Sweet Potato (*Ipomoea Batatas* L.) Production Determinants in North-East Benin: The Commune of Gogounou as a Case in Point

**Abstract** - In this article, the exogenous factors which determine the farmers’ choice to grow Sweet potato have been identified. Sweet potato acreage and yield determinants are also discussed based on production factor estimates. The analytical data were collected among 180 farmers in the Gogounou commune. The analyses show that the determinants of (i) choice to grow sweet potato, (ii) sweet potato acreage and (iii) harvested yield are respectively: number of dependants, schooling level and practice of an income-generating activity; land area devoted to maize, yam and cotton and finally amount of family labor per hectare. The study results point to the importance of reviewing the various strategies so far developed in the light of such determinants of sweet potato production. They also underscore the need to enhance the role of extension services and to promote easier access to agricultural credit. All this will help develop the production of sweet potato as well as agricultural diversification with a view to improving producers’ incomes and living conditions in Benin.

**Keywords**: Roots, tuber crops, production, determinants, Gogounou, Benin

I. INTRODUCTION

In countries of the Economic Community of West African States (ECOWAS), like in all other African countries, the agricultural sector plays a major role. It accounts for 30 to 50% of the Gross Domestic Product (GDP) and employs an active population representing 50 to 80% of the total population of the subregion [1]. However, the sector is characterized by small family farms of 0.5 to 10 ha which derive their income and livelihood from farm produce grown for own consumption, the local markets or exports. In Benin, close to 80% of the active population is engaged in agriculture which accounts for almost 70% of export earnings and 40% of the Gross National Product [2]. Cotton occupies a predominant position heading the list of export crops given its high added value to the GDP [3]. Over the past few years, the cotton sector is being confronted with serious disruptions both at the national and international fronts. As a result, farmers are turning to other crops, mainly food crops. To some extent, maize, sorghum, cassava, millet, yam, cowpea and groundnut are been grown by the farmers to meet the food needs of the people [4]. Such food crops are way down below the mark given the ecological potential of Benin. In addition to those major crops, other crops like sweet potato are grown on a small scale by the farmers.

Sweet potato is commonly cultivated as a hunger crop, hence its distinctive value for food security. It is termed subsistence crop in the production zones as it does not play a major role in international trade due to transportation and storage challenges.

In the present socio-economic context, where food security is a priority for all the Member States, subsistence crops though poorly researched, seem nevertheless to have the
potential to secure food to the people both in quantity and quality. Therefore, any policy aimed at promoting such crops would undoubtedly help in attaining the so much desired food self-sufficiency goals and, by so doing, contribute to poverty alleviation efforts.

Thus, it would be proper, on the one hand, to identify the determinants of the choice by the farmers to grow sweet potato, of sweet potato acreage and yield and, on the other hand, to propose appropriate avenues to raise the yield of sweet potato.

II. MATERIAL AND METHODS

Study Area

Data were collected among farmers in North-East Benin, and more precisely, among those of the commune of Gogounou. Gogounou lies at the southern tip of the Alibori Region between 10°50 and 11°45 Latitude North, and 2° and 2°55 Longitude East.

It spreads over 4,910 km², or 18.66% of the total land area occupied by the Alibori Department (26,303 km²). Its characteristics include a Sudan-Guinea type climate and mostly ferruginous soils of the agriculture-prone granite-gneiss basement. The alluvial plains in Gogounou are predominantly host to alluvial clayey sandy soils richly fed by organic matters deposited each year by high river tides [4]. The predominant vegetation in the commune is a grassy tree savanna highly degraded by anthropic activity, and thus giving gradually way to a shrubby savanna. The classified forests (forêt de l’Alibori Supérieur, forêt de la Sota, forêt des Trois Rivières) are equally endangered. Agricultural land is estimated at 1,705 km², about 35% of the total land area covered by the commune. The rest is made up of protected areas (177,200 ha), grazing land (123,500 ha) and lowland (360 ha) of which only 150 ha are exploited (Figure 1).

Data on the socio-demographic characteristics of the farmers, the factors inherent in the production of sweet potato and the quantity of tubers harvested were collected among 180 farm heads in three (03) villages randomly selected for individual surveys. The following data collection methods were used: semi-structured questionnaire, interviews and observations. Focused group discussions were also held alongside the surveys to collect data at the village level.

Analytical tools

Quantitative data were analyzed using descriptive statistical approach (Frequency tables, means and standard-deviations, Chi square test (χ²) and means comparison, logistic regression for the determinants of the choice to grow sweet potato, and linear multiple regression for sweet potato and yield determinants. Minitab 14 was used for that purpose.

Furthermore, content analysis was also used to explore qualitative data such as respondents’ stories and perceptions. Content analysis is a data interpretation endeavor that tries to strike a balance between the rigor of objectivity on the one hand, and unrestricted subjectivity on the other hand [5]. Content analysis involves three chronological phases: pre-analysis, exploiting the material and data processing, and finally inference and interpretation [6].

Specification of the regression models

Logistic and multiple regression models were used respectively to estimate the determinants of the choice by the farmer to grow sweet potato, as well as sweet potato acreage and yield determinants [7, 8, 9, 10, 11, 12].

- Specification of the logistic regression model (Logit)

Table 1 showed the variables introduced in the model. Thus, the logistic regression model is presented as follows:

\[ P = \exp(\alpha + \beta_0 \text{AGE} + \beta_1 \text{CAP} + \beta_2 \text{ENG} + \beta_3 \text{MAT} + \beta_4 \text{CHAR} + \beta_5 \text{AGR} + \epsilon) \]

(1)

Where: \( \epsilon \) = error factor; \( \alpha \) = constant term; \( \beta_i \) = parameters to be estimated.

- Specification of the multiple regression models

Two multiple regression models were used. The first model was used to identify the sweet potato acreage determinants while the second model will help in apprehending the determinants of harvested yield.

Tables 2 and 3 take stock of the different variables introduced in each of the models.

The theoretical multiple regression models stands as follows:

\[ \ln S = \beta_0 + \beta_1 \text{ACTIF} + \beta_2 \ln \text{SORG} + \beta_3 \ln \text{MAIS} + \beta_4 \ln \text{IGN} + \beta_5 \ln \text{COT} + \beta_6 \ln \text{AUTR} + \epsilon \]

(2)

where \( \epsilon \) was the error factor, \( \beta_6 \) the constant and \( \beta_i \) the regression coefficients to be estimated.

The theoretical model is as follows:

\[ \ln Q = \delta_0 + \delta_1 \ln \text{MOF} + \delta_2 \ln \text{ENG} + \delta_3 \ln \text{CAP} + \epsilon \]

(3)

where \( \epsilon \) was the factor error; \( \delta_0 \), the constant and \( \delta_i \) the regression coefficients to be estimated.

III. Results and discussions

Descriptive statistics of the variables used in the models

Respondents were mostly men with a mean age of 34.97 years (± 10.45), mostly married (84.4 %). Most of them did not go through any formal training. Only 38.9% of the producers had school education. Such schooling rate is lower than the overall mean of the region which stood at 46% [13]. This gap could be explained by the small size of the sample and the limited number of the villages covered by the study. On the other hand, very few farmers (23.3%) are able to read and write their mother tongue.

The average size of the households is 10.07 persons (± 7.07). The head of the household is the decision-maker.
However, a good number of independent production units escape his control. On average, 17.8% of respondents were children of household heads; 4.4% were relatives of household heads and the remaining 77.7% were household heads.

In the households, the average number of farm hands is 5.54 persons (± 4.361) compared to 4.52 persons (± 5.053) for non-farm hands. Thus, the mean dependency ratio (ratio of non-farm hand to farm hand as indicator of the burden born by the farm hand) is 1.34 person (± 2.02), meaning that a farm hand should in principle feed 1.34 person with his or her production. This is lower than the 1.45 consumer, 1.5 and 7.6 consumers per farmer recorded respectively for the commune of Malanville, the Lower Benin and in the communes of Boukombé [12, 14, 15].

Agriculture is the major activity for 95.5% of respondents who usually cultivate maize, cotton, groundnut, yam, sorghum, rice and sweet potato.

In Gogounou, sweet potato is grown in crates. Although cultivated by 73.3% of the people, it is not a priority crop in the farming system. The reasons given by the 26.7% of the people who cultivate sweet potato were:
- Low profitability of sweet potato production as compared to other crops like maize, cotton and yam;
- Lack of markets for sweet potato;
- Shortage of land and high loss risks;
- Shortage of farm labor for sweet potato; such labor usually goes to the harvest of cotton;
- As a matter of fact, because of competition from weeds, some shoots of sweet potato are not able to grow. For that reason, some farmers are obliged to use herbicides to control weeds;
- Difficulty in accessing sweet potato seeds; and finally
- The crop does not benefit from funding from development programs and projects.

In addition to agriculture, more than half (56.7%) of the farmers interviewed are engaged in minor income-generating businesses. Petty trade, handicrafts, motto-taxi riding, etc., are by far, their most common minor activities. 4.4% of farmers are in animal husbandry.

**Determinants of sweet potato production**

The survey showed that in Gogounou, sweet potato is grown in crates and, as a result, has a limited share in agricultural production in the commune. In Table 4, are presented the results of the logistic model developed with a view to identifying the exogenous factors which determine the production of sweet potato. The variables introduced in this model assist in explaining the 34.5 variations observed with respect to the choice of farmers to grow sweet potato. The remaining 65.5% of the variations are due to exogenous factors (difficult to measure if at all measurable) taken into consideration such as observance of cropping calendar, climatic conditions, choice of varieties, planting season, etc. Three (3) main variables, out of the seven (07) independent variables considered, basically determine the choice of farmers to grow sweet potato in the Gogounou commune: the number of dependents, the schooling level and the practice of another income-generating activity (Table 4).

In other words, the model could be written as follows:

\[ P = 2.85 - 1.35NCSO + 1.60CHAR - 2.81AGR + e_1 \] (4)

Only the number of dependents has a positive and significant impact at the probability level of 1% on the choice of farmers to grow sweet potato; which is obvious as sweet potato is a subsistence crop used by the farmers to diversify their food and, above all, to ensure food security for their households during the hunger period, especially when cotton is being harvested [16].

Schooling and the practice of another or other income-generating activities have significant but negative effects at the probability level of 1% on the choice of sweet potato production.

Thanks to schooling, farmers are indeed able to acquire some notions to be able to manage their operating account. The moment they realize that sweet potato is less profitable than other crops, they prefer to drop it out of their cropping system, thus providing a justification for the negative coefficient obtained, just the opposite of the positive sign expected. Therefore, there is a need to come up with concrete steps to develop the production of sweet potato.

Furthermore, when the respondents are engaged in a more profitable minor business, they prefer investing in it rather than in the production of sweet potato. Which raises the following question: how profitable is the production of sweet potato compared to other activities?

The age of the farmer, his literacy level and marital status as well as the position of the head of the production unit in the household have no significant effect on the choice to produce sweet potato. Therefore, those variables enjoy little importance in the decision-making process with respect to the production of sweet potato in the Gogounou commune.

**Determinants of sweet potato acreage**

Table 5 presents the results of the regression model. The multiple regression models is globally significant at 1% threshold. The variations of factors introduced in the model make it possible to explain 19.7% of variations of the area devoted to sweet potato production (Table 6). The 80.3% unexplained variations would have been caused by not easily measurable factors such as farmers’ income, production related constraints namely lack of markets, high loss risks, status of producer, course of production, etc..

Thus, the model could be written as follows:

\[ \ln S = -1.61 + 0.59 \ln MAIS + 0.28 \ln IGN - 0.30 \ln COT + e_2 \] (5)
Out of the five (05) factors considered, three have statistically significant effects on sweet potato acreage at the probability level of 1%, namely maize and yam plots having a positive effect, and cotton plots which, on the contrary, have a negative effect.

Any increase (or reduction) in maize or yam areas of 1% translates into increases (or reductions) respectively of 0.59 % and 0.28 % of sweet potato acreage. The positive correlation between maize plots and sweet potato acreage shows that demand for sweet potato depends on the production of the crop [16].

The link between yam acreage and sweet potato acreage could be due to the mere fact that some producers intercrop sweet potato with yam. Cotton acreage has a significantly negative effect on sweet potato acreage. Indeed, an increase (or decrease) of 1% of cotton acreage gives rise to a decrease (or increase) of 0.30 % of sweet potato acreage. This can be explained by the abandonment of the cotton sector by some farmers because of the challenges facing the sector [17]. Consequently, those farmers invest more in the production of food crops like maize, yam, sorghum or sweet potato.

The number of farm hands, area under sorghum and other crops (rice, cassava manioc, groundnut etc.) do not have statistically significant effects on area cropped with sweet potato. These are crops not cultivated by all the farmers. If grown at all, they are found only on small plots (on average 0.55 ha for sorghum; 0.04 ha for rice; 0.23 ha for vegetable crops; 0.05 ha for cassava; etc.).

Yield determinants of sweet potato production
The results of the regression model are shown in Table 7. The regression model is globally significant at 1% probability level. The factors introduced in the model point to a very low proportion (9.4%) of sweet potato yield variations. This suggests that one needs more than the inputs generally used to estimate production functions (labor, capital, fertilizers) in order to explain yield variations. A large part of unexplained variations (90.6%) would be due to difficult-to-measure factors such as climatic conditions, observance of the technical production process, etc.

Table 8 shows the factors which determine the economic efficiency level of farms.

In total, the production function stands as follows:

$$\ln Q = 3.41 + 0.20\ln M + e_1$$

The significantly positive constant shows that sweet potato can be cultivated without hired labor, fertilizers and capital.

The quantity of family labor was the only input with a statistically significant effect on the quantity of sweet potato harvested. An increase (or decrease) of 1% of the quantity of labor gives rise to an increase (or decrease) of 0.20% of yield harvested. This is due to the fact that little attention is granted to the crop and, as a result, some upkeep operations such as weeding (mainly) are poorly executed thus negatively impacting yield level. Indeed, as a creeper by nature, sweet potato is, according to the farmers, a plant which can barely stand competition from weeds [16]. Proper field upkeep, meaning more labor usage, would undoubtedly contribute to the increase of labor.

The quantity of mineral fertilizers used and the amount of capital invested in the production of sweet potato do not have any significant effect on the harvested yield. Only 22.7% of respondents apply mineral manure at a very low rate (84.46 kg/ha). Even though fertilizers boost output, they negatively impact the quality of tubers which rot faster with low organoleptic properties; hence their low level of utilization. As for invested capital, it has no significant effect on the yield as few farmers would seriously invest in the production of sweet potato. The capital here is essentially made up of the costs of depreciation of the agricultural equipment and of fertilizers purchased by a few farmers. The depreciation cost of the agricultural equipment also used for the production of other crops (maize, cotton, yam etc.) is generally born by the income generated from the sales of such crops [17]. The economy of scale factor has a role here.

IV. CONCLUSION
The decision to grow sweet potato, the acreage occupied by the crop and the yield obtained are respectively determined on the one hand by the farmer’s number of dependents, schooling level, practice of an income-generating activity (with negative effects for the last two) and, on the other hand, by the acreage devoted to the cultivation of maize, yam and cotton, and finally by the quantity of family labor used per hectare. The inclusion of the various determinants of sweet potato production could assist in enhancing the cultivation of the crop and, as a result, contribute to the diversification of agricultural production and the fight against food insecurity.

ACKNOWLEDGMENT
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REFERENCES


Table 1: Codes and modalities of variables for the logistic regression model

<table>
<thead>
<tr>
<th>Variable names</th>
<th>Code</th>
<th>Modalities</th>
<th>Expected signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potato production</td>
<td>P</td>
<td>No = 0</td>
<td>±</td>
</tr>
<tr>
<td>Age of farmers</td>
<td>AGE</td>
<td>&lt; 39 years = 0</td>
<td>±</td>
</tr>
<tr>
<td>Level of schooling</td>
<td>NSCO</td>
<td>Non schooled = 0</td>
<td>+</td>
</tr>
<tr>
<td>Level of literacy</td>
<td>NALP</td>
<td>Non literate = 0</td>
<td>+</td>
</tr>
<tr>
<td>Marital status</td>
<td>SIT</td>
<td>Married = 1</td>
<td>±</td>
</tr>
<tr>
<td>Position in household</td>
<td>STAT</td>
<td>Household head = 0</td>
<td>±</td>
</tr>
<tr>
<td>Number of dependents</td>
<td>CHAR</td>
<td>&lt; 10 persons = 0</td>
<td>+</td>
</tr>
<tr>
<td>Practice other (s) IGA</td>
<td>IGA</td>
<td>No = 0</td>
<td>±</td>
</tr>
</tbody>
</table>

NB: IGA = Income-generating activity

Source: Laboratoire d’entomologie appliquée et de Pesticides, Parakou; Survey, 2009.
Table 2: Codes and units of variables for the multiple regression model used for sweet potato determinants

<table>
<thead>
<tr>
<th>Variable names</th>
<th>Codes</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potato acreage</td>
<td>S</td>
<td>ha</td>
</tr>
<tr>
<td>Number of farm hands</td>
<td>lnACTIF</td>
<td>person</td>
</tr>
<tr>
<td>Sorghum acreage</td>
<td>lnSORG</td>
<td>ha</td>
</tr>
<tr>
<td>Maize acreage</td>
<td>lnMAIS</td>
<td>ha</td>
</tr>
<tr>
<td>Yam acreage</td>
<td>lnIGN</td>
<td>ha</td>
</tr>
<tr>
<td>Cotton acreage</td>
<td>lnCOT</td>
<td>ha</td>
</tr>
<tr>
<td>Acreage for other crops (rice, groundnut, etc.)</td>
<td>lnAUTR</td>
<td>ha</td>
</tr>
</tbody>
</table>

NB: ln designates the Natural log function

Source: Laboratoire d’entomologie appliquée et de Pesticides, Parakou; Survey, 2009.

Table 3: Codes and units of variables for the multiple regression model used for yield determinants

<table>
<thead>
<tr>
<th>Variable names</th>
<th>Codes</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of sweet potato harvested</td>
<td>lnQ</td>
<td>Kg</td>
</tr>
<tr>
<td>Quantity of family labour</td>
<td>lnMOF</td>
<td>HJ/ha</td>
</tr>
<tr>
<td>Quantity of fertilizers</td>
<td>lnENG</td>
<td>Kg/ha</td>
</tr>
<tr>
<td>Amount of capital</td>
<td>lnCAP</td>
<td>FCFA/ha</td>
</tr>
</tbody>
</table>

NB: ln designates the Natural log function

Source: Laboratoire d’entomologie appliquée et de Pesticides, Parakou; Survey, 2009.

Table 4: Results of the Logit model

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Coefficients</th>
<th>Z</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.85873***</td>
<td>3.73</td>
<td>0.000</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.598424</td>
<td>-1.04</td>
<td>0.297</td>
</tr>
<tr>
<td>NSCO</td>
<td>-1.35340***</td>
<td>-2.87</td>
<td>0.004</td>
</tr>
<tr>
<td>NALP</td>
<td>-0.628524</td>
<td>-1.08</td>
<td>0.280</td>
</tr>
<tr>
<td>SIT</td>
<td>0.365440</td>
<td>0.66</td>
<td>0.512</td>
</tr>
<tr>
<td>STAT</td>
<td>0.183415</td>
<td>0.34</td>
<td>0.733</td>
</tr>
<tr>
<td>CHAR</td>
<td>1.60203***</td>
<td>2.98</td>
<td>0.003</td>
</tr>
<tr>
<td>AGR</td>
<td>-2.81948***</td>
<td>-4.50</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Log-Likelihood = -68.321

Test that all slopes are zero: G = 72,127, DF = 7; P-Value = 0.000

Pearson Chi-Square = 78.0367****; ddl= 34 ; p= 0.000

Source: Laboratoire d’entomologie appliquée et de Pesticides, Parakou; Survey, 2009.

Table 5: Significance of the regression model

<table>
<thead>
<tr>
<th>SCE</th>
<th>CM</th>
<th>ddl</th>
<th>F</th>
<th>R^2</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2457</td>
<td>1.2076</td>
<td>6</td>
<td>5.11****</td>
<td>0.197</td>
<td>0.000</td>
</tr>
<tr>
<td>29.5217</td>
<td>0.2362</td>
<td>125</td>
<td>4.43****</td>
<td>0.197</td>
<td>0.000</td>
</tr>
<tr>
<td>36.7674</td>
<td>131</td>
<td></td>
<td></td>
<td></td>
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</table>

Source: Laboratoire d’entomologie appliquée et de Pesticides, Parakou; Survey, 2009.

Table 6: Determinants of sweet potato acreage

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.6176***</td>
<td>0.1324</td>
<td>-</td>
<td>0.000</td>
</tr>
<tr>
<td>lnACTIF</td>
<td>0.07948</td>
<td>0.06909</td>
<td>1.15</td>
<td>0.252</td>
</tr>
<tr>
<td>lnSORG</td>
<td>-0.04601</td>
<td>0.09938</td>
<td>-0.46</td>
<td>0.644</td>
</tr>
<tr>
<td>lnMAIS</td>
<td>0.5983***</td>
<td>0.2203</td>
<td>2.72</td>
<td>0.008</td>
</tr>
<tr>
<td>lnIGN</td>
<td>0.2861***</td>
<td>0.1064</td>
<td>2.69</td>
<td>0.008</td>
</tr>
<tr>
<td>lnCOT</td>
<td>-0.30365***</td>
<td>0.08791</td>
<td>-3.45</td>
<td>0.001</td>
</tr>
<tr>
<td>lnAUTR</td>
<td>0.07250</td>
<td>0.08251</td>
<td>0.88</td>
<td>0.381</td>
</tr>
</tbody>
</table>

Source: Laboratoire d’entomologie appliquée et de Pesticides, Parakou; Survey, 2009.
A. Paraïso is from Benin, lecturer at the University of Parakou, Benin Republic. His current research is related to the use of formulations containing low doses chemical insecticides in mixtures with spores of entomopathogens; characterization of Bees *Apis mellifera* adansonii; bee diseases in Benin and Africa; Bee parasites (*Varroa destructor*, *Braula caca*, *Acarapis woodi* and *Tropilaelaps* sp.) distribution and their impacts on beekeeping in Benin; bee hives predators (*Aethina thumida*, and *Galleria mellonella*); impacts of chemical pesticides on bee populations and promotion of good beekeeping practices in Benin.