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Analysis of Fonio, *Digitaria exilis* Stapf. Production in Northwest Benin, West Africa

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Abstract

La production du fonio est une activité très peu développée au Bénin. Elle se pratique exclusivement dans le Nord-Ouest du pays et fait partie des activités menées par les populations pour satisfaire leurs besoins tant alimentaires qu'économiques. La présente étude vise à analyser les déterminants de la production du fonio dans une perspective de sa promotion. Pour ce faire, une enquête a été conduite auprès de deux cent (200) chefs d'exploitation agricole du Nord-Ouest du Benin. Ceux-ci ont été choisis de manière raisonnée et aléatoire. Les données relatives à leurs principales caractéristiques sociodémographiques ont été collectées sur la base de questionnaires d'enquête. Il ressort des analyses que les déterminants du choix de cultiver ou non le fonio dans la zone d'étude sont : l'âge, le niveau de scolarisation et le nombre d'actifs agricoles. Il n'existe pas de contraintes socioculturelles liées au choix des producteurs de cultiver le fonio. Les résultats de cette étude offrent une opportunité de mise en place d'une politique de promotion de la spéculation, reconnue pour ses multiples avantages.

Mots clés : Cultures délaissées, céréales, production, fonio, Bénin.

Fonio production is a very weakly developed activity in Benin. It is only practiced in the Northwestern part of the country, where its production is undertaken by producers to satisfy their economic and food needs. This study aims at analyzing fonio production determinants in the perspective of its promotion. To this end, the study was conducted with two hundreds (200) fonio producers, who were randomly selected in the study sites for the purpose. Data in relation with socio-demographic characteristics were collected using questionnaires. The results of the study showed that, the determinants to produce or not fonio were as follows: the age, the level of education, and the number of active members in the agricultural unit. There were no sociological constraints in relation with fonio production in the sites. The results of the study offered the opportunity to develop strategies for the promotion of this cereal, well known for its multiples virtues and, in the frame of poverty alleviation in Northwestern Benin.

Keywords: Neglected crops, cereals, production, fonio, Benin.

Introduction

In many production regions or zones, fonio is considered as a marginal crop because of its very low yield (Jideani, 1990; Vodouhè *et al*., 2003; MAEP, 2010; Paraiso *et al*., 2011). Fonio yield is generally quite low and, depending on countries, varies between 200 and 900 kg/ha on average (Afio and Vodouhè, 1998). For this reason, fonio appears as a neglected cereal in many countries like Togo where, depending on the tonnage produced, it ranks last in food crops ranking (Dantsey, 1998). Nevertheless fonio is a well-known and appreciated crop by certain ethnic groups in the Plateaux, Kara and Savanna regions. That's why relatively important acreages are cultivated every year (Hadyatou, 1998). In Côte d'Ivoire too, producers give to this speculation non-negligible acreages that can reach 11.200 ha (AISA, 1991).

In the current context of hunger control through food self-sufficiency and diversification of farm productions, fonio is experiencing in several counties a renewed interest because of its eating qualities, its therapeutic virtues and its low ecological requirements (Jideani, 1999; Besançon, 2000; Vodouhè *et al*., 2003; Adoukonou-Sagbadja *et al*., 2006; Paraiso *et al*., 2011, Ballogoun, 2013). Because of its low glycemic index, fonio is proposed in the treatment of diabetes (Besançon, 2000). Thus, in Guinea and in many other African countries, fonio has become a quite well promoted crop.

In Benin, the Commune of Boukoumbé in the northwest of the country supplies alone more than 74% of the national production because fonio has a socio-cultural importance for the Otamari people, the predominant ethnic group in the region (Dramé and Cruz, 2002; Ballogoun, 2013). The other producing communes are: Cobly, Toucoutounan, Tanguiéta and Natitingou (MAEP, 2010). This region is characterized by a high level of poverty. In fact, the departments of Borgou, Alibori, Atacora and Donga are among the poorest zones in Benin with a human poverty index (HPI) higher than forty per cent (HPI > 40 %) (UNDP, 2008).

Available statistics show that, production as well as cultivated areas for fonio in this region are very small for a long time. In Boukoumbé, the production has decreased from 2700 Tons (T) in 1987 to nearly 1500 T in 1996 (Dossou-Yovo, 1998) i.e. a decrease of 44.44%. During the same period, cultivated areas have experienced a decrease of 28.57% (Dossou-Yovo, 1998). Moreover, only 38.98 tons of fonio were cultivated in Benin in 2006 and, the national production of fonio in Benin is not stable and varied from 4164 tons in 1991 to 947 tons in 2010 (MAEP, 2010).

The cultivated areas per capita in the production zones in Benin are very small, on average 0.64 ha for an average yield of 528 kg/ha, lower than the average yield (611.1 kg/ha) of the crop in Benin in 2010 (FAO, 2012; Ballogou, 2013).

Taking into account the profitability of fonio production that, according to USAID (2008), presents a net margin of 88 000 CFA F per hectare (ha) in Senegal, a promotion of this speculation would be, more than an asset, a specific aspect of poverty reduction policies, sectors promotion and farm productions diversification in the region.

Despite the little attention given to it and the constraints of its cultivation in Benin, fonio production appears as a profitable economic activity (Paraiso *et al*., 2011). It is in a perspective of fonio production promotion that this study aims at analyzing the determinants.

Materials and Methods

Study zones

Data used for analyses were collected from fonio producers in northwest Benin and more precisely in Atacora Department (Figure 1). In this zone, the following five (05) Communes were selected: Natitingou, Boukoumbé, Tanguiéta, Cobly and Toucoutouna.

Commune of Natitingou

Located at 421 meters altitude, the geographical coordinates of the city of Natitingou are 10° 18' 46" latitude north and 1° 23' 19" longitude east. Natitingou is located in the center of Atacora Department. It covers a surface area of 3,045 km^2, representing 12.8% of the total surface area of the Department (Afrique Conseil, 2006a). It is limited in the North by the Commune of Toucountouna, in the South and in the East by the Commune of Kouandé and in the West by that of Boukoumbé. The landscape of the commune of Natitingou, characteristic of the range of Atacora, is a rugged one. The climate is a Sudano-Guinean type, nuanced by the landscape of Atacora with two clearly distinct seasons: a rainy season from mid-April to mid-October, and a dry season that covers the period of mid-October to mid-April.

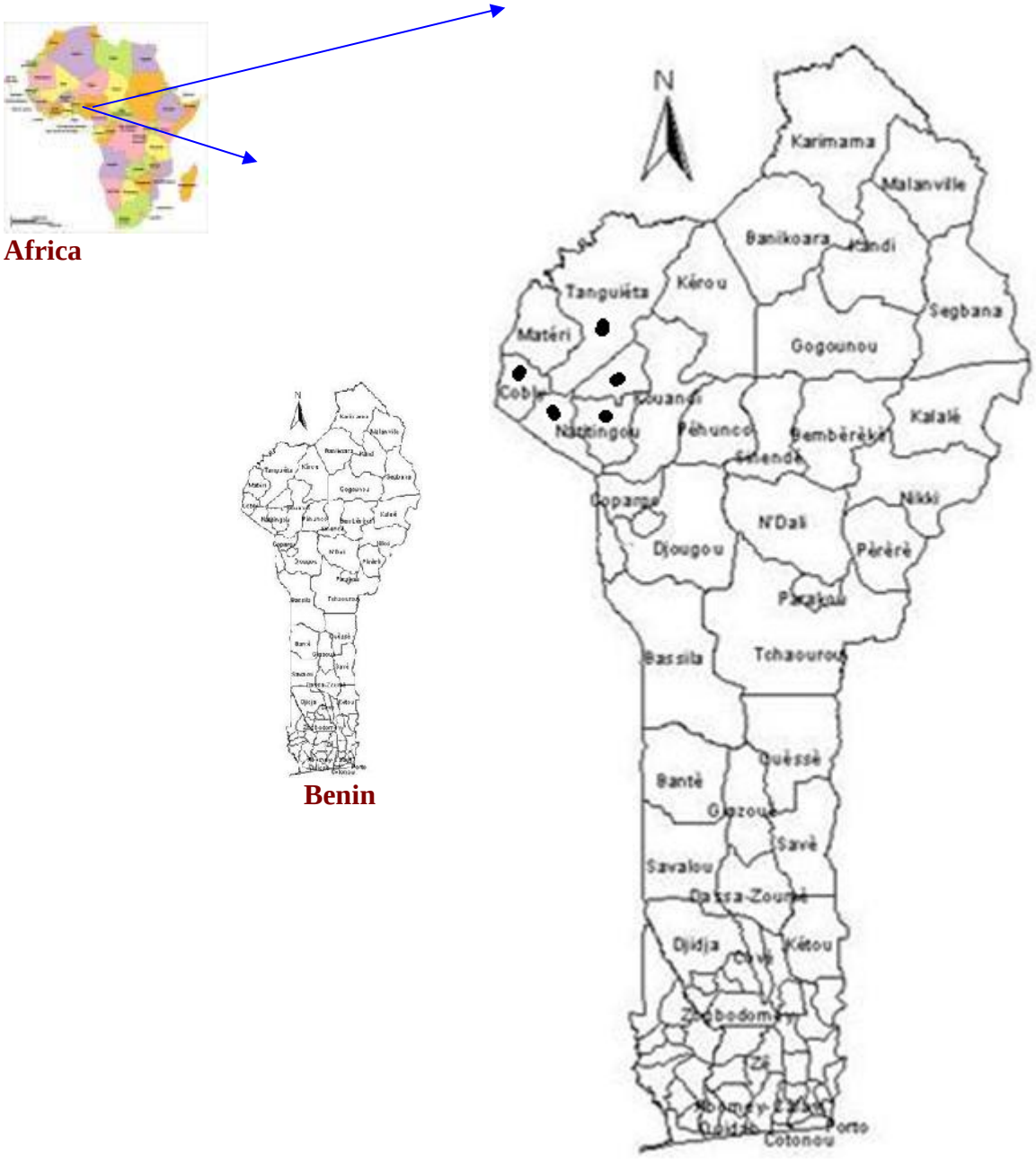

Figure 1: Study zones

Commune of Boukoumbé

It is located in the North-West of the Atacora Department. Its geographical coordinates are between 10° and 10°40' latitude north and 0°75' and 1°30' longitude east. Boukoumbé is in the Sudanian zone. It is limited in the North-East by the Commune of Tanguiéta, in the North-West by that of Cobly, in the South and in the East by the Communes of Natitingou and Toucountouna and in the West by the Republic of Togo (Afrique conseil, 2006b). The climate is Sudano-Guinean type and is characterized by a rainy season from April to October and a dry season from November to March.

Commune of Tanguiéta

Located at 234 meters altitude, the geographical coordinates of the Commune of Tanguiéta are 10° 37' 0" latitude north and 1° 16' 0" longitude east. It covers a surface area of 5,456 km² and is in the Department of Atacora (Afrique Conseil, 2006c). The Commune

of Tanguiéta is surrounded by hills and the Range of Atacora and is limited in the North by the Pendjari Park, in the South by the Communes of Toucountouna and Boukoumbé, in the West by the Communes of Matéri and Cobly, in the East by the Communes of Toucountouna, Kérou and Kouandé. The climate of the Commune of Tanguiéta is a Sudano-Sahelian type with a rainy season from May to November and a dry season from November to May.

Commune of Cobly.

The Commune of Cobly is located in Northwest Benin, in Atacora Department and is limited in the North by the Commune of Matéri, in the South by the Commune of Boukoumbé, in the East by the Commune of Tanguiéta and in the West by the Republic of Togo (Afrique Conseil, 2006d). It covers a surface area of about 825 km^2. It has a Sudano-Guinean climate type with a rainy season from May to October and a dry season from November to April.

Commune of Toukoutouna

Located in Northwest Benin, the Commune of Toucountouna is between the 10^{th} and 12^{th} parallels north and is limited in the South by the Commune of Natitingou, in the North by the Commune of Tanguiéta, in the South-West by the Commune of Boukoumbé and in the East by the Commune of Kouandé (Afrique Conseil, 2006). The quite wet climate (1230 mm per year) of the Commune of Toucountouna is part of the greater Sudanian climatic zone of the semi-arid type of Northern Benin. But it is precisely in the uni-modal rainy system as humid tropical climate of Atakora style.

Data collection

The study observation units are heads of agricultural exploitations (a head of exploitation being a fonio producer, with or without dependent children and having an agricultural exploitation) in the selected Communes with priority given to current fonio producers. In the five (05) Communes selected for the study, a total of two hundred (200) heads of exploitations were selected using a purposive and random selection. The purposive sampling consisted in identifying in each village all current fonio producers and choosing them systematically. In certain villages, the number of fonio producers being very low, their number was completed by a random selection of producers in order to reach the size of 200 producers previously fixed for the sample.

An individual questionnaire was used to collect the major socio-demographic characteristics of the producers. Semi-structures and focus group interviews were organized in order to understand the role of fonio in the visited zones. Finally, direct and indirect observations, then triangulation of information were used to ensure the accuracy of collected information.

Data processing

The qualitative analysis of data was done using descriptive statistics (frequency tables, means and standard deviations), Chi-square tests (χ^2) and means comparison and logistics regressions. The statistical software SPSS Version 16 was used to this effect. Moreover, the content analysis was also used to explore qualitative data such as stories and points of views of the surveyed people. The content analysis is an interpretation effort which balances between two poles on the one hand, the rigor of the objectivity and, on the other hand, the richness and the subjectivity (Bardin, 1977). As proposed by Wanlin (2007), the content analysis is organized around three chronological phases that are: pre-analysis, material exploitation as well as results treatment and finally inference and interpretation.

Specification of the regression model

Based on the hypothesis that the choice or decision of producer is to cultivate fonio – noted Y – is influenced by j socio-demographic and economic characteristics – noted Z – of the producer is the simple relationship:

$$Y_i = F(Z_i) \quad [1]$$

By transforming this equation into an econometric formulation, we obtain:

$$Y_i = \alpha_0 + \sum_j \alpha_j Z_{ij} + e_i \quad [2]$$

In practice, to appreciate the determinants of producers' choice to produce fonio, a logistic regression model was estimated. This is a LOGIT model. In fact, this model is the most used in adoption decision studies involving multiple choices (Hassan, 2008). Table 1 presents the variables introduced in the different models.

Table 1: Codes and modalities of the variables in the regression model

Variables name	Code	Nature	Modalities	Expected Signs
Commune	COMM	Discontinuous	Natitingou= 1; Boukombe=2; Tanguieta=3; Cobbly=4; Toucoutouna=5	±
Ethnic group	ETHNI	Discontinuous	Ditamari=1; Lamba=2; Natimba=3; M'Berme=4; Wama=5	±
Age	AGE	Discontinuous	0 = Lower than 40 years 1= Higher than 40 years	±
Sex	SEX	Discontinuous	0= Female 1= Male	
Marital status	SMAT	Discontinuous	Single = 0; Married = 1	±
Level of education	NSCO	Discontinuous	No= 0; Yes = 1	+
Literacy level	NALP	Discontinuous	Non= 0; Yes = 1	+
Household size	TAILL	Continuous	-	±
Number of farm assets	ACTIF	Continuous	-	+
Main activity	ACTIV	Discontinuous	Other than agriculture= 0 ; Agriculture=1	±

Therefore, the model is as follows:

$$Y = \alpha_0 + \alpha_1 COMM + \alpha_2 ETHNI + \alpha_3 AGE + \alpha_4 SEX + \alpha_5 SMAT + \alpha_6 NSCO + \alpha_7 NALP + \alpha_8 TAILL + \alpha_9 ACTIF + \alpha_{10} ACTIV + e_i \quad [3]$$

Where Y the variable to be explained; e_i the error term; α_0 the constant term; α_i parameters to be estimated. Since explanatory variables such as the Commune and the Ethnic group are not dichotomous qualitative mute variables, the software will treat each of their modalities as it is and calculate the coefficients. However, to make the results simple to read, each of these modalities has been considered as a variable and has been introduced in the regression model.

Results and discussion

Descriptive statistics of variables introduced in the regression model

Table 2 presents the descriptive statistics of the different variables introduced in the regression model.

Table 2: Socio-demographic characteristics of the surveyed people

Variables	Modalities	Number (%)
Commune	Natitingou	11 (5.5)
	Boukoumbe	84 (42)
	Tanguieta	28 (14)
	Cobbly	59 (29.5)
	Toucoutouna	18 (9)
Ethnic group	Ditamari	68 (34)
	Lamba	11 (5.5)
	Natimba	27 (13.5)
	M'Berme	74 (77)
	Wama	20 (10)
Age	Lower than 40 years	118 (59)
	Higher than 40 years	82 (41)
Sex	Male	192 (96)
	Female	8 (4)
Marital status	Single	10 (5)
	Married	190 (95)
Level of education	Educated	57 (28.5)
	Non-educated	143 (71.5)
Literacy level	Literate	35 (17.5)
	Illiterate	165 (82.5)
Main activity	Agriculture	197 (98.5)
	Other than agriculture	3 (1.5)

NB: Figures between brackets represent the total percentage of the surveyed people. Source: Survey data, 2011

Table 2 shows that Boukoumbé is the zone with the highest number of surveyed producers. In fact, Boukoumbé is the main fonio producing area in Benin. The surveyed people belong to five ethnic groups and most of them are men. Our results tally with the observations of some authors that show that, the commune of Boukoumbé alone supplies more than 74% of the national production on the one hand, and on the other hand, fonio cultivation in this region has a socio-cultural importance for the major ethnic group of the region (Dramé and Cruz, 2002; MAEP, 2010).

Fonio production in the study zone is an exclusively male activity. Moreover, most surveyed people are married and over 40 years old. These results tally with the observations of Ballogoun, (2013) in relation with fonio production in the same study zones.

With regard to formal education, more than half of the surveyed people have never been to school. Literacy rate is still lower since only 17.5% of the surveyed people are literate against 28.5% educated people. Agriculture remains the main activity in the study zone. These results agree with those of (Paraïso *et al*. 2012a; 2012b), relating to beekeeping activities in the same region.

In addition to these main descriptive variables, it should be noted that the average size of the households varied between 01 and 23, with a mean of 8 ± 4 people. As to the number of farm assets, it varied from 01 to 20 assets with a mean of 6± 3 assets per producer.

Determinants of fonio production

Variables introduced in the regression model explained 33.6% to 51.1% of the variations observed in producers' choice to grow fonio. Non-explained variations such as climatic conditions, level of prosperity of the households, etc., were attributed to factors hardly measurable and therefore were not introduced in this model. Moreover, the model was globally significant to the probability threshold of 1%.

Table 3: Results of the regression model

Variables	Coefficient	Significance
COMM *(Natitingou)*	-0.460	0.981
COMM *(Boukombe)*	-1.902	0.999
COMM *(Tanguieta)*	-23.,256	0.973
COMM *(Cobbly)*	17,946	0.984
ETHNI *(Ditamari)*	21.697	0.925
ETHNI *(Lamba)*	23.468	0.569
ETHNI *(Natimba)*	45.686	0.799
ETHNI *(M'Berme)*	1.606	0.922
AGE	-1.,479	0.006*
SEX	-1.383	0.198
SMAT	-0.529	0.727
NSCO	1.864	0.003*
NALP	-0.893	0.235
TAILL	-0.644	0.161
ACTIF	0.862	0.080***
ACTIV	-20.686	0.959
Constant	-41.890	0.999
Summary of the Model	R^2 de Cox et Snell=0.336; R^2 de Nagelkerke=0.511; p=0.000	

* Value significant at 1%; ** Value significant at 5%; *** Value significant at 10%

Source: Survey data, 2011

Caption: SMAT: Marital status; NSCO: Non-educated; NALP: Illiterate; ACTIF: Household size; ACTIV: main activities

The results obtained revealed that factors unique to producers have played a key role in their choice to produce fonio. In fact, among the variables introduced in the regression model, only the age, the level of education and the number of farms assets have had significant effects on the choice of producers to grow fonio in the study zone.

Six (06) factors remain crucial in the adoption of a technology as in the specific case of implementing a package or actions to promote agriculture. These adoption factors are: the complexity of the technology; the initial indispensable investment; the net profit expected; the possibility to access the necessary inputs and credit facilities; the risks related to the adoption of the technology and the possibilities to integrate the technology into the sociocultural pattern of the producer (Acakpo, 2004; Yabi, 2009). It emerges from this typology that the choice to produce fonio is mainly influenced by factors unique to the individual. In fact, among the variables introduced in the regression model, only the age, the education level and number of farm assets are the main determinants of the choice of the surveyed people to produce or not fonio in the study zones. The age of the surveyed person has had a negative and significant effect at 1% on his/her choice to grow or not fonio. This means, the younger producers are, the more they avoid producing fonio. This can be explained by the fact that fonio production activity is very time-consuming and labor-intensive. For young people, it is more profitable to devote one's labor power to a less labor-intensive speculation other than fonio. These results tally with the observations on the significant decrease in fonio production, a phenomenon in relationship with the decrease in cultivated areas in favor of other cereals, mainly maize, that is easier to cultivate and gives higher yields. Thus, it was noted that the cultivated acreages per capita in the study zone are very small, and the average yield lower than the mean in Benin in 2010 (FAO, 2012; Ballogoun, 2013).

Moreover, fonio production and post-harvest operations are very tedious and labor-intensive, labor force being increasingly scarce because of massive rural-urban migration in the production zones in Togo, Senegal and Benin (Adoukonou-Sagbadja *et al*. 2006; USAID, 2008; Ballogoun, 2013).

Unlike age, education level had a positive and significant effect at the probability threshold of 1% on the choice of producers to grow fonio. In fact, the more advanced producers' education level was, the higher the trend to produce fonio was. Somehow or other, education allowed producers to have access to information more easily. It is undoubtedly one of the advantages of fonio cultivation. The level of education is of paramount importance in terms of adoption or decision making. It determines clearly producers' choice instead of influencing the use of improved rice varieties in the Communes of Dassa-Zoume and Glazoué in the Center of Benin (Midingoyi, 2003).

The number of farm assets has a positive and significant effect at the probability threshold of 10% on one's choice to cultivate or not fonio. In fact, the higher the number of farm assets was, the more likely producers were to grow fonio. This observation confirms that fonio seems to be a labor-intensive activity. Thus, the more farm assets the household has and therefore labor, the more it can use that labor to produce fonio. Therefore, by using that labor to produce fonio, the household expects to diversify available food and thereby improve its food security. These results tally with the observations of (Adoukonou-Sagbadja *et al*. 2006; USAID, 2008; Ballogoun, 2013), which stipulate that fonio production and post-harvest operations are tedious and labor-intensive in the study zone and elsewhere in Africa. Variables such as the Commune, the ethnic group, the sex, marital status, the level of education, the size of the household and the main activity have not influenced significantly the choice of producers to cultivate fonio. The non-significant effect of the Commune can be explained by the fact that all the Communes selected for the survey were, although at various levels, fonio producing areas. Moreover, the activity does not have any social prohibition. In fact, fonio production, processing or consumption is not subject to any cultural restriction. Like previous variables, the level of education does not have a significant effect on the choice of fonio production. This could be attributable to the fact that very few producers being literate, they choose randomly to produce or not fonio.

CIMMYT (1993) cited by Honlonkou (1999) has categorized factors susceptible to determine the adoption of a technology by producers into:

- factors unique to producers: producer's level of education, his/her experience in agriculture, his/her age, his/her gender, his/her level of wealth, the size of his/her farm;
- factors related to the technology including economic and food functions of the product, the complexity of the technology, the relative cost of the innovation compared to substitute innovations;
- institutional factors that include access to credits, land tenure, availability of and accessibility to products and factors markets, availability and quality of information on technologies and the development of para and extra farm activities;

- factors related to the characteristics of the plot that include the nature of the soil, its fertility level before the adoption of the technology, the types of weeds and the climate.

The determinants of fonio production are not always identical to those of other speculations production. In the Commune of Gogounou in North-East Benin, producers' choice to grow sweet potato is mainly determined by the number of dependent people, the level of education and having an income generating activity (Paraïso *et al*, (2012c). In this case, the level of education is a determinant of the production of both speculations. Nevertheless, the divergence of factors determining the choice of these two activities creates a difference between their possible promotion strategies. These results tally with the observations made on food crops such as maize and rice (Yabi, 2009; Yegbemey, 2010). However, these results do not agree with those obtained on beekeeping or honey hunting in the same study regions. In fact, for honey hunting as well as for modern beekeeping, the age, marital status, the status in the household, religion, the level of education, experience with migration, the number of dependent people, the number of active women and children and access to credit do not have significant effects on the choice of honey exploitation forms by the producers (Paraïso *et al*. 2012d).

In the light of all the aforementioned, any fonio cultivation promotion policy in the study regions should take into account the importance of the education of the population and their literacy on the one hand and, on the other hand, promoting small mechanization in order to remedy the acute shortage of farm labor and, finally identifying major constraints to the production of this neglected but important cereal.

Conclusion

The age, the level of education and the number of farm assets are the main determinants of producers' choice to grow fonio in Northwest Benin. There is no sociocultural limitation to fonio promotion and production in this part of the country. Moreover, the determinants of fonio production are not always identical to those of other speculations. For this reason, this speculation should have a specific plan of promotion.

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