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Planting Time and Agricultural Land Productivity: The Case of Puna Yam (*Dioscorea rotundata*) in Oti Region of Ghana

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ABSTRACT

Yam production is heavily reliant on rainfall. Whilst some farmers plant from January to March before the onset of rains, others plant after the onset of rains in April. The impact of planting time on land productivity of puna yam (Dioscorea rotundata) was assessed using endogenous switching regression. Primary data was collected from yam farmers in the Oti Region of Ghana. The study revealed that planting of yam in April after onset of rains increases land productivity of puna yam. Aside planting time, capital investment, labour, less crowding of seed yams, planting on freshly raised mounds and extension contact enhance puna yam productivity. Therefore, farmers should plant puna yam in April after the onset of rains to obtain higher land productivity. Lastly, extension service intensification and access to weather information should be promoted to enhance yam productivity.

INTRODUCTION

Yam is an important food security crop in Ghana, especially in the middle and northern belts of the country. In Ghana, a total of 370,148 households are engaged in yam production annually (GSS, 2019). The importance of the crop to the Ghanaian economy is demonstrated by the fact that 10.8% of the annual value of harvested crops comes from yam. Aside, maize and rice, yam is an important source of energy in the Ghanaian diet. Over the years, there has been a steady increase in yam production. In 2010, the total amount of yam produced in Ghana was 5,960,000 Mt and this figure increased to 7,440,000 Mt in 2016, representing approximately 24.8% growth rate (MoFA, 2018). Another significant success of the yam subsector as presented by MoFA (2018) indicates a production surplus of 2,982,777 Mt in 2017. Ghana continues to be the leading exporter of yam even though it is the second-highest producer after Nigeria. In 2020, the quantity of yam exported to other countries by Ghana is 28,284 Mt (MoFA, 2021).

Despite the importance of yam to both the rural and national economies, the yam subsector faces a slew of challenges. As stressed by Asante *et al.* (2014) and Iddi *et al.* (2018), these challenges include

unreliable rainfall patterns, unavailability of good quality seed yam, low adoption of improved variety, poor post-harvest storage facilities, high production costs and moisture stress. Another key factor that most policymakers, as well as researchers, are worried about in the yam subsector is its low productivity despite the promotion of improved yam varieties West Africa Agricultural Productivity Programme (WAAPP) and Root and Tuber Improvement and Marketing Programme (RTIMP). The observed yield is far below the potential yield. In 2020, for instance, the observed yield was 17.7 Mt/ha as against the potential yield of 52 Mt/Ha (MoFA, 2021). This suggests that only 34.0% of the potential yield was achieved, calling for researchers to delve deep into the causes and come out with actionable recommendations for policymakers and rural yam farmers to adopt. The case is not different in the newly created Oti Region. Using 2016 production figures for districts that fall under the Oti region, an observed yield of 17.7 Mt/ha was obtained.

Oti Region is in both the Guinea Savannah and Forest Savannah Transition agro-ecological zones of Ghana. Most of the yam production in the country is produced in Guinea Savannah, which has mono-modal rainfall distribution. The single season for agricultural production has 180-200 days of rainfall with a mean annual figure of 1100mm (MoFA, 2021). This rainy season falls within the period from May to November. The onset of rains which used to be in April is becoming unreliable. Due to the sensitive nature of yam to heat, sometimes, farmers wait for the first rain to fall in April before planting. Other farmers also plant early before the onset of rains which is usually from January to March. These farmers sometimes carefully estimate the dormancy period of the yam and plant so that sprouting coincides with the first rains in April. Since yam is sensitive to rainfall and temperature, the planting season may have yield implications. Agriculture, in general, is sensitive to fluctuating weather variables such as rain and temperature. Though other sectors of the economy are affected by climate change, agricultural production activities are usually more susceptible than other sectors (Mbanasor *et al.*, 2015). As noted in Adifon *et al.* (2020), it has been established that rains at different times affect the yield of yam. The cultivation of yam is mainly dependent on rainfall and any change in the pattern of rainfall is likely to affect the planting time which has consequences directly on productivity. Meanwhile, what we do not know is how planting time affects yam productivity.

Also, it is imperatively clear that farmers who plant yam before the onset of rain in a year differ from those who plant after the first rain. Given that farmers may self-select themselves to plant in a certain period based on certain intrinsic factors peculiar to them, there is the need for an appropriate standard econometric model to be used. Farmers who plant before the onset of rain may have some common characteristics as against those who plant after the onset of the rain. Similarly, the factors influencing productivity of *puna* yam might differ between the two groups of farmers as Okongor (2021) contends that non-climatic factors are likely to have more impact. Since Adam *et al.* (2014) indicated that climate is a salient factor affecting agriculture productivity, it is important to investigate how planting time affects yam productivity. This will solve the dilemma of farmers in deciding what precise time to plant *puna* yam in order to get maximum productivity. This paper contributes to the current discourse on yam by focusing on whether or not planting before the onset of rain improves its land productivity. This information is critical as it provides empirical evidence to yam producers on when to plant to get maximum productivity. Policymakers and other duty bearers within the yam value chain are expected to use the recommendations from this research to improve policy design and implementation in the yam subsector. Also, the paper provides insights into the determinants of planting time of *puna* yam. Lastly, the paper provides knowledge to scanty literature available on yam productivity improvement strategies in Ghana and Africa as a whole.

MATERIALS AND METHODS

Study Area

The study was conducted in Oti Region which is one of the 6 newly created regions in Ghana. It was carved out of the Volta Region in 2018. The capital town of the region is Dambai. The region is bordered to the west by Volta Lake, East by Togo, south by Volta and North by Northern Regions. The region has a total land area of 9,116sq. Km. The region is noted for agricultural production. The districts in the northern part of the region are noted for yam production. The study was conducted in Krachi East, Krachi Nchumuru and Nkwanta North Districts. These three districts share boundaries with the Oti River.

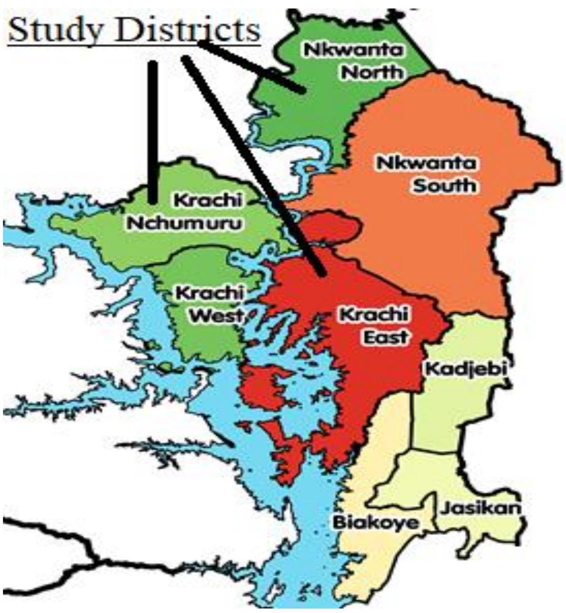

Figure 1: Map of Study Districts in the Oti Region of Ghana

Sources of Data and Sampling Procedure

The source of data for this study is primary. The farmer-level data was collected with the help of a semi-structured questionnaire through a one-on-one interview. The questionnaire captured key data points such as conventional inputs in yam production, socio-demographic characteristics of farmers, policy and institutional variables. All these data were disaggregated into the two planting periods of yams.

Out of nine districts in Oti Region, three (3), thus Krachi East, Krachi Nchumuru and Nkwanta North Districts were selected using a purposive sampling technique based on the tonnage of yam production. Using 2016 production figures, the decreasing order of yam production by districts are Krachi East Municipality, Nkwanta North and Krachi Nchumuru Districts. Nine communities from each of the districts were selected using a simple random sampling technique. Lastly, a list of farmers was obtained from opinion leaders and agricultural extension officers operating in the selected communities. Then, a simple random sampling technique was used to select sixteen yam producers from each community. Using 60525 as the total number of yam producers in the then Volta Region as reported by GSS (2013), and a 5% margin of error, the sample size calculation formula popularised by Yamane (1967) gives a sample size of 397 for this study. In total, 432 yam producers were interviewed but 406 were used for the study based on the validity of the administered questionnaires.

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

$$n = \frac{60525}{1 + 60525(0.05)^2} = 397.4 \quad (2)$$

Where: N is the total population of yam producers in the then Volta Region, e is the margin of error of the sample (e=5% which implies 95% confidence level), and n is the sample size.

Theoretical and Analytical Framework

It is conceptualised that farmers decide to plant yam before and after the onset of rain based on certain factors. The decision as noted by Khonje *et al*. (2015) is behavioural which is hinged on random utility maximization theory. A farmer will choose to plant yam in any of the two-time regimes based on whether or not the chosen regime will give him or her the higher utility. A farmer will plant yam before the onset of rain if and only if the utility derived (U_b) in terms of land productivity is higher than otherwise (U_a) resulting in the net difference as shown in Equation 3:

$$U_{ni}* = U_{bi} - U_{ai} > 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The impacts of planting time on land productivity of yam was analysed using the endogenous switching regression (ESR) model. ESR is an impact assessment model which can deal with sample selectivity bias and endogeneity (Dubin and McFadden 1984). It also deals with heterogeneity, thereby placing the early and late planters of *puna* yam on the yam pedestal. There are two-stage in the estimation of an ESR model. The first stage involves the selection model in which the dependent variable is dichotomous. Herein, it estimates the factors that influence farmers' decision to plant *puna* yam before or after the onset of rain. Following Lokshin and Sajaia (2004), the selection model is given in Equation 4:

$$I_i* = \alpha_j X_{ji} + u_i \quad with \quad I_i* = \begin{cases} 1 \;\; if \;\; a \;\; farmer \; plants \; late \\ o \;\; if \;\; a \;\; farmer \; plants \; early \end{cases} \quad (4)$$

Where: I_i* is the unobservable or latent variable representing planting time decision in this study, X_i is a vector of explanatory variables and u_i is a random error term that takes care of factors not included in the model as well as measurement errors.

From the selection equation, the Inverse Mills Ratio is estimated and included in the outcome equation in the second stage. The outcome model has two equations, one for early planters and the other for late planters. These are referred to as regimes. It is important to note that ESR is used when one perceives that the factors determining the outcome variable in the two regimes differ. In this study, it is assumed that determinants of land productivity of *puna* yam differ between early planters (those who plant from January to March before onset of rains) and late planters (those who plant in April after onset of rains). Based on the time of planting decision depicted in equation (3), the outcome models for the two separate regimes are:

Regime 1 (Late Planters): $Y_{LPi} = \beta_j X_{LPji} + \ell_{LPi}$ (5)

Regime 2 (Early Planters): $Y_{EPi} = \beta_j X_{EPji} + \ell_{EPi}$ (6)

Where: Y_{LP} and Y_{EP} are land productivity of *puna* yam for late and early planters respectively, *i* is the ith farmer, X_{LP} and X_{EP} are vectors of explanatory variables hypothesised to influence the land productivity of late and early planters of *puna* yam respectively, *j* is the jth explanatory variable, β_j is the vector of the coefficients. Lastly, ℓ_{LP} and ℓ_{EP} are the error terms for late and early planters respectively.

It is important to note that the three error terms, u_i, ℓ_{LP} and ℓ_{EP} are assumed to have a trivariate normal distribution, with zero mean and non-singular covariance matrix. As noted by Lokshin and Sajaia (2004), the full information maximum likelihood (FIML) estimation procedure is the efficient method to estimate endogenous switching regression models. The FIML method simultaneously estimates the selection equation which is probit and the outcome equation equations which are continuous. This estimation is conditioned on the null hypothesis that all regression coefficients are jointly equal implying drivers of decision of farmer to plant early or late are the same.

Average Treatment and Heterogeneity Effects

The average treatment effect on the treated (ATT) is the difference between the *puna* productivity of the late planter who decides to plant late and that of the late planter who decides to plant early. Following Khonje *et al.* (2015), Shiferaw *et al.* (2014) and Di Falco *et al.* (2011), ATT is estimated using the equation:

$$ATT_i = E(Y_{LPi} / I_i = 1) - E(Y_{EPi} / I_i = 1) \quad (7)$$

On the other hand, the average treatment effect on the untreated (ATU) estimates the difference between the expected *puna* productivity of the early planter who decides to plants early and that of the early planted who decides to plant late (unobserved or counterfactual situation). Also, following Khonje *et al.* (2015), Shiferaw *et al.* (2014) and Di Falco *et al.* (2011), the equation for estimating ATU is given as:

$$ATU_i = E(Y_{EPi} / I_i = 0) - E(Y_{LPi} / I_i = 0) \quad (8)$$

The base heterogeneity effect can be estimated for the treated (late planters) and the control (early planters) groups. For the treated group (late planters), the base heterogeneity (BH_1) is the difference in the mean land productivities of yam between the late planters observed in the sample and the counterfactual scenario of the control group (late planters). Also, for that of the control group (early planters), the base heterogeneity effect (BH_2) is the difference in the mean land productivities of yam between early planters observed in the sample and the counterfactual scenario. These are respectively stated as:

$$BH_1 = E(Y_{LPi} / I_i = 1) - E(Y_{LPi} / I_i = 0) \quad (9)$$

$$BH_2 = E(Y_{EPi} / I_i = 0) - E(Y_{EPi} / I_i = 1) \quad (10)$$

Lastly, the difference between ATT and ATU is the transitional heterogeneity.

RESULTS AND DISCUSSION

Summary Statistics of Variables

The summary statistics of discrete variable are presented in Table 1. The differences in the variables between the proportion of farmers who plant before rains and those who plant in April after onset of rains (thus early planters) were tested using the proportion test. As shown in Table 1, whilst 52% of the farmers who plant *puna* yam before rains have access to credit, 36% of their counterparts who plant after rains have access to credit. There is a significant difference between them. There are significant differences between the users of communal labour who plant *puna* yam variety before and after rains. Out of 406 farmers, 54% of the early planters use communal labour whilst 46% of late planters use communal labour. More early planters of farmers own a radio, a television set (TV) and land than late planters. Similarly, farmers who use their seed and plant early are significantly different from their counterparts' late planters. Contrary to the *a priori* expectation, more proportion of educated farmers are early planters than late planters.

The study used a t-test to statistically determine whether or not there are significant differences in continuous variables between early and late planters of *puna* yam variety. As presented in Table 2, there is a statistically significant difference between the ages of early and late planters. Early planters are relatively younger than late planters. Early planters have a larger household size than late planters. Late planters received much more credit than their counterpart early planters. Statistically, late planters are highly educated than early planters. Averagely, late planters have spent more years in education comparable to early planters. For conventional inputs (labour, seed yam, capital, and pesticides) used in *puna* yam production, there is no statically significant difference between what early and late planters use.

Table 1: Summary Statistics of Discrete Variables

Variable	Full sample	Early planters (January to March)	Late planters (April)	Z
Proportion of farmers who …				
are males	0.66	0.65	0.67	0.50
have access to credit	0.43	0.52	0.36	3.28***
use communal labour	0.50	0.54	0.46	1.69*
have radio	0.65	0.80	0.52	5.85***
own land	0.18	0.16	0.21	1.45
farm yam as a main crop	0.61	0.66	0.57	1.76*
use by-day labour to raise mounds	0.48	0.48	0.47	0.25
are engaged in contract farming	0.47	0.46	0.48	0.45
use their own seeds	0.71	0.80	0.62	4.05***
perceived late onset of rain	0.47	0.49	0.51	3.38
plant stakes	0.81	0.81	0.81	0.03
are educated	0.65	0.79	0.53	5.43***
receive extension service	0.38	0.40	0.36	0.88
own TV	0.66	0.87	0.46	9.06***

Table 2: Summary Statistics of Continuous Variables

Variables	Full sample	Planting time		T-test
		Before rains	After rains	
Age (years)	44.50	41.44	47.86	6.67***
Household size	7.06	7.55	6.52	2.91***
Number of mobile phones per household	2.68	2.08	3.35	6.20***
Amount of Credit (Gh)	898.55	702.54	1114.87	3.71***
Farming experience (years)	14.41	16.12	12.52	4.86***
Education (years)	6.34	4.07	8.85	10.18***
Intensity of rains (0=no, 1=low, 2=moderate, 3=high)	1.19	0.79	1.63	7.46***
Distance to farm (Km)	5.20	5.38	5.00	1.12
Labour (man-days)	222.02	216.47	228.156	1.01
Farm size (Ha)	2.63	2.60	2.67	0.57
Seed yam (MT)	0.08	0.08	0.07	1.51
Pesticides (Liters)	3.26	3.08	3.46	0.87
Capital (Gh)	1030.77	975.80	1091.43	1.02
Yam output (Mt)	61.75	57.16	66.82	2.10**

Determinants of Planting Time

In determining the factors that influence planting time, the selection or treatment model of the endogenous switching regression model was probit. The results from this are presented in Table 3. As shown in the table, the Hausman specification test recorded a Chi^2 value of 116.75 with a significant probability value. This implies that the null hypothesis that planting time is exogenous is rejected. This means that the treatment variable, planting time is endogenous and hence the justification for the use of endogenous switching regression model. For ESR, there is the need for such an instrument or instruments. This according to

Lokshin and Sajaia (2004) is a variable or variable in the selection equation which should not be included in the outcome or regime equation. The appropriateness of the instrument is also critical. To get an appropriate instrument, a falsification test suggested by Di Falco (2014) was performed and it was established that TV, radio and mobile phones are the appropriate instrument. This suggests that the instruments were correlated with the endogenous variable, planting time but uncorrelated with the unobserved variables (error terms) of the productivity equations in both regimes. Also, the diagnostic test as shown in Table 3 by F-test value of 13.19 is greater than 10 and statistically significant. This implies that the instruments, ownership of TV, radio and mobile phones used in the treatment model have passed the test of weak instruments. Therefore, the instruments used are strong as per Staiger and Stock (1997) criterion that if *F-test* for joint significance fails to exceed 10, the problem of weak instruments may exist.

Factors that statistically and positively determine the planting time of *puna* yam variety are age, education, ownership of TV, radio and mobile phones. Each of these variables is 1% statistically significant, implying that they have a high positive influence on planting time. On the other hand, distance to farm, ownership of seed yam and extension contact are factors that are statistically significant with negative direction of effects. Whilst distance to farm and ownership of seed yam are statistically significant at 1%, access to extension service is statistically significant at 10%.

The positive sign of the coefficients implies that older and more educated farmers have a high probability of planting late. The expected direction of effects meets a priori expectations. Yam production is labour-intensive. In Ghana, every production stage of yam is manually done. Asiedu *et al.* (2010) indicated that the tillage in yam production is more drudgery and laborious. As such, there is the likelihood that as one's age increases, the energy or efforts exerted in the production of yam decreases. This goes a long way to increasing the time of completion of each of the pre-planting stages of yam (land preparation stages) thereby making him or her to plant late (April after the onset of rains). As noted by Turinawe *et al.* (2015) and Ogada *et al.* (2014), age affects the technology adoption decision of farmers. This stems from the explanation that as farmers grow, they tend to be risk-averse whilst younger farmers are risk-lovers with high enthusiasm. Planting yams before the onset of rains is a high risk that younger farmers are ready to take.

Also, it was observed that many educated farmers are engaged in off-farm activities. Some are government workers, private business people, drivers, etc. Due to this, they are not able to go to farm more often as compared to non-educated farmers. Therefore, the stages of yam production are sometimes delayed culminating in them planting late. It is important to note that education helps farmers to gather information about the benefits of taking a certain decision (Kannan and Ramappa, 2017 and Donkoh and Ayamga, 2014). It is also key as it capacitates farmers with the skills of identifying and interpreting risks of planting early before the onset of rains. Also, a farmer who perceives that the rains will set of late has a higher probability of plant late.

The probability of planting late increases with ownership of TV, radio and mobile phone in a household. These are information and communication technology tools that help farmers to access relevant information about the weather as well as yam production. It is expected that farmers who own these tools are able to access information on when rains are supposed to set in, thereby prompting them to plant after the rains. It is possible that those who have this information are risk-averse farmers and hence are afraid of the dying of seed yam due to heat. This observation is in line with the point made by Essegbey *et al.* (2015) that crops suffer from heat stress thereby reducing the time available to farmers to plant in Ghana due to climate change. Also, farmers who own seed yams have more propensity to plant late than their counterparts. Farmers who have their seed yam are free from the hustle of searching for the setts. The time that would have been used to search for the seed yam is reduced enabling such farmers to plant early as compared to those who purchase seed yam to plant. It was observed that farmers who own seed yams are those whose main occupation is farming. As such, they have ample time to complete the planting of yam setts before the onset of rains. They are also risk lovers and hence do not fear non-sprouting of yams due to heat resulting from planting before rains. This finding is in support of the assertion by Asante *et al.* (2014) that yam production is highly affected by the high cost of seed yam.

As shown in Table 3, the coefficient of access to agricultural extension services is negative a statistically significant at 5%. The negative sign implies that farmers who have access to agricultural extension services have higher probabilities of planting yam from January to March than those who do not have access to agricultural extension services. Lastly, the probability of planting yam in January, February and March increases with increasing distance to farms. The direction of the effects does not meet a priori expectations.

Table 3: Factors Influencing Planting Time

Variables	Coef.	Std. Err.
Age (years)	0.0454***	0.0082
Sex (Male=1, Female =0)	0.1014	0.1699
Household size (number of persons)	0.0243	0.0271
Education (years)	0.1166***	0.0179
Farm to house distance (Km)	-0.1050***	0.0271
Farm size (Ha)	-0.0224	0.1770
Communal labour (1=yes, 0=no)	-0.1040	0.2015
Land ownership (own=1, rented=0)	0.0652	0.2483
Farming experience (years)	-0.0153	0.0115
Access to extension (1=yes, 0=no)	-0.5106**	0.2012
Access to credit (1=yes, 0=no)	-0.4783	0.2075
Own seed (1=yes, 0=no)	-0.5418***	0.1984
Off-farm engagement (1=yes, 0=no)	-0.0003	0.2157
Perception about onset of rains (0=early, 1=late)	0.3176**	0.1320
By day labour (1=yes, 0=no)	0.1161	0.1831
Main crop (1=yes, 0=no)	-0.0679	0.1900
Own TV (1=yes, 0=no)	1.0328***	0.1998
Own radio (1=yes, 0=no)	0.5664***	0.1951
Number of mobile phones per household	0.1997***	0.0512
_cons	-3.8407***	0.6349

Probit regression; n = 406; LR $chi^2(19) = 224.86$; Prob > $chi^2 = 0.0000$
Log likelihood = -168.4929; Pseudo $R^2 = 0.4002$
Hausman specification test: Chi2 (62) = 116.75 (Prob = 0.0000)
F (1, 383) = 13.1859 (Prob =0.0003)

Factors Affecting Yam Productivity

In assessing the impacts of planting time on yam productivity, this paper used endogenous switching regression. Full information maximum likelihood estimator was used for the estimation. From Table 4, the ESR model fits well for the data since the Wald test is statistically significant at 1%. This sign shows that the null hypothesis which states that all regression coefficients are jointly equal to zero is rejected in favour of the alternate hypothesis. This implies that drivers of *puna* yam productivity between early and late planters are different and hence using ESR is appropriate. The 1% statistical significance of the log-likelihood ratio test is a clear indication that the alternate hypothesis of the strong correlation between the error terms of the treatment and outcome models should not be rejected. This implies that stochastic factors which are excluded in the planting time and yam productivity models are related. The use of quasi-experimental data of this nature always results in the problem of endogeneity which needs to be dealt with by including at least one instrument.

Land productivity of yam in this study is the yield which is defined as the quantity of yam produced per unit area. Its unit of measurement is Mt/ha. As shown in Table 4, conventional inputs such as the quantity of labour, seed and capital are statistically significant in both early and later planters' models. Each of these inputs is highly significant at 1%. Meanwhile, pesticide is not statistically significant for both groups of yam farmers. The significant and the positive direction of the effect of labour on land productivity meet the a priori expected. This stems from the fact that production of *puna* yam is highly labour intensive. Starting from land clearing through to raising of mounds to harvesting, one requires enough labour to be able to maintain good agronomic practices. The current findings confirmed the assertion by Asiedu *et al.* (2010) that the drudgery in yam production is very high. The magnitude of the coefficients of labour implies that an increase in the quantity of labour employed by 1manday will result in an increase in the land productivity of *puna* yam by 0.0146Mt/Ha and 0.0280Mt/Ha for early and late planters respectively. Therefore, late planters have high land productivity than early planters.

Seed is one of the key inputs in *puna* yam production. Table 4 shows that seed has a negative effect on yam productivity in both early and late planters' models. As the seed of yam increases by 1Mt, the yam productivity will decrease by 25.5791Mt/Ha and 63.8785Mt/Ha for early and late planters respectively. A negative influence of quantity of seed yam on productivity was expected due to the current way of raising mounds where farmers use hire labour. The hired labourers work and are paid per day based on the number of mounds raised. This according to some farmers that the researcher interacted with indicated that mounds raised by hire labourers are crowded per unit area. This is done by labourers so as to get more mounds per unit area and make more money. In effect, the yam seeds are crowded preventing good aeration and maximum creeping of vines for higher yield. The stages of yam production are many requiring much capital. The cost of seed yam, labour, land, stake etc form the capital. Capital here is the monetary investment one makes in yam production. The positive effects of capital on land productivity of *puna* yam was expected. As the money invested in yam production increases by Gh¢1.00, the land productivity of *puna* is expected to increase by 0.015Mt/Ha for early planters and 0.021Mt/Ha for late planters. It suggests that the return to investment for late planting of yam is better than early planting.

For early planters, the socioeconomic factors that influence land productivity of *puna* yam are sex, household size, the distance of farm from the house, engagement in communal farming and extension contact. All these factors are statistically significant. With the exception of household size, all these factors have positive effects on land productivity of yam. Male farmers and those with extension contact and use communal labour are more productive in the early planters' model. Though household size and distance to the farm are statistically significant, their directions of effects on yam land productivity do not meet the a priori expectation.

In the late planters' model, age, year of education, farm distance, the intensity of rains during planting month, extension contact, credit, ownership of seed yam and hiring of labour on a by-day basis are statistically significant. As the years of education increase, the land productivity of yam increases as well. This is plausible since education helps farmers to easily understand how to use improved technology to increase agricultural productivity. Similarly, to early planters, late planters who have access to extension service are more land productive compared to their counterparts who do not have access to extension service. Famers who have access to credit, use their seed and those who intentionally plant stakes have higher land productivity than their colleagues. As expected, hiring labour on a by-day basis reduces land productivity of yam. This is due to the crowding of yam mounds by labourers who are hired and paid a daily wage.

Table 4: Drivers of Land Productivity of *Puna* Yam

Variables	Early Planters		Late Planters	
	Coef.	Std. Err.	Coef.	Std. Err.
Labour (mandays)	0.0146***	0.0036	0.0280***	0.0039
Seed Yam (Mt)	-25.5791***	6.5806	-63.8785***	8.3300
Pesticides (Litres)	0.0720	0.0850	0.0126	0.0648
Capital (Gh¢)	0.0015***	0.0004	0.0021***	0.0004
Age (years)	-0.0213	0.0341	-0.0814**	0.0327
Sex (Male=1, Female =0)	1.3821**	0.6574	-0.4476	0.6104
Household size (number of persons)	-0.1847*	0.1012	-0.0235	0.1042
Education (years)	-0.0519	0.0868	0.2181**	0.0893
Farm to house distance (Km)	1.1795***	0.1269	0.6722***	0.1125
Intensity of rain in planting month (0=no, 1=low, 2=moderate, 3=high)	0.9652	0.7069	1.1500*	0.6650
Communal labour (1=yes, 0=no)	2.4953***	0.7829	0.9454	0.7635
Land ownership (own=1, rented=0)	-0.3778	0.8917	0.6287	0.9154
Farming experience (years)	0.0584	0.0401	0.0550	0.0485

Access to extension (1=yes, 0=no)	2.2338***	0.7533	1.2221*	0.7230
Access to credit (1=yes, 0=no)	0.5573	0.7988	1.8720***	0.6680
Own seed (1=yes, 0=no)	0.4274	0.7321	2.4062***	0.7777
Staking (1=yes, 0=no)	1.3640	0.8159	1.4637**	0.7415
Interval between mounding to planting date (weeks)	-1.0222**	0.4785	-2.2152***	0.4142
By day labour (1=yes, 0=no)	-0.1881	0.6664	-1.8574***	0.7057
Main crop (1=yes, 0=no)	2.1465	0.7318	0.0216	0.6220
_cons	6.0266	2.2895	12.9381	2.7808
/lns1	1.3296***	0.0509		
/lns2	1.4815***	0.0621		
/r1	-0.0193	0.2254		
/r2	-0.7569***	0.2346		
sigma_1	3.779	0.192		
sigma_2	4.399	0.273		
rho_1	-0.019	0.225		
rho_2	-0.639	0.139		
LR test of indep. eqns.: chi2(1) = 9.30 Prob > chi2 = 0.0023				
Number of obs = 406 Wald chi2(20) = 1089.99				
Log likelihood = -1296.8938 Prob > chi2 = 0.0000				

It has also been established from the study that the shorter the planting weeks between the day of raising mounds to the day of planting, the more productive the *puna* yam. This suggests that planting on freshly raised mounds gives higher land productivity than old mounds. As shown in the table, if the week between mounding date to planting date increases by 1 week, land productivity decreases by 1.0222mt/ha and 2.2152Mt/ha for early and late planters respectively. This, according to some farmers is that, old yam mound develops head pans thereby affecting germination. The positive sign of the coefficient of staking means that farmers who plant stakes have higher land productivity than their counterparts. This observation supports the work of Andres et al. (2017) that staking of yam optimally exposes the leaves to the sunlight throughout its growth resulting in higher yields as compared to non-staked yams.

Impact of Planting Time on Land Productivity of *Puna* Yam

Table 5 presents the predicted land productivity of *puna* yam for the observed and the counterfactual. As noted by Di Falco and Veronesi (2013), a simple comparison between the observed mean of land productivity values between late and early planters does not give the true impact of planting time. The average treatment effect for the treated (ATT) and average treatment effects for the untreated (ATU) were estimated. A t-test was used to validate whether or not there is a significant difference between the observed and counterfactual land productivity of *puna* yam. The t-test for both ATT and ATU are 1% statistically significant each. The positive signs of the ATT and ATU meet the a priori expectations.

As evinced in the table, farmers who are late planters will get 24.15Mt/Ha of *puna* yam if they continue to plant late. However, late planters will get land productivity of 21.64Mt/Ha if they decide to plant early. This implies that late planters of yam will be worse of if they decide to plant early. Moving from late to early planting will result in a significant loss of 2.51Mt/Ha. This means that late planters will lose as much as 2.51Mt of yam per hectare representing an 11.60% reduction in yam land productivity. On the other hand, early planters will gain if they move from early planting to late planting. If an early planter continues to plant before the onset of the rains, he/she will get 20.73Mt/Ha. The ATU value of 2.37Mt/Ha suggests that early planters will gain as much as 2.37Mt/Ha if they change from early planting to late planting.

The current findings buttress the point made by Essegbey *et al.* (2015) that heat stress affects crops in Ghana. This study confirmed the work of Adewuyi *et al.* (2014) and Ayanlade *et al.* (2010) that low rainfall and prolonged dry spells affect the growth of crops thereby causing low yields in Africa. Usually, when yams are planted before the onset of the first rain, they are much exposed to a long period of high temperature. The high temperature increases soil evaporation and crop transpiration thereby reducing the soil moisture content for fast growth. As explained by Adifon *et al.* (2020), small moisture in the soil favour germination and the emergence of buds but these new buds and the leaves dry up making some of the setts die. Therefore, the low yield associated with early planters supports the work of Srivastava *et al.* (2012) that low rainfall affects yam yield. This is in line with Adifon *et al.* (2020) that rains in January and April affect the yield of yam in Benin. It beholds on farmers to properly calculate the planting time of yam to coincide with the onset of rains in April.

Table 5: Impact of Planting Time on Land Productivity of *Puna* Yam

	Planting time decision		**Treatment Effects (TE)**	**% Change in TE**	**Transitional Heterogeneity (ATT-ATU)**
	Late planting (Planting in April after onset of rains)	**Early planting (Planting from January to March before onset of rains)**			
Late planter (Farmers who plant in April after onset of rains)	24.15	21.64	ATT= 2.51 (t-test =17.88***)	11.60	0.14
Early planter (Farmers who plant from January to March before onset of rains)	23.11	20.73	ATU = 2.37 (t-test =15.44***)	11.43	
Base heterogeneity	1.04	0.91	0.14	0.17	

CONCLUSION

Yam is one of the main staple crops produced and consumed in the Oti Region of Ghana. The crop provides food and income for rural households in the region. One of the important varieties of yam cultivated in Oti Region of Ghana is *puna* yam. Despite the indispensability of *puna* yam, its planting time is highly variable. Many attribute this to the fact that yam production in Ghana is entirely rainfed. Unlike other crops, the dormancy period of yam is long due to its storability of water in the tuber. Therefore, while some farmers plant *puna* yam from January to March before the onset of the first rain in the season, others plant it in April after the rains. This has effects on sprouting and land productivity or yield. Given this, the current study assessed the impacts of planting time on land productivity of *puna* yam in the Oti Region of Ghana. An endogenous switching regression econometric model was used to achieve this objective.

The study revealed that socioeconomic characteristics influence farmers' planting time decisions. Specifically, farmers who own TV, radio and mobile phones have a higher probability of planting late. Whilst farmers who have access to agricultural extension service plants early, those who are educated plant late. This suggests how crucial information and knowledge are in yam production. The conventional inputs that are highly important as revealed by the study are seed, labour and capital. Overcrowding of *puna* yam seeds is prevalent in the areas and hence reduces land productivity for both early and land planters. Late planters are more victims of this than early planters. Other factors that have a significant impact on *puna* yam land productivity include extension contact, education, staking, age, sex, seed ownership, and distance from farm to house, as well as the interval between planting date and mounding date.

As the study revealed, farmers who plant late (in April) after the onset of rains have higher land productivity of *puna* yam than their counterparts who plant early (January to March). This shows the importance of planting time of *puna* yam. The importance of rains or moisture during the planting period of yam cannot be relegated to the background.

It is therefore recommended that yam farmers should be provided with the necessary weather information to enable them to make prudent planting time decisions. This information can be made accessible to farmers through mobile phones, TV or radio. Also, the provision of extension services should be intensified to cover other farmers. *Puna* yam farmers should consider planting their setts or seeds in April after the onset of rain rather than rushing to plant before the rains begin in the season. It is also recommended that planting should be done on freshly raised mounds. This prevents the rotting of the yam setts or seeds.

CONFLICT OF INTEREST

There is no conflict of interest regarding the publication of this work.

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