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Characterization of the Production System of Tiger Nuts Nutritionals Tubers Cultivated and Marketed in Benin

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Abstract: Nutsedge is a neglected perennial plant whose roots produce tuberous seeds with high nutritional potential. The valuation of this species requires knowledge of the national availability. This study aims to assess the availability and production systems of tiger nuts in the face of food insecurity in Benin. A survey was done conducted in the 7 agricultural development centers of Benin using a GPS to locate the production areas for tiger nut tubers and a survey sheet has been administered to producers. The resultats show that 5 poles out of 7 practice the cultivation of tiger nut in Benin. Pole 3 is the leading producer of tiger nut with a rate of 54.13% followed by poles 4, 5, 1 and 2 with 15.60%, 15.60%, 11.93%, 11% respectively. The quantity of tiger nut grown in Benin is estimated in 2019 at 25,170 kg over 80.85 ha. Of the cultivated varieties, the yellow varieties are predominant and are oriented towards external markets. The tiger nut agricultural calendar is July to August. Land clearing consists of clearing the ground, grubbing up and destroying previous crops. In order to break dormancy, tiger nut tubers from old harvests are immersed in water for 3 days and then sown. Producers use the tubers harvested in previous campaigns as seed for future campaigns. The cultivation of tiger nut is done by producers manually without the assistance of mechanical machinery or animal traction. Growers grow nutsedge alone or in combination with other crops. The main reasons for the association of tiger nut and okra cultivation are: the lack of land and the search for shade during the harvest. When spreading, 8 bags are used on average per hectare. In the municipalities of Boukoumbé, Matéri, Ouèssè, Ouinhi, Tanguiéta and Toucountouna, the use of manure is the only type of fertilizer used. In addition, the combination of fertilizers during spreading is provided by a few producers living in other municipalities, namely: Cobly, Kérou, Malanville, Savè, and Dassa-Zounmè. The types of manure that producers use when spreading with mineral fertilizers (Urea and NPK). Thus all producers in all municipalities make use of cow purse, plant debris and poultry droppings. As for the effects of climatic factors, they have a favorable impact on the yield of tiger nut. The survey revealed very low availability of tiger nut and production systems are rudimentary and subject to considerable production constraints.

Keywords: Nutsedge Tubers, Production Constraints, Agricultural Development Poles of Benin

1. Introduction

The fight against poverty and food insecurity in developing countries is today a concern of the international community. The climatic disturbances of recent decades, aggravated by soil degradation, compromise food crop production, which is essentially based on rainfed cultivation. This situation leads people to a situation of recurrent and growing vulnerability [1]. National strategies for improving food security are now guided by the use of varieties adapted

to climatic constraints, by the diversification of crops and the development of secondary crops. Thus, crops such as fonio, maize, onion, sesame, sugar cane, sorrel and Nutsedge provide income support for producers of millet, sorghum, cowpea, etc., Benin's flagship products. Yellow nutsedge (*Cyperus esculenstus*) is a weed plant that produces tubers whose nutritional value is comparable to cassava tubers [2], sweet potatoes [3, 4], yam [5]. In addition, this plant has a fatty acid profile comparable to the oils usually encountered, namely: Olive [6], Avocado [7], Peanuts [8], Rice bran [9], Maize [8]. In Benin, tiger nut production is estimated respectively in the communes of Boukoumbé at 38 tonnes for an area of 71 ha at the end of the 2002-2003 season; Matéri, in the north of the country, to 11 tonnes over an area of 19 ha [10]. Despite these nutritional characteristics, which should represent an excellent point of support for the development of the species and induce high production, it is noted that the Beninese government is not developing programs to revitalize the sector. In view of this observation, it is urgent to study the entire production system of this species in order to identify the production constraints and to think about its revitalization. It is in this context that this work specifically aims to characterize the production systems of tiger nut tuber As grown and marketed in Benin by evaluating the level of production and cultivation techniques of tiger nut in Benin.

2. Material and Methods

2.1. Study Framework

The investigations were conducted throughout Benin through the 7 agricultural development poles.

2.2. Data Collection Methods and Tools

2.2.1. Plant Material

The plant material consists of edible nutsedge tubers cultivars that we have used de help populations to quickly recognised the speculation.

2.2.2. Data Collection Equipment

The survey is carried out in the 7 agricultural development centers in order to diagnose the tiger nut production systems. The equipment used for the survey is a GPS to locate the production areas and the survey sheets to be administered to the respondents.

2.3. Methodology

During this survey, the size of the sample, i.e. the total number of producers to be surveyed for the agricultural survey in the producer poles, was determined using the normal approximation of the binomial distribution proposed by [11]:

$$N = \frac{p(1-p)(U_{1-\alpha/2})^2}{d^2}$$

with:

p: The proportion of households that cultivate tiger nuts in the study area. It will be calculated using data from the last general population and housing census [12].

$U_{1-\alpha/2}$ = 1,96: La valeur de la variable aléatoire normale pour un risque α égal à 0,05.

d^2: The maximum admissible error fixed between 1% ≤ d ≤ 15%. The margin of error of estimation to be retained for this study is 5%.

Thus, 218 heads of tiger nut-producing households will be surveyed for this study. The number of people surveyed per commune will be determined by multiplying the percentage of heads of tiger nut-producing households in each commune by N. This percentage of heads of tiger nut-producing households per commune was calculated using the formula below used by [13]:

$$\%\ Heads\ of\ Tiger\ nut\ Producer\ Households = \frac{NTPHHM}{TNHTPHAM}$$

NTPHHM = Number of nutsedge tubers Producing Household Heads per Municipality

TNHTPHAM = Total Number of Heads of nutsedge tubers Producing Households in All the Municipalities selected.

Thus, on the basis of this formula, 5 heads of Nutsedge tubers-producing households will be surveyed in Tanguiéta, 42 in Cobly; 61 in Boukoumbe; 26 in Malanville; 24 in Kerou; 5 to Materi; 5 in Toucountouna; 12 in Dassa; 12 in Save; 10 in Ouesse; 16 in Ouinhi. By municipality, reasoned sampling will be adopted to select the districts and villages with high, medium and low tiger nut production. The choice of study villages will also be based on their representativeness (importance of heads of tiger nut-producing households), farming techniques, accessibility to localities, open-mindedness of producers to collaborate with the research team and the socio-cultural group present. At the level of each village, heads of tiger nut-producing households will be randomly selected. Initially, an exploratory study was conducted in the study area in order to have an overview of the farming practices of tiger nut production. This is followed by an agricultural survey (in-depth study) using a semi-structured questionnaire to collect quantitative and qualitative information from heads of tiger nut-producing households. The data to be collected relate to: (i)- Socio-economic characteristics of tiger nut producers; (ii) biophysical indicators, types of soil recognized by socio-cultural groups, the importance of tiger nut in the production of food crops, criteria for choosing new land for yam cultivation; (iii)- to peasant cultivation practices of tiger nut in the face of environmental problems (types of soil and cultivation areas, main speculations practiced, methods of soil preparation, periods of planting or sowing, periodicity of field maintenance, methods of managing the fertility of the soils, cropping associations, cropping history, pest management, yields, revenue from tiger nut production); (iv)- the perceptions of producers (different target groups) on pedoclimatic and agronomic factors and the intrinsic qualities of tiger nut major to its good productivity in their environment and to the constraints linked to the sustainability of these innovative practices and improvement approaches.

Participant observations through transects will be organized with representative groups.

2.4. Statistical Analyzes

Après codage, les données recueillies sont analysées à l'aide du logiciel SPSS (Statistical Package for the Social Sciences) version 16.0 pour déterminer des statistiques descriptives en termes de pourcentage et de moyenne. Ces données quantitatives sont ensuite soumises à une analyse de variance (ANOVA) en utilisant la procédure PROC GLM du logiciel SAS (Statistical Analysis System) version 9.2. Des comparaisons de moyennes multiples sont faites avec le test de Student Newman-Keuls [14].

3. Results

3.1. Sociodemographic Characteristics of the Study Population

Gender composition of the study population by municipality.

Table 1 provides information on the gender balance of tiger nut producers in Benin, all municipalities combined.

Table 1. *Summary of respondents according to Age * Sex * Municipality.*

Municipality			Sex		Total
			Male	Female	
Boukoumbé	Age	<15	26	3	29
		15-29	23	0	23
		30-44	7	2	9
	Total		56	5	61
Cobly	Age	<15	11	2	13
		15-29	17	6	23
		30-44	3	3	6
	Total		31	11	42
Dassa-Zounmè	Age	<15	4	2	6
		15-29	5	1	6
	Total		9	3	12
kérou	Age	<15	10	3	13
		15-29	6	2	8
		30-44	2	1	3
	Total		18	6	24
Malanville	Age	<15	7	4	11
		15-29	13	2	15
	Total		20	6	26
Matéri	Age	15-29	4	1	5
	Total		4	1	5
Ouèssè	Age	<15	3	1	4
		15-29	3	1	4
		30-44	0	2	2
	Total		6	4	10
Ouinhi	Age	<15	7	0	7
		15-29	8	0	8
		30-44	1	0	1
	Total		16	0	16
Savè	Age	<15	3	2	5
		15-29	6	0	6
		30-44	1	0	1
	Total		10	2	12
Tanguiéta	Age	15-29	4	1	5
	Total		4	1	5
Toucountouna	Age	15-29	5	0	5
	Total		5	0	5
Total	Age	<15	76	17	93
		15-29	89	14	103
		30-44	14	8	22
	Total		179	39	218

Through Table 1, we see that the production of tiger nut is an activity carried out largely by men. In the commune of Boukoumbé, of the 61 heads of households surveyed, 56 are men and 5 women. Of the households surveyed in the said commune, 29 have members under the age of 15, 23 in the 15-29 age group and 9 between 30-44 years old. The commune of Cobly is full of 42 surveyed households, of which 31 households are managed by men and 11 by women. The 42 households are divided into age groups, of which 13 have members under the age of 15, 23 in the 15-29 age group and 6 aged 30-44. In the commune of Dassa-Zounmè, 12 heads of households were questioned. A third of households are headed by women. Household members are divided equally 6 between two age groups less than 15 years and 15-29 years. The commune of Kérou has 18 male household heads and 6 female household heads. These households include members belonging to three age groups: 13 for members under 15, 8 for the 15-29 age group and 3 for the 30-44 age group. In the commune of Malanville, the 26 households surveyed are divided into 11 with members under the age of 15 and 15 in the 15-29 age group. The 26 heads of household are made up of 20 men and 6 women. In the commune of Matéri, the 5 heads of household who were taken into account for the survey belong to the age group of 15-29 years. The role of head of household is provided by both men and women, namely 4 men and 1 woman. The commune of Ouèssè is home to 10 heads of producer households surveyed whose members are distributed according to age as follows: 4 are at the head of households with members under 15 years old, 4 others lead members of 15-29 years old and 2 whose members are over 30 years old. In this commune, all the households surveyed are headed by women. As for the commune of Ouinhi, of the households surveyed, 7 house members under the age of 15, 8 house members whose age group is between 15 and 29 years and 1 household has 1 member over 30 years of age. All household heads are men. In Savè, 12 households are surveyed whose heads of households have members respectively of 5 under 15 years old, 6 between 15-29 years old and 1 over 30 years old. In all of these households, 10 are male and 2 are female. Of the heads of households surveyed, 10 are men and 2 are women. In Tanguiéta and Toucountouna respectively 5 heads of households are taken into account. All the members belong to the age group of 15-29 years old. In these 2 communes, namely Tanguiéta and Toucountouna, respectively 4 and 5 heads of households are men, while the only female head of household is in Tanguiéta.

3.2. Sociolinguistic Groups

The sociolinguistic groups of tiger nut producers vary from one region to another (Table 2).

Table 2. *Sociolinguistic groups.*

		Sociolinguistic groups								Total
		Gua ou Otamari	Mahi	Idaacha	Nago ou Yoruba	M'bèrèmè	Ditammari	Bêtammaribé	Waama	
Commune	Boukoumbé	60	0	1	0	0	0	0	0	61
	Cobly	6	0	0	0	1	18	17	0	42
	Dassa-Zounmè	1	4	4	3	0	0	0	0	12
	kérou	24	0	0	0	0	0	0	0	24
	Malanville	26	0	0	0	0	0	0	0	26
	Matéri	5	0	0	0	0	0	0	0	5
	Ouèssè	0	10	0	0	0	0	0	0	10
	Ouinhi	0	16	0	0	0	0	0	0	16
	Savè	1	0	0	11	0	0	0	0	12
	Tanguiéta	1	0	0	0	0	4	0	0	5
	Toucountouna	0	0	0	0	0	0	0	5	5
Total		124	30	5	14	1	22	17	5	218

Table 2 provides information by municipality on the distribution of producers according to sociolinguistic groups. It can be seen that, in general, out of the 218 producers surveyed, 124 are Gua or Otamari, 30 are Mahi, 5 are Idaacha, 14 are Nago, 1 is M'bèrèmè, 22 are Ditammari, 17 are Bêtammaribê and 5 are Waama.

3.3. Nutsedge Production Level

Benin is subdivided into 7 Agricultural Development Agencies. The culture of the tiger nut is represented in poles 1, 2, 3, 4 and 5 (Figures 1 & 2).

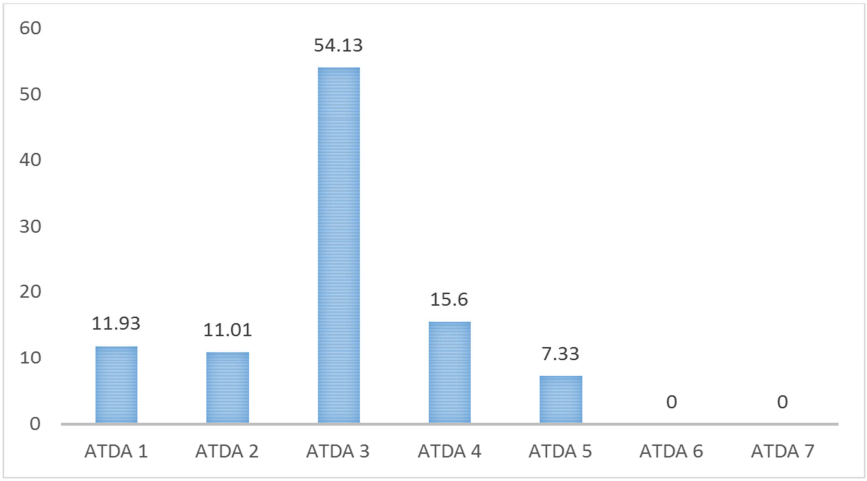


Figure 1. *Production of tiger nut per ATDA.*

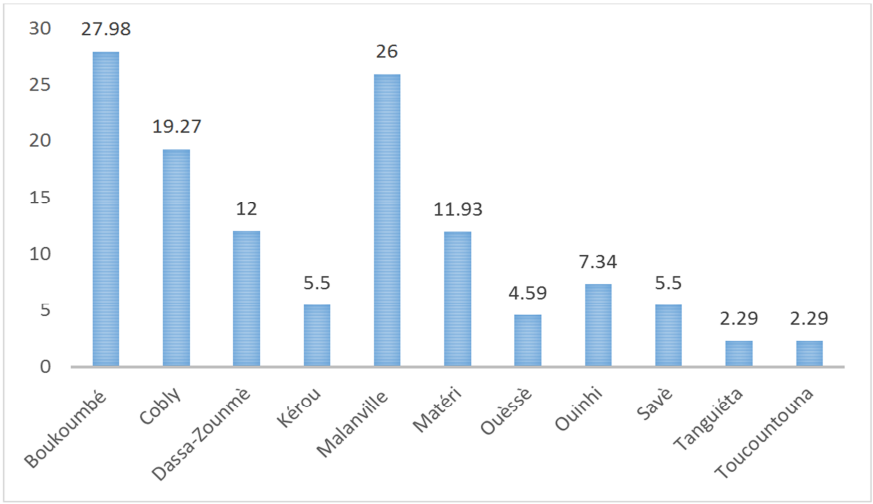


Figure 2. *Production of tiger nut per municipality.*

Pole 1, made up of the municipalities of Karimama and Malanville, includes 26 respondents, or 11.93% of all respondents. Pole 2, represented by the commune of Kérou, is home to 24 producers of the 218 producers surveyed throughout Benin. Thus, 11% of tiger nut producers are found in the commune of Kérou. Pole 3, represented by the communes of Boukoumbé, Cobly, Kérou, Matéri, Tanguiéta, Toucountouna, is full of 100 producers among the 218 producers surveyed throughout Benin. Thus, 54.13% of tiger nut producers are found in this agency. Tiger nut cultivation is carried out in pole 4 by a sample of 34 producers distributed in the communes of Savè, Dassa-Zoumé, Tchaourou surveyed among the 218 producers surveyed throughout Benin. Thus, 15.60% of tiger nut producers are found in this agency. As for pole 5, only the commune of Ouinhi produces yellow nutsedge. In this commune, 34 producers distributed in the communes of Savè, Dassa-Zoumé, Tchaourou, were surveyed among the 218 producers surveyed throughout Benin. Thus, 15.60% of tiger nut producers are found in this agency. Furthermore, poles 6 and 7 are not represented in the production of this speculation.

3.4. Nutsedge Tubers Production System

3.4.1. Detail on the Cultivation Systems Based on Tiger Nut in 2019

Table 3 provides information on the sources of funding for tiger nut producers. Thus we see that all tiger nut producers, all municipalities combined, finance the tiger nut crop campaign from their own funds. Through these data, which convey the membership of producers in groups, we see that producers do not depend on any group or peasant organization. Similarly, producers have no contact with extension structures that can best help them improve speculation cultivation techniques. Similarly, producers have no contact with research structures or projects that can best help them improve speculation cultivation techniques. Producers have no contact with Non-Governmental Organizations that can best help them improve speculation cultivation techniques. With regard to the actual cultivation of tiger nuts, producers have contracts with suppliers of agricultural inputs in the context of production, traders and other actors for the sale of tiger nuts at harvest. With regard to tiger nut cultivation land, producers cultivate on local authority land. All the producers had access to the land by inheritance.

Table 3. *Support for tiger nut cultivation.*

	Main source of tiger nut funding [a]	Farmer group or association/ organization	contacts extension structures	Research contacts or projects?	NGO contacts/ exchanges?	contracts with input supplier traders and other actors	Property rights[b]	Modes of land access[c]	Availability of new land[d]	Total areas (in ha) of new land fallow or fallow between 4 and 10 years
N Valid	218	218	218	218	218	218	218	218	218	218
Mean	3,00	0,00	0,00	0,00	0,00	0,00	3,00	2,00	4,00	,00
Mode	3	0	0	0	0	0	3	2	4	0

[a] 1= State subsidy; 2= Micro finance institutions (to be specified); 3= Financing of production with own funds; 4= Loan from a neighbour; 5= Loan from relative.

[b] 1= Individual/personal property, 2= Domain of the State or the Town Hall (areas of forests, savannahs or classified domain); 3= Property of a local authority to be specified; 99= others to be specified.

[c] 1= Occupation/ exploitation without prior authorization of classified forests or public domain; 2= Inheritance; 3= Gift; 4= Loan (temporary use of the domain of others without formal monetary or in-kind compensation, specify in this case who the lender is); 5= Purchase (in this case, specify the cost of selling the plot in local units and per hectare); 6= Rental (in this case, specify the rental cost of the plot in local units and per hectare and the duration per cost), 99=other to be specified.

[d] 1= new fallow or fallow land for abundant tiger nut cultivation, 2= new rare earth; 3= new very rare earth; 4= new fallow or fallow land for 4 to 10 years for tiger nut cultivation in the village non-existent.

Table 4. *Origin of seeds and sowing period.*

		Fréquency	%	% valid	% cumulative
Origin of seeds	Previous campaign	218	100,0	100,0	100,0
Sowing period	July August	218	100,0	100,0	100,0

Across all the municipalities taken into account in this study, producers use the tubers harvested during previous campaigns as seed for the campaigns to follow. The tiger nut agricultural calendar is spread over a quarter. The term starts in July and ends in August. This term is the same in all municipalities. Sowing is done from July to August because it is the rainy period par excellence. The producers unanimously believe that outside this period, the tiger nut could not give a good yield.

3.4.2. Tillage for the Production of Tiger Nuts

Table 5 presents the main cultural operations for the production of tiger nut. Thus, for the cultivation of tiger nut, it is necessary to clean the production land, till the soil, sowing, spreading and maintaining the crop until harvest. Land clearing consists of clearing the ground, grubbing up and destroying previous crops. After plowing, before sowing, the seeds must be treated to ensure a high rate of emergence from dormancy. In order to break dormancy, tiger nut tubers from old harvests

are immersed in water for 3 days and then sown. During sowing, the ridges are made according to the following dimensions: 20 cm high by 20 cm wide and a 20 cm gap must be respected between the plants. The cultivation of tiger nut is done by producers manually without the assistance of mechanical machinery or animal traction. Thus, we see that producers use family labor for the said culture. The main reasons for the association of tiger nut and okra cultivation are: the lack of land and the search for shade during the harvest. These two reasons are the same for all tiger nut producers.

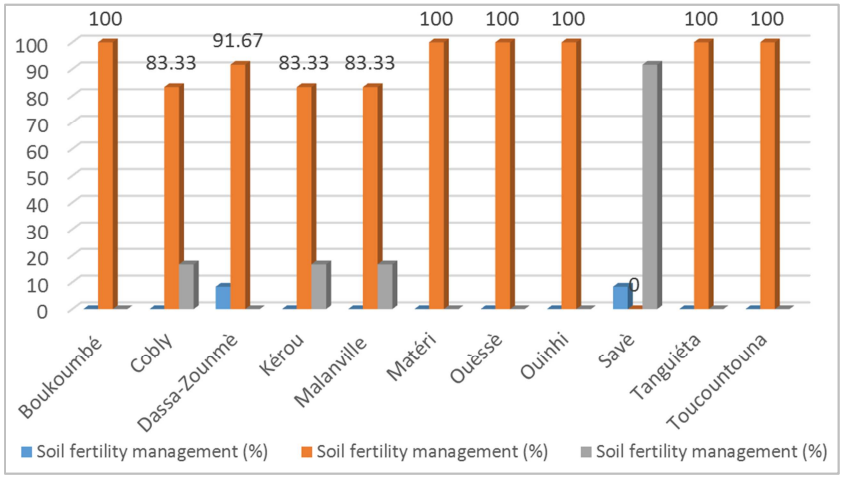
Table 5. *Crop operations and calendars.*

		Fréquency	%	Valid %	Cumulative %
Crop operations and calendars	1; 2; 3; 4; 5; 6; 7; 8; 9; 11; 14; 15[a]	218	100,0	100,0	100,0
Techniques/mode	Manual	218	100,0	100,0	100,0
Type of labor	Family	218	100,0	100,0	100,0
Culture system	Mono + associated	218	100,0	100,0	100,0
Associated crop	Okra	218	100,0	100,0	100,0
Reason for association	1; 2[b]	218	100,0	100,0	100,0

[a] 1= cleaning; 2= Destruction; 3= précédents culturaux; 4= Floor cleaning/preparation; 5= plowing; 6= Treatment of seeds 7= Planting: alignments and sowing; 8= 1st Field weeding 9= weeding; 11= fertilization; 12= Pest management; 13= Disease management; 14= 1st harvest; 15= 2nd harvest

[b] 1= lack of land; 2= seeking shade during harvest

3.4.3. Soil Fertility Management Techniques



F1: Organic manure; F2: mineral manure

Figure 3. *Soil fertility management techniques.*

Figure 3 shows the soil fertility management techniques according to the municipalities. Thus, we see that in the municipalities of Boukoumbé, Matéri, Ouèssè, Ouinhi, Tanguiéta and Toucountouna the use of manure is the only type of fertilizer used. In addition, the combination of fertilizers during spreading is ensured by a few producers living in the other municipalities, namely: Cobly, Kérou, Malanville, Savè, and Dassa-Zounmè. Thus, producers who have organic fertilizer also as a supplement. The organic fertilizers used are of two types. These fertilizers are NPK and urea. But all the producers during organic spreading use a mixture of NPK and urea. During spreading, we see that 8 bags are used on average per hectare.

3.4.4. Effect of Climatic Factors on Tiger Nut Yields

Table 6 presents the effects of climatic factors on the yields of tiger nut. Thus, we see that precipitation, rainy seasons, rains, dry season, temperature, insolation, harmattan and climate have a favorable incident on the yield of tiger nut.

Table 6. *Effect of climatic factors on tiger nut yields.*

	Fréquency	%	Valid %	Cumulative %
Effect of rainfall on nutsedge yield	218	100,0	100,0	100,0
Length of rainy season on nutsedge yields	218	100,0	100,0	100,0
Rainfall distribution on tiger nut yield	218	100,0	100,0	100,0
Duration of the dry season on the yield of tiger nut	218	100,0	100,0	100,0
Température sur rendement du souchet	218	100,0	100,0	100,0
Tiger nut Yield Temperature insulation on tiger nut yield	218	100,0	100,0	100,0
Harmattan on tiger nut yield	218	100,0	100,0	100,0
Climate impact on yield	218	100,0	100,0	100,0

3.4.5. Pest Management

Table 7. *Pest management.*

		Fréquence	%	Valid %	Cumulative %
Types of pests	Termites	218	100,0	100,0	100,0
Organs attacked	Tubers	218	100,0	100,0	100,0
Method of struggle	Harvest early	218	100,0	100,0	100,0

Reading Table 7 helps to understand that the tiger nut is likely to be attacked by pests. These pests are termites. These pests attack nutsedge tubers underground. No termite control method is known to producers, regardless of the municipalities. Thus, the palliative means adopted by all the producers of all the municipalities combined is to harvest the tiger nut tubers just at maturity before the attack of the pests. Because the pests only start attacking the tubers when they are mature.

3.4.6. Marketing and Revenue Management of Tiger Nut Cultivation

Table 8 summarizes information on the marketing and revenue management of tiger nut cultivation.

3.4.7. Marketing and Revenue Management of Tiger Nut Cultivation

Table 8. *Sales period.*

	Methods	%	Valid %	Cumulative %
Période de vente	All year	218	100,0	100,0
Average selling price/local unit	1000 F/paume (≈ 1Kg)	218	100,0	100,0
Number of harvests/cycle	2	218	100,0	100,0
Harvest period	9; 12	218	100,0	100,0
Harvesting methods	Turning the soil	218	100,0	100,0
sales market	2; 5	218	100,0	100,0

1January 1st; 2- February; 3rd of March; 4-April; 5- May; 6- June; 7- July; August 8; 9-September; 10-October; November 11th; 12- December
2- 1 = village market, 2= market in the capital of the commune, 3= regional market for the marketing of agricultural products, 4= direct export to major urban centres, 5= Togo;

Thus, we see that the tiger nut can be marketed all year round. The local unit of sale for tiger nut is the "palm" which is equivalent to 3 kg. The tiger nut harvest is done twice a year. The first harvest is done in September and the second in December. Harvesting tiger nut is tedious and tedious because producers harvest by scraping the ground to dig up the tubers at the end of the root branches. Once the harvest is done, the producers send the harvest to the market. The markets are: the markets of the production villages, the markets of the chief towns of the communes, the regional markets for the marketing of agricultural products, direct export to the major urban centers and Togo.

3.4.8. Nutsedge Production Constraints

Table 9. *Production constraints.*

		Fréquency	%	Valid %	Cumulative %
Valid	1; 2; 3; 4; 5; 6; 7; 8; 9; 10	218	100,0	100,0	100,0

1= Parasite attacks 2= Destruction of young plants by animals; 3= Climatic hazards; 4= Decline in soil fertility; 5= High cost of plantation maintenance; 6= Plantation fires; 7= Saturation of space: lack of cultivable land for tiger nuts; 8= Difficulties in access to fertilizer; 9= Lack of technical supervision; 10= Lack of modern harvesting technique; 11= Lack of investment and significant state subsidy

The constraints encountered during the cultivation of tiger nut are more typical, namely: Parasite attacks, destruction of young plants by animals; climatic hazards; declining soil fertility; the high cost of maintaining the plantations; plantation fires; saturation of space: lack of cultivable land for tiger nuts; difficulties in accessing fertilizer; lack of technical support; the lack of modern harvesting techniques; lack of investment and significant state subsidy (Table 9). These constraints are the same for all tiger nut producers in all municipalities.

4. Discussion

The purpose of this work was to evaluate the availability and the system of tiger nut production in Benin. Indeed, this has assessed the availability and production systems of tiger nut. l'ATDA 3 brings together several tiger nut producing towns, namely: Tanguiéta, Matéri, Cobly, Boukoumbé and Toucountouna with a proportion of 54.13% and thus becomes the leading tiger nut producing cluster in Benin. Of all these municipalities, the 2 best producers are that of Boukoumbé with 57.7% and Cobly with 35.6%. Tiger nut producers for all municipalities combined, the average year of experience is 6.39 years. This average is very low compared to the number of years of experience of Nigerien producers. Indeed, the producers have experience in 5 to more than 70 years in the cultivation of tiger nut. This

information confirms that the cultivation of tiger nut in Niger is old. [15]. Producers who practice tiger nut cultivation have an average of 10 fields for an average area of 5 ha. For the tiger nut crop, the producers finance the work on their own funds and do not benefit from any support from groups, extension structures, research structures, projects or non-governmental organizations. Tiger nut cultivation land is inherited from local communities and is all used so that producers lack land to expand their crops including tiger nut. But the areas vary over the years. In 2018, 6.5% produced 1/8 hectare, 89.9% produced ¼ hectare and 3.2% produced ½ hectare. But these yields are insufficient compared to the work of other authors because the average number of tubers per pot only reaches 10 t after the first month of cultivation, however at the end of the second month, this number has reached 62.1 tubers. per jar. The total number of tubers obtained is about 41772 tubers/m^2 [16].

Whereas [17], in the central Haouz region was only able to obtain 1986 tubers per clone per year. These results seem low compared to 16420 tubercles/m^2 obtained by [18]. In the field and for the species C. esculentus [19] were able to obtain 163004 per clone after 18 months of culture. But in general, the number of tubers per square meter oscillates between 1100 and 8700 [20-22]. Most of the tubers, 98.8%, are found 20 cm deep from the ground [17]. The deepest tubers are the largest. The variety of tiger nut grown in the different municipalities is essentially yellow. These varieties of tiger nut produced in Benin are mainly cultivated mainly produced for reasons of socio-cultural values and oriented towards the market. The tiger nut agricultural calendar is spread over a quarter. The term starts in July and ends in August. This term is the same in all municipalities. These results are in agreement with those of [22-23], who estimate that the growth is maximum in summer and that from September it begins to decrease gradually. According to (1982) [24] the height of the plant can reach one meter in light soils. Sowing is done in July because it is par excellence the rainy period. The producers unanimously believe that outside this period, the tiger nut could not give a good yield. This quarterly period corresponding to the vegetative cycle of yellow nutsedge differs from that of C. rotundus because its flowering begins one month after planting. The full flowering stage is reached after two months, while the maturation of the caryopsis is staggered over the last two months. According to [17], the vegetative growth of the same weed extends from 21 to 28 days after emergence. Flowering initiation started after 28 days. Full flowering is reached between the 28th and 35th day after the emergence of the shoots. In Jamaica the weed is able to flower within 39 days after planting depending on the photoperiod [22]. The maturity of C. rotundus L. is reached 45 days after planting the tubers [25]. The cultivation of tiger nuts requires like all the others cultures of given operations. The main cultural operations for the production of tiger nuts are the cleaning of the production land, the plowing of the soil, the sowing, the spreading and the maintenance of the crop until the harvest. Land clearing consists of clearing the ground, grubbing up and destroying previous crops. After plowing, before sowing, the seeds must be treated to ensure a high rate of emergence from dormancy. In order to break dormancy, tiger nut tubers from old harvests are immersed in water for 3 days and then sown. The tubers used for sowing come from previous harvests. Contrary to this result which shows that the multiplication is done by the tubers, this weed plant multiplies mainly by the vegetative way, the seeds do not play an important role in the multiplication of the species [26-29]. The common result of these authors is justified by the fact that the vegetative apparatus of the tiger nut represents 66% of aerial biomass, while the reproductive apparatus represents only 34%. This means that the vegetative development takes precedence over the development of the reproductive apparatus. The cultivation of tiger nut is done by producers manually without the assistance of mechanical machinery or animal traction. These characteristics of the type of tillage are mandatory in order to have a good yield. Thus, when sowing tiger nuts and in order to have a good yield of all varieties combined, ridges of 20 cm high and a gap of 20 cm between the plants are needed. The land used for the cultivation of tiger nuts is sandy-stony land. All the work carried out in the cultivation of tiger nuts is carried out by family labour. Fertilizers used are either of the mineral or organic type. To this end, we see that 0.9% use organic fertilizer while all tiger nut producers use mineral fertilizer. In addition, some producers combine the two types of fertilizer. The latter represent 7.3% of all producers in all municipalities. In the municipalities of Boukoumbé, Matéri, Ouèssè, Ouinhi, Tanguiéta and Toucountouna, the use of manure is the only type of fertilizer used. In addition, the combination of fertilizers during spreading is provided by a few producers living in other municipalities, namely: Cobly, Kérou, Malanville, Savè, and Dassa-Zounmè. The dose of fertilizer used by producers during spreading is 8 bags of organic fertilizer and 8 bags of mineral fertilizer are used on average per hectare. The cultivation of tiger nuts, like any other culture, encounters constraints. These constraints are of various orders, namely: precipitation, rainy seasons, rains, dry season, temperature, insolation, harmattan and climate have a favorable incident on the yield of tiger nut. In addition to these climatic factors, other constraints are also important to mention, namely: parasitic attacks, destruction of young plants by animals; climatic hazards; declining soil fertility; the high cost of maintaining the plantations; plantation fires; saturation of space: lack of cultivable land for tiger nuts; difficulties in accessing fertilizer; lack of technical support; the lack of modern harvesting techniques; lack of investment and significant state subsidy. Contrary to the tiger nut which presents the vagaries of the weather as a production constraint, the genus Dioscorea has diversified in various environments, both in humid lowland and mountain environments and in regions with a marked dry season [30]. The tubers, characteristic of this genus, are generally considered as a form of adaptation to extreme seasonal variations (drought or cold) allowing the plant to survive in the ground. However, the presence of several species of yams

in the dense African rainforest [31] shows that yam tubers are also an adaptation to variations in light conditions which allow the plant to quickly reach the canopy to flower and fructify during the formation of a windfall, after having remained waiting in a dark undergrowth. Pests attack nutsedge tubers underground. No termite control method is known to producers, regardless of the municipalities. Thus, the palliative means adopted by all the producers of all the municipalities combined is to harvest the tiger nut tubers just at maturity before the attack of the pests. Because the pests only start attacking the tubers when they are mature. At maturity, the tiger nut harvest is done twice a year. The first harvest is done in September and the second in December. Harvesting tiger nuts is difficult and tedious because the producers harvest by scraping the soil to dig up the tubers at the end of the root branches. Once the harvest is done, the producers send the harvest to the market. The markets are: the markets of the production villages, the markets of the chief towns of the communes, the regional markets for the marketing of agricultural products, direct export to the major urban centers and Togo for food processing such as the production of porridge [32-33] and oils. Holders of large areas are generally producers who carry out other commercial activities that allow them to have income to meet the investment requirements of this fertilizer-consuming crop (8-12 bags of 50 kg/ha) and labor. The average yield of tiger nuts in the region is 3.62 t/ha and it reaches its optimum at 5 t/ha [34].

5. Conclusion

This work aimed to characterize the production systems of tiger nut tubers grown and marketed in Benin. It appears that yellow nutsedge is a neglected plant in Benin despite the fact that its tubers are richer than many food plants. Its cultivation is done in poles 1 to 5. The most productive commune is that of Boukoumbé. Its cultivation is subject to constraints because it is rainfed and not mechanized and is not subject to any development program.

In a quest for food security in Benin, endogenous ways for healthy nutrition and sustainable food security are to be explored. The cultivation system of tiger nut cultivars, therefore, remains one of these endogenous solutions to be promoted in Benin.

References

[1] Ousseina S. (2012). Étude des ressources fourragères de la Station Sahélienne Expérimentale de Toukounous: diversité, structure, dynamique, qualité et disponibilité. Thèse de doctorat de l'Université Abdou Moumouni, Niamey. 119 pp.

[2] Maieves H. A.; Cardoso de Oliveira D.; Bernardo C.; de Oliveira Muller C. M.; Amante E. R. (2012). Microscopy and texture of raw and cooked cassava (Manihot esculenta Crantz) roots. J Texture Stud. 43 (2): 164–73.

[3] Olayiwola I. O.; Abubakar H. N.; Adebayo G. B.; Oladipo F. O. (2009). Study of sweet potato (Ipomea batatas Lam) foods for indigenous consumption through chemical and anti-nutritive analysis in Kwara State, Nigeria. Pak J Nutr 8 (12): 1894–7.

[4] Lai Y. C.; Huang C. L.; Chan C. F.; Lien C. Y.; Liao W. C. (2011). Studies of sugar composition and starch morphology of baked sweet potatoes (Ipomoea batatas (L.) Lam). J Food Sci Technol. doi: 10.1007/s13197-011-0453-6.

[5] Abara A. E. (2011). Proximate and mineral elements composition of the tissue and peel of Dioscorea bulbifera tuber. Pak J Nutr 10 (6): 543–51.

[6] Ollivier D.; Artaud, J.; Pinatel C.; Durbec, J. P.; Guerere M. (2003). Triacylglycerol and fatty acid compositions of French virgin olive oils, characterization by chemometrics. J Agric Food Chem 51: 5723–31.

[7] Moreno O.; Dorantes L.; Galindez J., Guzman R. I. (2003). Effect of different extraction methods on fatty acids, volatile compounds, and physical and chemical properties of avocado (Persea americana Mill.) oil. J Agric Food Chem 51: 2216–21.

[8] Christopoulou E, Lazaraki M, Komaitis M, Kaselimis K. (2004). Effectiveness of determination of fatty acids and triglycerides for the detection of adulteration of olive oils with vegetable oils. Food Chem 84: 463–74.

[9] Dubois V.; Breton S.; Linder M.; Fanni J.; Parmentier M. (2007). Fatty acid profiles of 80 vegetable oils with regard to their nutritional potential. Eur J Lipid Sci Technol 109: 720–32.

[10] Rapport Annuel 2011-2012 CeCPA Matéri, 2015).

[11] Dagnelie P. (1998). Statistique théorique et appliquée. Tome 2: Inférences statistiques à une et deux dimensions. De Boeck et Larcier, Paris-Bruxelles, France Belgique. 659 p.

[12] INSAE. (2016). Effectifs de la Population des Villages et Quartiers de Ville du Benin (RGPH-4, 2013)[Census of Population of Villages and City Districts of Benin].

[13] Dagnelie, G.; De Vries, M. J.; Maier, J.; & Spekreijse, H. (1986). Pattern reversal stimuli: motion or contrast? Documenta Ophthalmologica, 61, 343-349.

[14] Sossa, E. L.; Amadji, G. L.; Vissoh, P. V.; Hounsou, B. M.; Agbossou, K. E. & Hounhouigan, D. J. (2014). Caractérisation des systèmes de culture d'ananas (Ananas comosus (L.) Merrill) sur le plateau d'Allada au Sud-Bénin. International Journal of Biological and Chemical Sciences, 8 (3), 1030-1038.

[15] Bori H.; Toudou D. A. K.; Moumouni D. M. A.; Adam T. (2018). La culture de souchet (Cyperus esculentus) au Niger: Origine, atouts et contraintes; Journal of Animal & Plant Sciences, 2018. Vol. 37, Issue 1: 5997-6007 Publication date 31/07/2018, http://www.m.elewa.org/JAPS; ISSN 2071-7024.

[16] Berrichil A., Bouhache M. et Reda Tazil M. (2004). Contribution à l'étude de la croissance et du developpement de Cyperus rotundus L. adventice de la plaine irriguée des Triffa (Maroc oriental); Ai. awamia 112 Vol. I N'4. 2004.

[17] Hilali S. (1995). Etude floristico-agrorromique de la flore adventice des vergers d'agrumes du périmètre imgué du Haouz ccntral (Marrakech-Maroc). (}oissance, phénologie et réseles glucidiques. Cas du Cypcrus rotundus L. Thèse dc troisième cycie. (Univcrsité Cadi Ayyad, Marakech).

[18] Williams R. D. (1982). Çrowth ancl reproduction of Cypcrus çsculenlus L. and Llyperus rotundus L. Weed ltes. 22. r49-t54.

[19] Lapham J. et Drennan D. S H. (1984). Intraspecific regulation of population of the clorral herbe, Cyperus csculentus. Joumal of Applied Ecology? 4, I0I I - I024. glucidiques. Cas du Cypcrus rotundus L. Thèse dc troisième cycie. (Univcrsité Cadi Ayyad, Marakech).

[20] Hauser, E. W. (1962). Establishment of nutsedge from space-planted tubers. Weeds, 10 (3), 209-212.

[21] Baker R. S. (1964). Reproducrive capacity of purple nutsedge (Cyperus rotundus L.) tubers. Abstr. Weed Sci', l Soc. Am: 63-64.

[22] Hilnmerton J. L. (1968). Nutglass in Panama: first impression' Pans, 14' 339-345 isHladik A.; Bahuchet S.; Ducatillon C. & Hladik C. M. (1984). — Les plantes à tubercules de la forêt dense d'Afrique centrale. Rev. Ecol. (Terre Vie), 39: 249-290.

[23] Wills C. D. 1975. Fffèct of light and ternperature on growth of purple nutsed. qe. Wcccl Sci., 23, 93-96.

[24] Merlier H.; Montegut, J. (1982). Adventices tropicales. Groupement d'études et de recherche pour le développement de l'agronomie tropicale, imprimerie nationale, 490 p.

[25] Labrada R.. Candad F., Hemaldez J. and Baez J. (1985). Bioecological particularities of *Cypenrs rotundus* L. ll. Chemical composition germination and emergence under different factors. Agfotecnica dc Cuba, 11 (2), 57-I 6.

[26] Hauser E. W. (1962). Establishment of nutseclge from space planted tubers. Weed ' 10, 2W-212.

[27] Hill, E. R.; Lachman, W. H. & Maynard, D. N. (1963). Reproductive potential of yellow nutsedge by seed. Weeds, 11 (2), 160-161.

[28] Mulligan, G. A. et lunkins B. E. (1976). Thc biology of canadien Weeds. 17. Cyperus esculentus L. Can-J. Plant Sci., 56, 339-350.

[29] Thullen R. J. et Keely P. E. (1979). Seecl gelmination in Cyperus esculentus and Cyperus rotundus. Weed Sci., 21,502-505.

[30] Jeannoda V. Jeannoda V. H. Hladik A. (2003). Les ignames de Madagascar: Diversite´, utilisations et perceptions. Hommes et Plantes 2003; 47: 10-23.

[31] Hladik, A.; Bahuchet, S.; Ducatillion, C. & Hladik, C. M. (1984). Les plantes à tubercules de la forêt dense d'Afrique Centrale. Revue d'Ecologie, Terre et Vie, 39 (3), 249-290.

[32] Houndji, V. S. B., Amoussou Fagla, B., Noukpozounkou, Z. J., Kovobahou, D. A., Mélila, M., Chabi, N., Amouzou, S. K., Azokpota, P. (2019). Organoleptic and Microbiological Characteristics of Edible Nutsedges (*Cyperus Esculenstus* L.) Porridge Produced and Consumed In Togo. Journal of Chemical, Biological and Physical Sciences, *Section B: Biological Sciences,* 10 (1), 021-030.

[33] Amoussou Fagla, B., Kovobahou, D. A., Houndji, V. S. B., Noukpozounkou, Z. J., Mélila, M., Chabi, N. W., Amouzou, S. K., Azokpota, P. (2019). Porridge of Edible Nutsedges Produced in Togo: Traditional Production Processes and Socio-Economic Interest. Journal of Food and Nutrition, 6: 3-12.

[34] Toukoua D., Dine, S., Assoumane I., Badage, G. (2002): Plan d'action filière souchet; République du Niger/Ministère de l'agriculture et de l'élevage Rapport final. 99 p.