Socio-economic analysis of Pachyrhizus erosus cultivation in Benin: Profitability and cost function analysis.

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The introduction of P. erosus cultivation in Benin is for producers an alternative to improve their cropping system and for the population to improve their food system. Therefore, to remove the different constraints related to P. erosus adoption, this study has analyzed the perceptions of producers and the economic performances of P. erosus introduced in Southern and Center Benin. The data were collected from fifty eight (58) producers in 2011-2012, seventy three (73) in 2012-2013 and fifty nine (59) who have experienced P. erosus production. Analyses were made using the margin calculation methodology, the productivity calculation methodology, Kendall's T tests and cost function modeling. The results revealed that P. erosus production is very profitable with a net margin of Fcfa /ha 2,064,284.63 /ha against Fcfa/ha 192,152.01 /ha, Fcfa/ha 551,900.93 /ha and Fcfa/ha 109,351.28 /ha respectively for cassava, sweet potato and maize.

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Introduction

Tropical root crops such as cassava (Manihot esculenta, Euphorbiaceae), yams (Dioscorea spp, Dioscoreaceae), sweet potato (Ipomoea batatas, Convolvulaceae) and cocoyams (Colocasia esculenta and Xanthosoma spp., Araceae) are widely grown and consumed in the tropics. All these crops are characterized by high levels of carbohydrates (starch and/or sugars) with low amounts of protein. Cassava is one of the most widely consumed crops in Africa, with gari as its most popular processed product consumed by nearly 300 million people in West Africa (Oseni, 2012). In Benin, cereals and root tubers are the staple food of Benin population with a weekly food consumption of 07 days for about 98% of the households (AGVSAN 2008). After maize, roots and tubers are the second major source of calories in national food in Benin (Gandonou *et al.*, 2010). These roots and tubers are characterized by high-carbohydrate content (starch and sugars) with low-protein content. Cassava is the most consumed root in Africa especially in *gari* form, its main derivative product. But with the current population growth, maintaining the self-sufficiency ratio in staple foods compels farming households to intensify their production. However, roots and tubers production, due to their requirements namely in phosphorus, quickly deplete soils thereby jeopardizing the sustainability of the production systems (Adegbola *et al.*, 2011). Moreover, their share in the food system shows their importance in food security and consequently in human nutrition. However, if these food products are very important in energy intake in the diet of the populations, their main nutritional drawback is their low-protein content (Westby, 2002) in an African context where protein and micronutrient deficiencies are widespread among vulnerable populations, the majority of whom are less than five years old and pregnant and breastfeeding women. Among other derivative products of roots and tubers, *gari* is widely consumed in various forms in West Africa (Oduro *et al*., 2000). The major inconvenience of *gari* as food is its low-raw-protein, essential minerals and vitamin content (Afoakwa *et al*., 2010). For lack of a fortification approach of roots and tubers derivative products which have shown their limits, one of the alternative solutions to the difficulties to have access to protein sources could be the introduction of a plant species likely to replace cassava by bringing an additional nutritional value as differentiation parameter. Hence the feasibility of introducing *P.*

erosus in the cropping system which, beyond its nutritive function, can contribute to land restoration.

Yam bean (Pachyrhizus spp) also called "Ahipa" is a leguminous plant that forms reserve roots. The tuber roots of *P. erosus* contain up to five times more proteins than cassava and noticeable rates of zinc and iron (Evans *et al*, 1977; Velasco and Gruneberg 1999; Kale 2006). Therefore, it can make a balanced died contrary to cassava that is only energetic with a protein content that is almost nil (Sidibé *et al*., 2005). *P. erosus* has therefore an important potential to improve quantitatively and qualitatively the staple food, in order to make more sustainable the concerned cropping systems and give new options of revenues in Sub-Saharan Africa and in Benin in particular. According to Adjahossou (2002 and 2006), Pachyrhizus spp has good aptitudes, including its adaptation to environmental stresses (alternation of draught and heavy rains), its capacity to fix atmospheric nitrogen up to 200 kg of N/ha. Its production in Benin will contribute to better food in quantity and in quality, to improving soil fertility in organic matter and in nitrogen and to increasing the level of household incomes. Despites these potentialities, there is a lack of economic studies to accompany agronomic ones. In fact, economic studies on the cultivation of *P. erosus* are indispensables to know factors determining its profitability and those likely to affect its adoption. According to Osty, 1978, it is accepted that it is the farmer who manages production factors at the level of his farm and it is from his global operation that he deems it appropriate to adopt an innovation. However, technical performances of a technology, let it be in rural area, are not enough to demonstrate its impact on the economic performances of its adopters (Honlonkou, 1999). This study lies in this perspective with the view of the socio-economic analysis of *P. erosus* production in Southern and Center Benin.

1. Methodology

1.1 Theoretical background

Agricultural technology adoption models are based on farmers' utility or profit-maximizing behaviours (Pryanishnikov & Zigova 2003). The assumption here is that farmers adopt a new technology only when the perceived utility or profit from using this new technology is significantly greater than the traditional or the old method. While utility is not directly observed, the actions of economic agents are observed through the choices they make. In fact, the producer is rational and tries to minimize his charges (fixed and variable). He maximizes his profit constrained by his charges, and obtaining the possible highest net profit is frequently identified as the first objective of most producers. According to (Dimara *et al.,* 2003), the costs and the revenue as being the principal guide highlighting the evaluation process of decision-making. Therefore, this analysis is based on the cost minimization and farmers' perceptions will be tackled in order to identify the constraints and advantages of *P. erosus*. The productivity of major crops will also be dealt with because they are the alternatives that come to producers.

1.2 Empirique framework analysis

1.2.1 Productivity of production factors

Productivity has the advantage of being operational and to give a good idea of internal remuneration of the production factors. The productivity of a factor can therefore be expressed by the relation of physical quantities; in this case, it takes a very concrete characteristic (Desclaude *et al,*. 1971). Labor productivity, net from the other factors is calculated by subtracting from the raw product (PB) the other charges and by dividing the difference obtained by the labor charges in used unit of workers (Taylor *et al.,* 2002). It measures the remuneration of the family labor that is compared with the labor in the study area. The productivity of the capital represents the interest deducted from the capital and is compared with the interest paid on loans in the study area and land productivity represents the amount that producers have paid for lands or would have paid for lands if they are not land owners and it is compared with the amount of land rental in the study zone (Ojehomon *et al.*, 2012).

$$\textbf{Labor productivity} = \frac{PB - COATR_1}{\textbf{Labor productivity } (m-d)} \qquad \textbf{(1)}$$

Regarding capital productivity, it is calculated by taking into account the costs of inputs and the paid labor. If $\mathbf{COATR_2}$ is the cost of the other factors except capital cost, therefore we have:

$$\textit{Capital productivity} = \frac{PB - COATR2}{Capital\ cost} \qquad \textbf{(2)}$$

When the cost of the other production factors except the cost for land rental is designated by $\mathbf{COATR_3}$, land productivity is calculated by the formula:

$$\textit{Land productivity} = \frac{PB - COATR3}{Quantity\ of\ land} \qquad \textbf{(3)}$$

- **Sensitivity analysis**

It aims at simulating from the cost price of *P. erosus* the effect of the selling price on the profitability (ratio B/C and the productivities of the production factors) of *P. erosus* by the producers. In fact, Ahipa is a new crop introduced in Benin and the selling price is not yet known. Thus, by simulating from the cost price of the system (removal of flowers with staking or removal of flowers without staking) that has better technical performance technique (yield), we identify:

a) at which selling price the ratio B/C ≥ 5% of the production costs and its effects on the productivities,

b) at which selling price the ratio B/C and the factors' productivities are better than major crops.

But the fundamental question is to know if this price is accessible by comparing it to the price of cassava and by taking into account the advantages and constraints of *P. erosus* production.

- **Analysis of perceptions**

Kendall's concordance test was used to classify perceptions (advantages and constraints) of *P. erosus* producers. In fact, when we have k elements of classifications, we can determine the relationship between them by using Kendall's concordance coefficient W with $0 \leq W \leq 1$ (Sidney,S,. *et al*., 1988). The coefficient W is a measure of the level of harmony between the characteristics (Andy, 1992). The statistical table is used to determine the significance of W for N (number of rank) ≤7 (Cohen, 1976) at the thresholds of 5% and 1% while the test of Ki2 is used when N>7. The Ho nil hypothesis tests the independence between perception criteria. To do this, individual data are collected on its advantages and constraints and, one rank is allocated to each criteria. In addition to trainings on technical itineraries, the NGO BORNEfonden has organized taste tests per trial site where products from *P. erosus* processing were tasted. The advantages of *P. erosus* were measured against the following criteria: high nutriments content (iron, protein), soil fertility improvement, varied range of derivative products from its processing and possibility to be consumed raw. With regard to the constraints, they are related to weeding, sowing, removal of flowers, plowing, weeding techniques and pods harvesting.

1.2.2. P.erosus' cost function analysis

Production analysis can be done by investigating a production function, a cost function, or a profit function. In fact, the center of attention in the study of the theory of the firm from an outputside perspective is on the cost functions expressed with output as the independent variable. In many microeconomic theories study courses, the discussion of production economics essentially begins with so costs of production with only scant attention to the underlying production function (technical force) and optimal factor combinations (Beattie and al., 1985). Typically, microeconomics describes the behavior of firms by means of a production function: So, the cost function can't be expressed without making link with production function that establishes the relationship between output and inputs.

Using econometric tools, the standard approach involves specifying parametric functional forms for a function, and finding a way of estimating the associated parameters using real world data. For convenience, it is often assumed that all functions are differentiable. However, the translog production functions represent in fact a class of flexible functional forms for the production functions (Ch. Allen, St. Hall, 1997). One of the main advantages of the respective production function is that, unlike in case of CobbDouglas production function, it does not assume rigid premises such as: perfect or "smooth" substitution between production factors or perfect competition on the production factors market (J.Klacek, et al., 2007). Also, the concept of the translog production function permits to pass from a linear relationship between the output and the production factors, which are taken into account, to a nonlinear one. Due to its properties, the translog production function can be used for the second order approximation of a linear-homogenous production, the estimation of the Allen elasticities of substitution, the estimation of the production frontier or the measurement of the total factor productivity dynamics.

Applications of duality theory typically begin with specification of a functional form for an indirect profit function or an indirect cost function, as opposed to beginning with a production function as is done in the primal approach (Beattie and al., 1985). The translog cost function C(r, y) takes the form:

$$Ln\,C = \alpha + \gamma_y \ln(y) + \sum_{i=1}^{n} \beta_i\, lnr_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{m} \beta_{ij}\, lnr_i lnr_j + \sum_{i=1}^{n} \theta_{iy} \ln(r_i)\ln(y) + \frac{1}{2}\gamma_{yy}[\ln(y)]^2 + \varepsilon \quad \textbf{(4)}$$

Here C is cost, y is output of *P.erosus*, r is the price of input i. $\alpha, \gamma,\ \beta$ and θ are the parameters to be estimated. Any cost function must be homogenous of degree 1 in input prices. In the translog function 1, this requires that:$\sum_{i=1}^{n} \beta_i = 1, \sum_{1=i}^{n} \beta_{ij} = 0, \sum_{i}^{n} \theta_{iy} = 0.$

In general, it is difficult to obtain a sample large enough to estimate the full cost function. Thus, estimating the cost function as a single-equation even with restrictions imposed for linear homogeneity in the input prices may be either impossible or inappropriate. Estimating the full dual system (i.e., cost and share equations together) leads to much higher efficiency. Such joint estimation can compensate for the information inadequacy in the equation (4) alone. From translog cost function and Shephard's Lemma, we derive the input share equation:

$$S_i = \beta_i + \sum_{i=1}^{n} \beta_{ij}\, lnr_i + \sum_{i=1}^{n} \theta_{iy} \ln(y) + \varepsilon \quad \textbf{(5)}$$

Where $(i = 1,2,3 \ldots . n)$, $S_i = \frac{r_i x_i}{C}$ and x_i is the quantity of the ith input. These shares must add up to 1. This is true for all prices and output. It requires

$\sum_{i=1}^{n} \beta_i = 1,\ \sum_{1=i}^{n} \beta_{ij} = 0,\ \sum_{i}^{n} \theta_{iy} = 0$ and ε is a random variable with mean zero and finite variance.

Some additional econometric considerations are the following:

- because of cost shares must add to 1, one of the share equations from (5) is redundant,
- the individual equations of the system are seemingly unrelated of Zellner and
- restrictions must be imposed across equations to ensure uniqueness of estimated parameters which occur in more than one equation.

The system was estimated using the joint generalized least squares procedure. Although, any one parameter appearing in several equations has the same estimated value.

1.2.3. Model variables definition, data description and study area

In this model, we have one output, y *P.erosus* output. As input we have: hired labor, farm capital, fertilizer, and seed. In the dual system input prices are used rather than physical quantities. There are wage of hired labor (r_1), user cost of farm capital (r_2), fertilizer price (r_3) and seed (r_4).

The dependent variables are as follows:

- S_1 is total wages paid to hired labor,
- S_2 is operation expenses on capital items,
- S_3 is expenses on fertilizers and
- S_4 is expenses on seed.

The data used for this study were collected from experimentations conducted in four (4) intervention sites of the NGO BORNEfonden: These are the communes of Za-kpota, Bonou, Adjohoun and Dangbo (in Southern Benin). The commune of Za-kpota is located in the agro-ecologic zone (VI) which is the zone of the terre de barres favorable to maize, tubers and groundnut production. On the contrary, the communes of Bonou, Adjohoun and Dangbo are in the agro-ecologic zone (VIII) which is the zone of fisheries where there are alluvial soils which are very fertile and very productive for maize, tubers and market gardening production. The NGO has provided training on the technical itineraries for producers on P.erosus production and they are supervised by the NGO BORNEfonden. Therefore, panel data has been compiled from three (03) years of *P.erosus* compaign production. Thus, the panel data used in the empirical analysis was derived from three surveys on *P.erosus* producers in southern Benin taking into account the campaigns 2011-2012, 2012-2013 and 2013-2014, those producers who have been supervised by NGO BORNEfonden and trained on *P.erosus* system production technique. The first survey data were collected in 2012 on a sample of 58 *P.erosus* producers randomly drawn from the study areas. From the first survey in 2012, new producers who have already experienced other activities of the NGO were completed on the list of *P.erosus* experimenters during the 2012-2013 campaign and those who have not followed well the technical recommendations during the 2011-2012 campaign were replaced. So, the sample was 73 *P.erosus* producers in 2013 and 59 *P.erosus* producers in 2014. So that a balanced panel of 190 observations could be constructed.

1.2.4. Pachyrhyzus erosus system production

The production is done in pure stand. Among the species of the genus Pachyrhyzus, erosus is one of the very early-flowering species. It gives its first flowers 87 days after seeding and harvest can take place after 4 to 7 months (Sorensen, 1996). Cropping techniques consist in sowing two (2) grains per hill and thinning at one (1) plant per hill or sowing one grain per hill and sow again two to three weeks after the first sowing. The recommended seeding rate is 31,250 plants/ha with spaces of 0.40 m × 0.80m and weed four times: two (2) weeks, six (6) weeks, 11 weeks and 14 weeks after sowing; (weeding should continue in case of weed invasion of the plots). The area cultivated per producer is 525 m^2 out of which 25 m^2 where producers do not remove flowers in order to produce grains. Moreover, removing inflorescences (suppression of flowers) was recommended to the learners on the 500 m^2 for the production of tubers. Mineral fertilizers is applied after the first weeding at the dose of 10 kg of NPK and 3 kg of KCl. Staking was not highly recommended but this depended on the availability of stakes for each farmer (stakes are put for the plants of *P. erosus* from the 20th day after seeding). Staking is not also well proven by research. Tubers are harvested 20 to 25 weeks after seeding and the pods are harvested as soon as they are matured to avoid them breaking in the fields. Framers' supervision consisted in visiting each trial plot twice a week by a staff of the NGO, either to assist in implementing an operation, or to check if the operation is carried out correctly in order to fill out the questionnaire. Depending on each case during the visit, specific recommendations are made for each producer.

1.2.5. Analysis' method

Descriptive statistical and quantitative methods were used to analyze the data collected. The descriptive statistics used were frequency distribution, mean, mode and tables. Productivity analysis was used to determine the level of profitability and compare it to three most important crops in study area. The nonparametric test was used to deal with farmers' perception. The quantitative methods employed were the ordinary least square to caption the effects of farmers, socioeconomic variables in the production of agricultural product on cost production. The t-test was used to test for the statistical significance of the variables.

2. Results and discussion

2.1 Major crops in the study zones

The adoption of *P. erosus* depends on the advantages that it gives to producers compared to the major crops they were practicing. Thus, three major crops practiced in both agro-ecological zones were considered in the frame of this study in order to compare the results and to make propositions for the adoption of *P. erosus*. Tables 1 and 2 present the results of Kendall' test in order to prioritize majors crops respectively in the agro-ecological zones VI (zone of *terre de barre*) and zone VIII (fisheries zone). The results of Kendall's test show that the value of W of Kendall is 0.42 and is significant at the threshold of 1%. The results in tableau 1 show that the three major crops are respectively maize, cassava and groundnut. The results of table 2 show that maize, cassava and sweet potato are the major crops in the fisheries zone. These results tally with the characteristics of each agro-ecological zone. In fact, from the results of the diagnostic study, maize is raw material for the preparation of pastry and cassava is used to prepare gari, both staple foods of the population in the study areas. Since this study is about the tubers of *P. erosus*, maize, cassava and sweet potato crops are retained for the rest of the analysis in order to compare their profitability with that of *P. erosus*. Maize was retained in the analysis because of its rank in both agro-ecological zones and its importance in the food of the households.

2.2 Quantity of labor in men-days per hectare (m-d/ha) per cropping operation

The results of table 3 show that the cultivation of *P.erosus* is more labor demanding in general than the other crops and the T-test reveals a significant difference with the major crops considered. Plowing, weeding and flower removal operations are those requiring important quantities of labor. In fact, producers estimate that deep plowing gives big tubers of *P.erosus.* Maintaining *P.erosus* requires at least three (03) weeding operations and regular flower removal two (02) times at least per week in order to have good yield.

2.3 Economic performances

2.3.1 Production cost and marginal cost of *P. erosus*

Tableau 4 presents the costs invested per hectare for the different crops. The T-test results are significant for variable costs and show that there is a difference between the different costs from one crop to another. The labor cost occupies an important place in the production cost. At the level of *P. erosus* crop, the production cost F cfa 991,246.02 /ha with about F cfa 932,987.63 /ha for the invested labor. With regard to major crops, the production costs are F cfa 369,035.90 /ha, F cfa 375,539.03 /ha and F cfa 295,829/ha respectively for cassava, sweet potato and maize. The cultivation of *P.erosus* therefore requires more investment than the other crops. Regarding the marginal cost of *P.erosus*, it is F cfa 48.66 F cfa/kg. This marginal cost will serve as the basis of simulation in order to identify an average selling price to secure producers' gain.

2.3.2 Net margins and factors productivities

Net margins and production factors productivities of the different crops are presented in table 6. All net margins obtained are positive and these results stipulate that all costs incurred in the production are covered by the raw product. The results of the T-test reveal a significant difference between net margins and factors productivities. The labor productivity obtained is F cfa 4,515.24 m-d for *P. erosus* crop. Labor productivities of cassava, sweet potato and maize crops are respectively F cfa 3,359.88 /m-d, F cfa 3,936.88 /m-d and F cfa 2,136.005 /m-d. These results show that the production of *P. erosus* remunerates family labor. For each crop, labor productivity is higher than the daily cost of the paid labor in the study zones, which is on average F cfa 1,200 /m-d. Moreover, land is a remunerated good no matter the crop considered because the values obtained are higher than land rental cost in the study zones, which is on average F cfa 110,000 /ha. The value of land productivity obtained for *P. erosus* crop is the average of F cfa 412,091.78 /ha. The one obtained for the other crops is F cfa 180,343.27 /ha, F cfa 201,430.23 /ha and F cfa 125,617.38 /ha respectively for cassava, sweet potato and maize. Land remuneration seems less good for the maize field than in the case of the other crops. In fact, maize is cropped mainly for household food. With regard to capital productivity, the very high value obtained for each crop is of course due to the relatively low levels of employment of this production factor compared to this revenue.

2.3.3 Sensitivity analysis

The results in table 6 show the effects of simulating the cost price on the ratio B/C and the production factors productivities. The simulations were done from the cost price of *P. erosus* tubers; that is F cfa 48.66 /kg. The ratio B/C is higher than 5% when the cost price increases by 10%, that is a market price of F cfa 53.52 /kg. At this selling price, labor productivity is lower than those of the major crops with a good remuneration of the land and the capital.

2.4. P. erosus crop producers' perception

This section presents *P. erosus* crop experimental producers' perceptions.

- **Advantages related to the cultivation of *P. erosus***

Kendall's concordance test W allowed prioritizing the different criteria. The value of W of Kendall is 0.274 and is significant at the threshold of 1% and shows the level of concordance between the different criteria. The criterion varied range of derivative products occupies the first place followed by the high nutriment content and then the criterion soil fertility improvement. In fact, roots of *P. erosus* can be processed into gari, into bread-making flour used bakery products, liquor, snack, etc. Adégbola *et al*. (2011). The works of Padonou (2010) revealed that, gari from P. *erosus* contains 4.77% protein, 1.74% ashes and 0.35% lipids. Its water content is 11.25%, thus it can be kept for longer time than gari from cassava and respects the required standards. According to Adjahossou (2002 and 2006), *P. erosus* has good aptitudes including its adaptation to environmental stresses (alternation between drought and heavy rains), its capacity to fix atmospheric nitrogen up to 200 kg of N/ha.

- **Constraints related to the cultivation of *P. erosus***

Although well appreciated, the cultivation of *P. erosus* has some constraints that have been raised by experimenters. Kendall's concordance test W has allowed prioritizing the different constraints and the results are recorded in table 8. The value W of Kendall is 0.558 and significant at the threshold of 1%, indicating thus the degree of concordance between the different constraints. The main constraints are respectively removal of flowers, weeding and sowing. Removing flowers is tedious because it is done per plant, irritates the skin and using a pair of scissors that aches fingers. According to technical recommendations, four weeding are recommended; two (2) weeks, six (6) weeks, 11 weeks and 14 weeks after seeding (weeding should continue in case of weed invasion of the plots). Producers are constrained to respect these recommendations because the minimal number of weeding is three (3) for 15% of the producers against 48% of the producers who practice at least four weeding (4). Since raw seeding is not practiced, producers find difficult the mode of raw seeding and the rate of 80*40 cm with two (2) grains per hill and thinning at one (1) plant per hill or sowing one grain per hill and do a second sowing two to three weeks after seeding.

2.5 Cost function analysis

The table 9 presents the estimated parameters of cost function and the associated asymptotic t-value. About the Goodness-of-fit of the model, the R-square is 43.24% and the significance of the Breusch-Pagan test of independence: Chi2 = 144.76, Pr = 0.0000; justifies the choice of a SUR modeling approach. The estimated parameters reported in this table 9 may be used to compute the elasticities of input demand.

2.5.1 Factors affecting input demand

The table 10 provides the results about factors that affect input demand for *P.erosus* production in South Benin. The model reveals that 27.55%; 36.23%; 34.81% and 28.01% respectively of input demand as labor, capital, fertilizer and seed effects are explained by the selected exogenous variables. The non-explained variations are due certainly to natural geographical characteristics. According to the table 10, prices of labor, fertilizer and seed affect labor demand. In fact, the decreasing in seed and capital prices increase labor demand. In the way, the capital demand is affected by the prices of labor of capital of seed. It shows that the farmers could increase their land for *P.erosus* production but they are limited by the interest on farm mortgages. Also the prices of seed and the total wage paid to hire labor decrease the labor demand. After sowing

P.erosus, farmers must deal with at 4-5 times for weeding. That demand more labor and increase their farm expensive.

The fertilizer demand is affected by the prices of capital, fertilizer and seed. The decreasing in prices of those variables lead to increase the fertilizer demand. It is the same for seed demand. The decreasing in prices of labor, capital and seed lead to seed demand increasing. That explains that farmers are so limited by the prices of those variables.

These results indicate that for each input demand, the variables that affect greatly its demand and should be considered in any diffusion policy.

Conclusion and implications

The study carried out in the experimentation zone, has allowed us to know producers' perception on the cultivation of *P. erosus*; to estimate its technical and economic performances. Despite the constraints related to *P. erosus* production, it is very well appreciated by experimenters, because of its many advantages such as processing into varied range of derivative products, its high nutriment content and soil fertility improvement. In the light of the economic results, *P. erosus* is more profitable and its land remuneration is higher than that of major crops. Also, the prices of seed, fertilizer, capital and wage paid to hire labor affect input demand as seed, capital, labor and fertilizer. Research should therefore put a particular accent on looking for appropriate solutions to the identified constraints. Likewise, the marketing component should be developed in order to help producers to find outlets.

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References

Adegbola Y. P., Djenontin I. N. S., Sossou C. H., Hinnou C. L., Thiele G. & Mensah G., 2011. Etude diagnostique participative pour le projet «Ahipa» au Bénin.

Adjahossou, D.F., Adé, J.,2002. Etude de quelques paramètres de conservation de l'eau sur des plantes de trois accessions du genre Pachyrhizus erosus soumises à la sécheresse. Ann SciAgron Bénin 2002 ; 3 : pp. 1-18.

Adjahossou, D.F., 2006. Ablation des inflorescences et rendement en tubercules chez le haricot igname (Pachyrhizuserosus). In Cahiers Agricultures vol. 15, n° 2, mars-avril 2006. 7p. version pdf, consulté sur www.google.fr le 26/03/2012 à 12h42.

Allen Ch., Hall St., 1997. Macroeconomic Modelling in a Changing World, John Willey & Sons, New York

Andy Igho J.,1992. Fundamental statistics for education and the behavioural sciences, 414p.

Afoakwa, E. O, Edem, K. J, Budu, A. S, Annor, G. A., 2010. Souring and starch behaviour during co-fermentation of cassava and soybean into gari 'farina'. As. J. Food and Ag-Ind., 3: 371-385.

AGVSAN., 2008. Analyse Globale de la vulnérabilité de la sécurité Alimentaire et de la nutrition. République du Bénin.

Beattie, B, R., Taylor C.R., 1985. The economics of production. Copyright 1985 by John Wiley and Sons, Inc. All rights reserved. Published simultaneously in Canada.

Desclaude et Tondut.,1971. "Gestion de l'entreprise agricole " volume II, 3ème édition. pp 144

Dimara, E., Skuras, D.,2003. Adoption of agricultural innovations as a two-stage partial observability process, Agricultural Economics 28, 187-196.

Evans, M.D., Boulter, A.R., Eaglesham, J., Dart, P.J.,1977. Protein content and protein quality of tuberous roots of some legumes determined by chemical methods. Qual. Plant, Plant Foods Hum. Nutr., 27 (3-4), 275-285.

Honlonkou, N. A.,1999. *Impact économique des techniques de fertilisation des sols : cas de la jachère mucuna au Sud-Bénin.* Thèse de doctorat de troisième cycle, CIRES, Université Nationale de Côte d'Ivoire.

Kale, P.R.,2006. Studies on nutritional and processing properties of storage roots of diff erent yam bean (*Pachyrhizus* spp.) and wild mung bean (*Vignavexillata*) species. Ph.D. diss. Universitat Gottingen, CuvillierVerlag, Gottingen, Germany

Klacek J., Vosvrda M., Schlosser S.,2007. "KLE Production Function and Total Factor Productivity", in Statistika, No. 4.

Oduro, I.,Ellis, W. O., Dziedzoave, N.T., Nimako-Yeboah, K.,2000. Quality of gari from selected processing zones in Ghana. *Food Control*, **11**: 297-303.

Ojehomon. V.E.T., Adewumi. M.O., Omotesho. O.A., Ayinde. K., Diagne. A., 2012. Adoption and Economics of New Rice for Africa (NERICA) Among Rice Farmers in Ekiti State, Nigeria. Journal of American Science, 2012; 8(2).http://www.americanscience.org

Oseni A.L., 2012. Empowerment initiatives: Garri processing empowers women. West Africa Insight, 3(6): 3–5.

Padonou S.W., 2010. Ahipa Processing Report 2010. 8p.

Pryanishnikov,I., Zigova, K., 2003. Multinomial logit models for Austrian labour market. Austrian Journal of Statistics 32, 267–282.

Rogers, E. M., 2003. "Diffusion of innovation," 5th edition. Macmillan Co., New York.

Sidney, S., N. John Castellan, Jr.,1988. Nonparametric statistics for the behavioral sciences, Second Edition, 399p.

Taylor, J.E.,2002. Agricultural household models : Genesis, evolution and extensions. Review of Economics of the Household 1, 33-58, 2003. Received February 21, 2002; Accepted September 5, 2002.

Velasco, L., Grüneberg, W.J..1999. Analysis of dry matter and protein contents in fresh yam bean tubers by near-infrared reflectance spectroscopy. Commun. *Soil Sci. Plant Anal.*, 30: 1797-1805.

Westby, A. 2002. Cassava utilization, storage and small-scale processing. In Cassava: Biology, production and utilization ed. Hillocks, R.J., Tresh, J.M. and Bellotti, A.C. pp. 281–300. CAB International.

Table 1: Major crop in the zone of the "*terre de barre*"

Crops	Average rank	Rank
Maize	1.00	1
Cassava	2.08	2
Groundnut	2.92	3
Sweet potato	4.00	4
Sample		**26**
W of Kendall		**0.972*** **

***** Significant at the threshold of 1%**

Table 2: Major crops in the zone of the fisheries

Crops	Average rank	Rank
Maize	1.02	1
Cassava	2.25	2
Sweet potato	3.25	3
Groundnut	3.48	4
Sample		**47**
W of Kendall		**0.774*** **

***** Significant at the threshold of**

Table 3: Labor per cropping operation (m-d/ha)

Items		**Main crops**			**T-test for the whole**
	P. erosus	**Cassava**	**Sweet potato**	**Maize**	
Clearing	37,35	43,821	37,58	42,21	8.53^{NS}
Sowing/planting	24,82	13,908	15,34	15,63	5.75^{NS}
Weeding	84,74	27,595	35,42	32,85	9.82***
Harvesting	83,46	26,137	35,32	27,79	8.54*
Removal of flowers	148,45				
Total labor in m-d	378,83	108,49	114,54	134,04	9.21***
Sample	**73**	**20**	**12**	**73**	

^{NS} **Non significant, * Significant at 10%, *** Significant at 1%**

Table 4: Production cost (FCFA/ha) and cost price (FCFA/Kg)

Items		Major crops			T-test
	P. erosus	**Cassava**	**Sweet potato**	**Maize**	
Labor	932,987.63	323,772	314.748	240,948	-8.970***
Fertilizer	57,096.75	-	-	38,450	7.654**
Seed	0	43,440.56	59.047.69	20,140.28	5,630*
Variable cost	990,084.38	367,212.56	373,795.69	299,538.28	-7.511***
Fixed cost	1,161.64	1,823.34	1,743.34	3,708.87	-4.88[NS]
Total cost	991,246.02	369,035.90	375,539.03	295,829.41	-9.902***
Marginal Cost (Unit)	48.66		-		

[NS] Non significant, * Significant at the threshold of 10%, ** Significant at the threshold of 5%, * Significant at the threshold of 1%**

Table 5: Net margins and factors productivities

Items		Major crops			T-test
	P. erosus	**Cassava**	**Sweet potato**	**Maize**	
Raw product	3,055,430.65	561,191.91	927,439.96	412,598.43	-8.943***
Gross margins	2,065,346.27	193,979.35	553,644.27	113,060.15	-8.874***
Net margins	2,064,284.63	192,156.01	551,900.93	109,351.28	-9.531***
Ratio B/C	2.08	0.52	1.47	0.36	-7,834**
Labor productivity (F cfa/m-d)	4 515,24	3359,88	3 936,88	2136,005	- 7.754**
Land productivity (F cfa/ha)	412,091.78	180,345.27	201,430.23	125,617.38	-8.865***
Capital productivity (%)	308.48	152.32	247.64	136.50	-7.170*

*** Significant at the threshold of 10%, ** Significant at the threshold of 5% and *** Significant at the threshold of 1%**

Table 6: Simulation of the cost price of *P. erosus*

Simulation rate of the cost price		5%	10%	15%	20%	25%
Price	48.66	51.09	53.52	55.96	58.39	60.83
Raw product	991,246.02	1,040,808.32	1,090,370.62	1,139,932.92	1,189,495.24	1,239,057.55
Total cost	991,246.02	991,246.02	991,246.02	991,246.02	991,246.02	991,246.02
Ratio B/C	0	0.05	0.1	0.15	0.2	0.25
Labor productivity	1,278.09	1,355.90	1,433.71	1,511.52	1,589.32	1,667.13
Land productivity	0	98,945.67	197,891.37	296,837.06	395,782.75	494,728.44
Capital productivity	100	105.005	110.01	115.02	120.02	125.03

*Table 7**: Advantages of*** **P. erosus** ***crop***

Criteria	**Average rank**	**Rank**
Processing into several derivative products	2.40	1
High-nutriments content (iron, protein)	2.43	2
Improves soil fertility	2.70	3
Raw consumption	3.08	4
Sample	**58**	
W of Kendall	**0.274*****	

**** :** Significant at the threshold of 1%

Table 8: Constraints of *P. erosus* cultivation

Criteria	Average rank	Rank
Removal of flowers	1.39	1
Weeding	2.14	2
Sowing	3.84	3
Plowing	4.52	4
Pods harvesting	4.42	5
Weeding techniques	4.70	6
Sample	**58**	
W of Kendall	**0.558*** **	

***** :** Significant at 1%

Table 9: Estimated coefficients of the Translog Cost Function

Parameters	Value	*t* ratio
α (intercept)	-6.95	-0.11
γ	-1.95	-0.50
β_1	3.23	0.32
β_2	-7.33	-1.51
β_3	12.68	3.10
β_4	-0.73	-0.21
β_{12}	1.96	1.30
β_{13}	-5.2	-3.86
β_{14}	0.45	0.44
β_{23}	0.82	2.81
β_{24}	-0.13	-0.58
β_{34}	0.08	0.37
γ_{11}	0.08	0.78
$\gamma\beta_1$	0.78	1.38
$\gamma\beta_2$	-0.009	-0.08
$\gamma\beta_3$	-0.39	-2.34
$\gamma\beta_4$	-0.16	-0.58

Table 10: Elasticities of input demand

	Price of								
Demand for	Labor	Capital	Fertilizer	Seed	Output	Constant	Obs	Chi2 (probability)	R-square
Labor	0.49^{***}	-0.34^{***}	-0.14	-0.41^{***}	-0.047	1.70(1.97)	190	72.26(0.000)	0.2755
Capital	-0.50^{***}	-0.65^{***}	-0.14	-0.41^{***}	-0.04	1.73(1.98)	190	107.93(0.000)	0.3623
Fertilizer	0.97^{***}	-0.26^{**}	-0.97^{***}	-0.45^{***}	-0.15^{*}	3.87(2.03)	190	101.48(0.000)	0.3481
Seed	-0.53^{***}	-0.30^{***}	0.43	-0.37^{***}	-0.03	-0.44(2.15)	190	73.93(0.000)	0.2801