region. The establishment of the dams has made possible the cultivation of dry season vegetables among other crops such as rice. Thus, dry season vegetable cultivation goes a long way to complement the rain fed system that has been with the people since time immemorial. Unfortunately, to the best of our knowledge there is not much empirical work to suggest the gains from these irrigation sites.

The main objective of the study was to investigate the factors that influence the adoption of dry season vegetable farming and its effect on income of farmers in the Golinga and Bontanga micro-dams in the Northern Region. Specifically, the study seeks to (1) determine the factors that influence dry season vegetable farming, (2) measure the effects of dry season vegetable farming on farmers' income, (3) and identify other factors that influence incomes of both dry season and rain fed vegetable farming in the study area. In this study, the terms dry season vegetable farming and irrigation vegetable farming are used interchangeably. It should be noted that it is not necessarily a foregone conclusion that dry season vegetable farming in addition to rainfed farming would translate into a higher income than sole rainfed. There are anecdotal evidences that once a farmer has the opportunity to do dry season farming he/she would not take rainfed farming serious as compared to his/her counterpart whose only hope is in rainfed farming.

MATERIALS AND METHODS

Study area

The research was conducted in two irrigation areas; Golinga and Bontanga in the Tolon and Kumbungu districts respectively, both in the Northern Region of Ghana. The districts together share boundary with West Mamprusi District to the north, Central Gonja to the South, North Gonja to the West and Savelugu/Nanton Municipality and Tamale Metropolis both to the East. The major ethnic group of the study area is Dagomba. The main occupation in the area is farming. Under a Millennium Development Authority (MiDA) facility, government rehabilitated the Bontanga Irrigation and Golinga Irrigation schemes (GNA, 2012). Specifically, this involved the expansion of the land under cultivation, upgrading of access to roads leading to the laterals, construction of threshing floors, laying off-take pipes and gates and checking structures on the new laterals.

The region is located in the Guinea Savanna vegetation with unimodal rainfall pattern. The districts experience two major seasons; the dry season and the rainy season. The rainy season is between April/May to September with a peak in July/August, while the dry season starts from November to March. The Golinga irrigation site has a potential area of about 100 hectares while Bontanga has 570 hectares. But the former has a developed area covering about 40 hectares with the net irrigable area covering about 20 hectares while the latter had all the 570 hectares under irrigation. The main crops cultivated on the project area are rice, okra, tomatoes, onions and other leafy vegetables.

Sampling
A multi stage sampling procedure was used in the selection of the study sample. In the first stage, vegetable farmers were selected purposively in the Golinga and Bontanga micro-dam sites. In the second stage, vegetable farmers were put into two groups as irrigation water users and non-users. The stratum of irrigation users or adopters of dry season irrigation farming consisted of farmers who owned or rented land and used for vegetable production in the season under review. The second stratum referred to as non-users or non-adopters comprised of households who neither owned irrigated land nor were involved in irrigation farming. The use of stratified sampling was based on the fact that the two groups are homogenous with heterogeneity within each group. Finally, using simple random sampling procedure, 120 vegetable farmers from each stratum were selected. This gave a total sample size of 240 vegetable farmers. The choice of 120 farmers from each group is to provide adequate representation of vegetable farmers in the study area. Data were collected from the 240 vegetable farmers through the administration of a semi-structured questionnaire. The data entry and analysis were done with the aid of STATA version 11.2.

Theoretical Framework
Technology is defined in terms of an innovation that is perceived as new and helps us to increase output. This means that irrigation can be considered as a technology, given that rainfed vegetable farming in the study area is the traditional practice. For decades back, technological advancement have been the major driving force in agriculture's development (Schultz, 1964). Although with the onset of technological advancement in agriculture there are still food insecurity problems in parts of the world, the situation would have been very precarious without technology development. Rogers (2003) defined adoption as the 'full use of an innovation as the best course of action available'. This means that rejection is a 'decision not to adopt an innovation' (Rogers, 2003). While adoption is when an individual makes use of a new technology, diffusion is when the use of the technology spreads across a community or even globally. Several studies have explained how new technologies are adopted (Donkoh and Awuni, 2011; Nkegbe *et al*., 2012) or how they spread across communities (Rogers, 2003; Feder *et al*., 1985). In all these studies, the reason for the adoption or diffusion of a new technology or innovation is that the expected returns from adopting the technology outweigh the cost of its adoption. This is based on the assumption that farmers are rational. A detailed explanation to the underlying causes of technology diffusion is given by Foltz (2003).

In investigating the determinants of dry season farming and its effects on income the appropriate methodological framework is Heckman's (1979) two stage method of correcting for sample selection bias. This has been well discussed in Greene (2003). Two theoretical models that are relevant in this current study are the Switching regression and the Treatment effect models as follows.

Switching regression model
The relationship between dry season vegetable farming and the vector of explanatory variables is specified as:

$$A^{*} = \gamma Z_i + u_i \quad (1)$$

where A^{*} is the latent value for dry season vegetable farming. The criterion functions for A^{*} are

$$A = 1 \quad iff \quad A^{*} = \gamma Z_i + u_i > 0 \,, \quad (2a)$$

and

$A = 0 \quad iff \quad A^{*} = \gamma Z_i + u_i \leq 0$ (2b)

The income regime for the two farming systems (dry season vegetable farming plus rainfed and sole rainfed) is also given as:

$Regime\ 1$: $S_{1i} = \delta x_{1i} + e_{1i}$ $iff\ A_i = 1$ (3a)

$Regime\ 2$: $S_{2i} = \delta x_{2i} + e_{2i}$ $iff\ A_i = 0$ (3b)

where Z_i, x_{1i} and x_{2i} are exogenous variables. From Lokshin and Sajaia (2004), the error components u_i, e_{1i} and e_{2i} assume a trivariate distribution, zero mean and a covariance matrix given as:

$$Cov(u_i, e_{1i}, e_{2i}) = \begin{bmatrix} \sigma_u^2 & \sigma_{1u} & \sigma_{2u} \\ \sigma_{1u} & \sigma_1^2 & . \\ \sigma_{2u} & . & \sigma_2^2 \end{bmatrix} \quad (4)$$

where σ_u^2 is the selection equation error term variance, while σ_1^2 and σ_2^2 are the variances of the error terms in the two regimes, σ_{1u} is the covariance of u_i and e_{1i}, σ_{2u} is the covariance of u_i and e_{2i}. The covariance betweene_{1i} and e_{2i} is not defined since S_{1i} and S_{2i} do not exist simultaneously.

The two farming system equations are estimated by two stage estimation (see Lee, 1978). To account for selectivity bias, e_{1i} and e_{2i} are extrapolated as:

$E(e_{1i}/u_i \leq \gamma Z_i) = E(\sigma_{1uu_i}/u_i \leq \gamma Z_i) = \sigma_{1u}\frac{\emptyset(\gamma Z_i)}{\Phi(\gamma Z_i)}$, and

$E(e_{2i}/u_i \leq \gamma Z_i) = E(\sigma_{2uu_i}/u_i \leq \gamma Z_i) = \sigma_{2u}\frac{\emptyset(\gamma Z_i)}{1-\Phi(\gamma Z_i)}$ (5)

where $\emptyset$ is the probability density function, Φ is the cumulative distribution function. $\frac{\emptyset}{\Phi}$ is the Inverse Mills Ratio(IMR) which is defined as:

$$\lambda_{1i} = \frac{\emptyset(\gamma Z_i)}{\Phi(\gamma Z_i)} \text{and} \lambda_{2i} = \frac{\emptyset(\gamma Z_i)}{1-\Phi(\gamma Z_i)} \quad (6)$$

Therefore, the equations 3a and 3b become:

$Regime\ 1$: $S_{1i} = \delta x_{1i} + \sigma_{1u}\lambda_{1i} + e_{1i}$ $iff\ A_i = 1$ (7a)

$Regime\ 2$: $S_{2i} = \delta x_{2i} + \sigma_{2u}\lambda_{2i} + e_{2i}$ $iff\ A_i = 0$ (7b)

Where e_{1i} and e_{2i} , the new residuals have zero conditional means. These residuals are, however, heteroscedastic. Therefore, estimating the equations by weighted least squares, (WLS) rather than ordinary least squares, OLS, would give efficient parameter estimates.

Treatment effect model

Unlike the switching regression model, the selection model directly enters the outcome model as an explanatory variable in the treatment effect model. Thus, in measuring the effects of adopting dry season vegetable farming on vegetable income we have

$$Y = X_i'\beta + \delta A_i + \varepsilon_i \quad (8)$$

where $Y\ is$ income, X_i' is a set of factors that influence adoption of dry season vegetable production, A_i is as defined earlier. From Maddala (1983), estimating equation 8 with ordinary least square would not measure the true effects of the variables on the outcome. Thus although $X_i'\beta$ may be correctly specified, δ may not measure the true value of A_i, therefore the adoption model (equation 1) should be estimated and the predicted value should be used to construct an IMR which together with the predicted values of adoption would be additional regressands in the income model. In this case according to Maddala (1983), equation 8 takes the form;

$$Y_i = \beta'(\Phi_i X_i) + \delta'(\Phi_i A_i) + \sigma\phi_i + e_{2i} \quad (9)$$

where $\Phi_i \equiv \Phi(z_i'\gamma)$

Empirical model

In the first stage of this study, the empirical model that specifies the determinants of the probability of household adopting dry season farming is given as:

$$adoption = \beta_0 + \beta_1 age + \beta_2 age^2 + \beta_3 sex + \beta_4 education + \beta_5 household\ size + \beta_6 off-farm + \beta_7 Experience + \beta_8 land\ ownership + \beta_9 FBO + \beta_{10} extension\ visit + \beta_{11} credit + e_1 \quad (10)$$

Access to land was omitted because it correlates with adoption. The second stage is presented as:

$$Output\ Value = \beta_0 + \beta_1 Farm\ size + \beta_2 Seed + \beta_3 Labour + \beta_4 Insecticide + \beta_5 Adoption\ of dry\ season\ farming + e_3 \quad (11)$$

In the case of the switching regression the income equations for the two farming systems are the same as equation 11 except that the adoption model is absent.

Definition of variables

In this study, the production variables (both inputs and income) are aggregates of 12 different vegetables, namely, pepper, tomatoes, green pepper, garden eggs, cabbage, lettuce, okra, onion, *alefu*, *bra*, *ayoyo* and *chorchomisi*. The variables used in the models are described in Table 1.

Table**1: Description of variables and their a prior expectations**

Variable	Definition	Expected sign
Adoption	A dummy variable measuring farmers' system of vegetable production: 1 if dry season vegetable farmer and 0 if rain fed vegetable farmer.	NA
Demographic, socioeconomic and institutional variables		
Age	The total number of years from birth of a farmer and age multiplied by itself gave the variable age squared.	-/+
Sex	A dummy variable that defines the natural or biological make-up of the farmer and takes a value of 1 and 0 for males and females respectively.	-/+
Education	The total number of years a farmer had spent in formal education.	+
Household size	The total number of members in a farmer's house that cook from the same pot.	+
Off-farm	A dummy variable that defines the farmer's participation in economic activities outside the farm. It takes a value of 1 for farmers who engaged in off-farm activities and 0 for those who did not.	-
Experience	The total number of years a farmer had cultivated vegetable.	+
Land ownership	A dummy variable that takes a value of 1 if a farmer owns a land and 0 if otherwise.	+
FBO	The total number of years a farmer had been in a farmer based organization or economic group.	+
Extension	The total number of times a farmer had been contacted by an extension agent in the 2013 production season.	+
Credit	A dummy variable that takes a value of 1 if a farmer had access to credit for vegetable production in 2013 and 0 if not.	+
Production variables		
Income	The sum total of income or net revenue from the production of the 12 different vegetables.	
Farm size	The total number of acres cultivated by a farmer.	+
Seed	The total kilograms of seed used by a farmer in planting the entire farm size.	+
Labour	It was measured in man days.	+
Fertilizer	The total kilograms of fertilizer used.	+
Insecticides	The total litres of insecticides used by a farmer.	+

RESULTS

Determinants of dry season farming

As indicated earlier, two main models have been estimated in this study; namely: a switching regression and a treatment effect model. It should be recalled that in the study area we have two main systems of vegetable farming, namely, rain fed plus dry season irrigation farming (system 1) and sole rain fed farming (system 2). Thus in this study, adopters refer to the former group while non-adopters are the latter. This section presents the maximum likelihood estimation results of the models.

From the results in Table 2, the factors that significantly influenced farmers' adoption of dry season farming were age, experience, years of group membership, frequency of extension visits and access to credit. On the other hand, sex, household size, education, engagement in off-farm activities and land ownership did not significantly affect farmers' decision to adopt dry season vegetable farming. The estimated Wald chi-Square was 120.63 and significant at 1%. The significance of this test indicates that the variables included in the two regression models are statistically significant in explaining the decision to adopt dry season vegetable production and the variations in crop value.

Age and age squared were statistically significant at 5% with positive and negative marginal effect on adoption of dry season vegetable farming respectively. Experience had 1% significant positive effect on adoption. This means that the higher the number of years a farmer cultivates vegetables, the higher the probability of adopting irrigation technology. In other words, the more experienced a farmer is in vegetable farming the higher the probability of non-adoption. The FBO variable was also statistically significant at 1% with a positive marginal effect. This means that farmers who belonged to a farmer group for longer years have a higher (16% more) probability of going into dry season vegetable farming than their counterparts who were non-FBO members. Lukytaweti (2009) and Armendariz and Morduch (2005) found that membership to economic group enabled one to access credit either in kind or in cash since it serves as collateral to one another's loan facility. While both the extension and credit variables also had positive marginal effects, the former was significant at 5% while the latter was 1% significant.

Table 2: Determinants of adoption of dry season vegetable farming

Variable	Marginal effect	Standard error
Age	0.091**	0.045
Age squared	-0.001**	0.001
Sex	-0.133	0.220
Education	-0.007	0.027
Household size	-0.011	0.015
Off-farm	0.065	0.200
Experience	0.072***	0.017
Land ownership	-0.125	0.208
Farmer based organization	0.160***	0.061
Extension	0.082**	0.0408
Credit	0.085***	0.313
Constant	-2.253	0.889
Wald chi square	120.630***	

NOTE: *** and ** indicates statistical significance at 1% and 5% respectively

Determinants of crop value in dry season and rainfed farming systems

Table 3 shows the second stage of the switching regression model. This shows the factors influencing both dry season and rain fed vegetable production in the study area. In this study, the dependent variable is crop value rather than the physical quantities since the study involved several vegetables with different measuring units. Therefore, the total revenue for each vegetable was calculated and finally aggregated to give the crop value. From the results, labour, quantities of seed, fertilizer and insecticides significantly influenced income under irrigation farming while farm size, labour and quantity of fertilizer significantly affected income under rain fed farming system. However, while farm size was not significant under dry season vegetable farming, seed and insecticide were not significant under rainfed farming.

From the elasticity values estimated, the returns to scale for dry season vegetable production is 1.217 while that of rainfed vegetable production is 0.955. Thus there is increasing returns to scale in dry season vegetable farming while decreasing returns to scale characterize rain fed vegetable farming in the study area. Lambda being significant indicates the presence of selectivity bias in the irrigators' model. However, having corrected it, the estimates are unbiased and measure the pure effects on income.

Table 3: Determinants of dry season vegetable production

Variable	Dry season		Rain fed	
	Coefficient	Std. error	Coefficient	Std. error
Farm size	0.072	0.108	0.191***	0.052
Seed	0.210**	0.102	-0.183	0.182
Labour	0.263*	0.144	0.304**	0.124
Fertilizer	0.401***	0.093	0.428***	0.093
Insecticides	0.271**	0.138	0.215	0.181
Constant	1.011	0.278	2.349	0.414
Lambda	-0.217**	0.106	-0.070	0.135

NOTE: ***,** and * indicate statistical significance at 1%, 5% and 10% respectively

Effect of adoption of dry season farming on income

The essence of estimating a switching regression was to determine the respective factors that influence income in the two main vegetable cropping systems in the study area. To determine whether or not dry season vegetable farming in addition to rainfed farming resulted in high income for farmers, a treatment effect model was estimated. This section discusses the maximum likelihood estimation results of the treatment effect model and the result is presented in Table 4. From the result, all the variables in the model including the irrigation variable were significant and positive. This means that an increase in these inputs would lead to a higher vegetable crop value and hence, confirm the results of the switching regression discussed in the previous section. Thus, except for the difference in magnitude of income response to changes in the production inputs, the directional effects and implications remain the same.

The estimated positive coefficient of irrigation means that farmers who cultivated vegetables during the dry season in addition to their vegetable production in the rainy season has a higher income than those who cultivated vegetables only in the dry season. This finding confirms that of Diao *et al*. (2005) and Huang *et al*. (2006) which showed that farm incomes of irrigating households was 50-79% higher than non-irrigating households. Similarly, Hussain and Hanjra (2003) noted that the average monthly expenditure of household would increase by 24% due to higher farm incomes.

Table 4: Effect of irrigation on Crop value

Variable	Coefficient	Std. error
Farm size	0.133**	0.059
Seed	0.463***	0.165
Labour	0.347**	0.151
Insecticides	0.346**	0.145
Irrigation	0.346*	0.187
Constant	0.831	0.398

NOTE: ***, ** and * indicate statistical significance at 1%, 5% and 10% respectively

DISCUSSION

The positive and negative signs respectively of age and age squared in the adoption model mean that the probability of dry season vegetable farming participation is greater for the relatively young farmers. It stands to reason that the elderly will frown at adopting this technology all-year-round knowing their strength cannot lead them to do strenuous works such as weeding, making of beds, nursing of seedlings, watering and many other activities associated with irrigation farming. This means that the youth could be targeted for support if dry season farming is to be promoted in the region. Another group of farmers that can be supported are experienced farmers. They have been in vegetable cultivation for some time and therefore have accumulated enough skills for both rainfed and dry season farming. Irrigation farming requires some level of technology usage and also requires that the farmer regulates the water supply for a better production. It is important for the farmer to know some management practices such as applying the right amounts of water and fertilizer in dry season farming. In this case, farmers with higher experience are able to effectively put their expertise on the ground, and hence take the risk of engaging in irrigation farming.

Similarly, farmers who belonged to a farmer group for longer periods had a higher probability of going into dry season vegetable farming. These farmers, perhaps, were able to use their groups to negotiate their access to irrigation scheme sites compared with those who were new in the group or did not belong to a group at all. Also, irrigation farming requires proper timing of activities. For instance, watering has to be done at the right times and regularly, therefore group membership may serve as a check to one another, providing labour to one another, especially when a neighbour is indisposed.

Extension workers are very important in agricultural activities. They provide technical advice to farmers on production technologies and in recent times, link farmers to agricultural credit providers. In the case of irrigation farming, extension officers provide advice and assistance to the farmers on water requirements and management. It is important to note that the condition under which irrigation farming is done is not the same as that of rainfed farming. This means that farmers have to have enough knowledge on these conditions. Extension services are one sure way of getting information to the farmers. In this study, the positive marginal effect of the extension variable did not come as a surprise. Furthermore, the role that agricultural credit can play in technology adoption cannot be over-emphasized. Given that dry season farming involves the purchase of equipment such as pumping machines and watering cans, it is not surprising that the credit variable had a positive marginal effect, suggesting that farmers who had access to credit had a higher probability of participating in dry season vegetable production than their credit constrained counterparts.

The labour variable was found to exert positive effect on crop value probably due to the fact that vegetable production in general is tedious and requires more labour. From the land preparation to harvesting of vegetables requires labour. When vegetables are not harvested according to the time expected, the farmer will surely lose everything through deterioration. The coefficients of 0.263 and 0.304 for irrigators and non-irrigators respectively mean that as labour use increases by 100%, income will increase by 26.3% and 30.4% respectively. These figures, representing labour productivities in the respective production systems indicate that labour is more productive in the rainfed system, which is reasonable and expected. The dry season farming is more capital intensive and therefore, capital productivity is expected to be higher than labour.

The results also show that there are positive gains associated with fertilizer usage in vegetable production. Farming in the region is becoming impossible without fertilizer usage due to the constant depletion of soil nutrients. The production elasticity for fertilizer was 0.401 for the irrigators and 0.428 for the non-irrigators. Thus, an increase in fertilizer use by 100% will result in an increase in income by 40.1% and 42.8% in irrigated and rainfed vegetable production respectively.

Seed quantity in the irrigators' model was positive with an elasticity of 0.210. However not only was seed insignificant in the non-irrigators' model, it was also negative. The estimated elasticity of seed means that a 100% increase in seed quantity would increase farmers' crop value by 21%. Increasing the planting density of seed would increase income *ceteris paribus*. Atilaw and Korbu (2011) stated that seed is a fundamental input for improving crop production and productivity. It is important therefore that not only are farmers encouraged to increase their seed density, but also, researchers should provide more improved seed varieties to these farmers in order to reap maximum gains.

The positive significance of insecticides in the irrigation model implies that a 100% increase in insecticide use will result in 27% increase in crop value under irrigated farming. It stands to reason that the more insecticides a farmer uses the greater his income level will be *ceteris paribus.* Though pesticide use in agriculture is good, its excessive use has raised concerns. Jayanthi and Kombairaju (2005) noted that, the World Health Organization estimates of insecticide-related deaths occurring each year is 20,000. Therefore, Niu and Yu (2002) concluded that insecticides and fungicides are the most important pesticides that affect humans through the consumption of food because they are applied shortly before or even after harvesting.

The positive and significant farm size variables in the rainfed model means that farmers producing vegetables during the rainy season need to increase their farm sizes if greater incomes are to be realised. The reason for the insignificance of the farm size variable in the irrigators' model could be that farm sizes are limited and almost the same for all the dry season farmers.

Finally, the estimated positive coefficient of irrigation means that farmers who cultivated vegetables during the dry season in addition to their vegetable productions in the rainy season had a higher income than those who cultivated vegetables only in the dry season. This is an important finding that justifies support for enhancing irrigation farming especially in vegetable production in the study area and by extension, Ghana as a whole.

CONCLUSION

The study aimed at investigating the effects of dry season vegetable farming on income in the Golinga and Bontanga irrigation sites. We found that adopting dry season vegetable farming increases one's farm income. The reality is that without access to land at the irrigation sites one cannot practice vegetable farming. Land per head at the site is very limited. This is exacerbated by increasing population. Also from the results of the switching results, there is more use of modern inputs (intensification) in dry season farming than rainfed (extensification). While dry season farming drives farmers' income, the former is also driven by some policy variables such as credit, extension services and FBO membership.

RECOMMEDNATIONS

The option is for government and the private sector to bring more land under irrigation (i.e. build more of these micro dams), otherwise with increasing population and climate change the future for vegetable production is bleak. There should also be more intensification of vegetable farming, especially rainfed agriculture. Similarly, farmers must be supported to increase their access to extension services and credit as well as their membership of FBOs. Finally, dry season vegetable production can be promoted if it can be brought under the ongoing Youth in Agriculture Programme (YAP), considering the high probability of adoption by younger farmers.

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