International Journal of

JAEFS

Agriculture, Environment and Food Sciences

Volume 7 • Issue 1 • March 2023

e-ISSN: 2618-5946

edit PUBLISHING

www.jaefs.com

International Journal of Agriculture Environment and Food Sciences

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YEAR: 2023

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The journal is published in **March, June, September and December.**
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RESEARCH ARTICLE

International Journal of Agriculture, Environment and Food Sciences 2023; 7(1): 107-116
DOI: https://doi.org/10.31015/jaefs.2023.1.12

Analysis of the foundations of market gardening activity in the Commune of Athiémé (Benin)

Marcelle-Agathe Monde[1] • **Claude Ahouangninou**[2] • **Djafarou Abdoulaye**[1]
Landry Denis Yawo Kiki[3] • **Samuel Massede**[4] • **Brice Tente**[1]

[1] Laboratoire de Biogéographie et Expertise Environnementale/UAC/ Bénin
[2] Laboratoire des Sciences Végétales, Horticoles et Forestières (LaSVHF)/École d'Horticulture et d'Aménagement des Espaces Verts ; Université Nationale d'Agriculture de Porto-Novo, Bénin
[3] Laboratoire Pierre PAGNEY : Climat, Eau, Ecosystèmes et Développement/UAC
[4] Département de Géographie et Aménagement du Territoire, Université d'Abomey-Calavi, Bénin ; B.P. 526, Cotonou, Bénin

Citation: Monde, M.A., Ahouangninou, C., Abdoulaye, D., Kiki, L.D.Y., Massede, S., Tente, B. (2023). Analysis of the foundations of market gardening activity in the Commune of Athiémé (Benin). International Journal of Agriculture, Environment and Food Sciences, 7 (1), 107-116

Received: 21 December 2022
Revised: 01 February 2023
Accepted: 05 February 2023
Published Online: 02 Martch 2023

Correspondence: Marcelle-Agathe Monde
E-mail: marcelleagathemondefifatin@gmail.com

Abstract

Vegetable production has been a booming activity in Benin for several years, as in most countries of the West African region. The Beninese state and many other organizations are working together to develop this activity, create jobs and strengthen food security in the country. In rural areas, this agricultural sub-sector is considered one of the important measures to guarantee food security and promote income diversification. However, questions arise about the viability of this form of activity. This study aims to analyze market gardening operations in the Commune of Athiémé in Benin. To achieve this objective, different data collection techniques are used, namely documentary research, observation, interviews and questionnaire surveys with market gardeners and an interview guide administered to local authorities. A sample of 206 market gardeners is questioned. The socio-demographic data of market gardeners and agricultural statistics (areas, production and yields, etc.) are collected. The results obtained showed that market garden production is a highly developed activity in the Commune of Athiémé and is practiced at all times of the year. The most developed methods of accessing land are by inheritance (31.9%) and by purchase (31.9%). Family labor was used most often on market gardening farms (76.21%). For water supply to farms, the dominant systems were those relating to irrigation, the use of rainwater and floodwater. The basic water distribution or irrigation equipment was motor pumps, which was used by 93.57% of market gardeners. For the fertilization, the majority of market gardeners prefer the use of Urea (44.44%) and NPK (35.28%). Only 10.83% use cow purse and poultry dung. For the control of crop pests and diseases, producers use a variety of chemical pesticides. Improved production systems, including training for producers, improved irrigation systems, soil fertilization and plant protection measures will promote the sustainability of vegetable farms.

Keywords: Analysis, vegetable farm, production system, vegetable crops, Athiémé

INTRODUCTION

Agriculture, the main rural activity in developing countries due to the number of people it occupies and the volume of its production, is one of the alternatives that allow people to ensure their survival (Atidegla *et al*., 2017). Agriculture is of paramount importance for strengthening the Beninese economy. Benin's agricultural sector contributes an average of 32.7 percent to Gross Domestic Product (GDP), 75 percent to export earnings, 15 percent to government

revenues, and provides about 70 percent of employment (Sossou, 2015). In Benin, vegetable production is characterized by a diversification of cultivated species (Ahouangninou *et al*., 2013). The income generated by this market gardening activity allows several hundred families to meet their daily needs (Adjatin *et al*., 2019). Market gardening is an important activity through which unemployment and the food crisis are mitigated, and also a means of obtaining income to support family needs (Ngakiama *et al*., 2019). According to Dossou-Yovo (2019), water availability for market gardening activities distinguishes between irrigated production systems in Benin, lowland production systems (that depend on seasonal rainfall and are reinforced by an irrigation system), and rainfed production systems in wetlands. The availability of water is a determining factor for market garden production. Market gardening is an important activity in the sense that in order to accelerate the growth of the agricultural sector, Benin adopted a Strategic Plan for the Recovery of the Agricultural Sector (PSRSA) in 2011, which is based on the development of 13 priority sectors, including the market gardening sector in view of the enormous potential it holds in terms of contribution to food and nutritional security, economic growth and rural job creation. Similarly, the Strategic Plan for the Development of the Agricultural Sector 2017-2025 places market gardening among the priority sectors to be developed in Benin (MESRS, 2017). The five-year action plan (2016-2021) and the government's action program (2017-2021) place market gardening among the nine priority sectors that should benefit from massive investments (PADMAR, 2019). At the national level, a total of five (5) major vegetable production areas have been identified based on criteria such as geographic location, types of vegetables produced, and production systems. At the national level, based on criteria such as geographical location, types of vegetables produced and production systems, five (5) major vegetable production areas are identified (Alinsato *et al*., 2018). The Commune of Athiémé is located in this part with high potential for vegetable production. This study aims to analyze the foundations of market gardening in the Commune of Athiémé.

MATERIAL AND METHODS

Study area

The Commune of Athiémé is located in the southwest of the Republic of Benin, between parallels 6°28′ and 6°40′ North latitude and meridians 1°35› and 1°47› East longitude (Figure 1). It covers an area of 238 km2 and shares a natural border with Togo, which is the Mono River. The Commune is located in the agro-ecological zone of the Mono department, which is made up of low valleys and alluvial formations. The climate is sub-equatorial, characterized by four seasons, including two dry seasons and two rainy seasons. It is favorable to market gardening activities which become intense during the months of November, December, January and February. This long period, corresponding to the great dry season, is a period of water withdrawal that leaves room for market gardening. Thermal conditions play an important role in vegetative growth. Temperatures are relatively high and vary between 26.15°C in August and 29.55°C in March.

The relief, marked by numerous depressions and banks (cordons) of sand and sandstone is monotonous and generally flat, eroded in places. The existing depressions constitute watersheds or valleys sheltered by ponds, swamps and plains, very suitable for off-season crops and market gardening. The soils on the whole are clayey, black hydromorphic clay, sandy clay or sandy clay soils very suitable for multi-cropping. The research environment is marked by the presence of the Mono River, which is the main river with a wide valley and watersheds and which irrigates almost all the villages of the Commune (INSAE, 2004).

At the last General Census of Population and Housing (RGPH4, 2013), this Commune had 56,483 inhabitants, 51.2% of whom were women compared to 48.8% men with a natural growth rate of 3.2%. This population constitutes a potential agricultural workforce in the Commune.

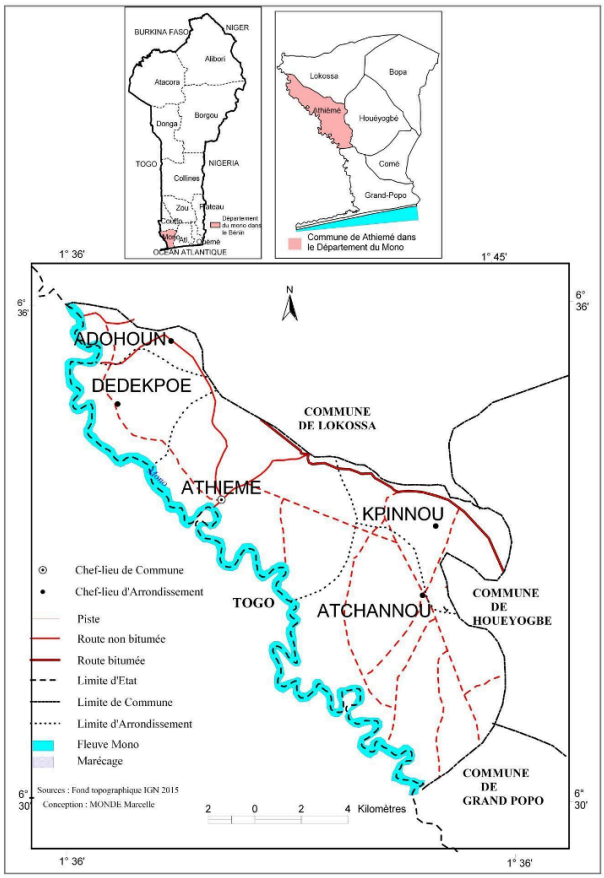


Figure 1. Geographical situation of study area

Data collection

This part concerns the data as well as the collection tools and techniques. These data include the socio-demographic characteristics of market gardeners, the main crops grown, the production systems, in particular data on the mode of access to land, the crops adopted, the type of labor, tools and materials, size of farm, water supply system, water supply sources, water distribution equipment, cropping operations i.e. types and means of fertilization, types of fertilizers used and forms of phytosanitary treatment. These data made it possible to analyze the foundations of market gardening in Athiémé. The different techniques used were: documentary research, observation, interviews, and surveys by questionnaire.

The sampling approach chosen is the non-probability approach, but the sample size n is obtained from the Schwartz (1995) formula:

$$n = Z\alpha^2 \times pq / i^2$$

In this formula,

n is the sample size ;

Zα= Deviation set at 1.96 at a 95% confidence level;

p is the total proportion of market gardeners in the five arrondissements (Adohoun- Atchannou- Dédékpoe-Kpinnou and Athiémé) to the total agricultural populations of the Commune of Athiémé obtained as follows: (858/5300 = 0.1619) ;

q=1-p: (1-0.1619= 0.8381);

i: precision or risk of error fixed at 0.0503.

n = $(1.96^2 \times 0.1619 \times 0.8381) / (0.0503)^2$ = 206.02 market gardeners.

The distribution of locations and number of farms surveyed is presented in Table 1.

A total of 206 people were interviewed for the data and information collection. This number was selected according to a reasoned choice that took into consideration the number of years of practice, the size and the geographical location of the farms. In addition to this sample, three specialists were surveyed (in vegetable production, in plant production, in ecotoxicology). It is the same as the Head of the Local Development and Planning Department and the Head of the State Affairs and Environment Department of the Athiémé Town Hall. The five Arrondissement chiefs of the Commune contributed to the control of the occupation of the exploitation units.

Data processing and analysis

The data collected was processed in two phases. The first phase consisted of cleaning up the database. This step consisted mainly in harmonizing the response modalities served by each respondent. It was done in the Excel 2013 spreadsheet. The second phase, which is the analysis of the data, consisted mainly of the use of descriptive statistics (average, absolute and relative frequency) and proportion comparison tests to describe the data. These statistics were generated with the R 4.0.3 software. The analysis also focused on the qualitative aspects of the production system in order to assess the living and working conditions of the market gardeners. The production of graphs involved the use of the R software package ggplot2.

Table 1. Distribution of villages/towns and people surveyed.

Arrondissements	Total number of rural households	Total number of market gardeners surveyed by district (n)	Proportion of market gardeners surveyed (%)
Adohoun	1785	22	10,68
Atchannou	894	47	22,82
Kpinnou	630	50	24,27
Dedekpoe	531	32	15,53
Athiémé	1460	55	26,7
Total	**5300**	**206**	**100**

Source: Fieldwork results, January 2020

RESULTS

During this study, 206 market gardeners were registered. Analysis of Table II shows that 73.79% of the respondents were male. The study of the educational level of these actors shows that the vast majority of them have primary education, i.e. 33.01% of respondents. 93.03% were already married and the Kotafon were the ethnic group most involved in market gardening in the study area (Table 2).

Main crops grown

Market gardening is a highly developed activity in the Commune of Athiémé. It is practiced at all times of the year. However, in the different districts, some crops are produced more than others, depending on market demand. An analysis of Figure 2 below shows that the three market garden crops most often cited in Adohoun district and mainly produced by market gardeners are chili, tomato and vernonia. In the arrondissement of

Table 2. Socio-demographic characteristics of producers.

Variables	Modalities	Number	Percentage (%)	X^2 (p-value)
Sexe	Woman	54	26.21	<0.001
	Man	152	73.79	
Level of education	Any	25	12.14	0.022
	Primary school	68	33.01	
	Secondary school	56	27.18	
	University	57	27.67	
Marital status	Single	11	5.47	<0.001
	Maried	187	93.03	
	Widow/widower	3	1.49	
Ethnic	Adja	25	12.14	<0.001
	Adja Tala	37	17.96	
	Nago	1	0.49	
	Fon	4	1.94	
	Goun	1	0.49	
	Kotafon	85	41.26	
	Mina	5	2.43	
	No specified	18	8.74	
	Sahouè	5	2.43	
	Toguido	1	0.49	
	Watchi	23	11.17	
	Yorouba	1	0.49	

Table 3. Main crops.

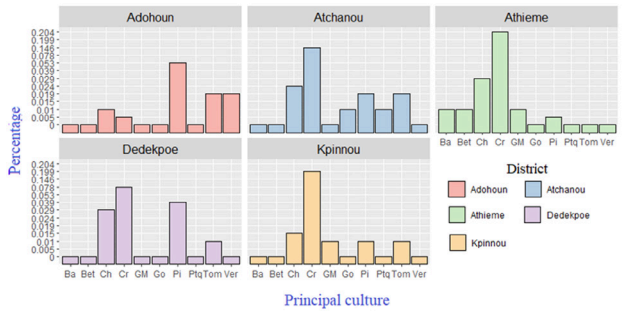
N°	Listed vegetable products (french name)	Scientific names	Local name KOTAFON	Local name MINA	Percentage(%)
1	Crincrin	*Corchorus tridens*	Adèmin	Adémin	63.1
2	Chou	*Brassica oleracea*	Chou	Chou	10.7
3	Piment	*Capsicum frutescens*	Vavo	Yebessé	12.6
4	Amarante	*Lycopersicum esculentum*	Têtè	Têtè	0.00
5	Grande-morelle	*Solanum macrocarpon*	Gboma	Gboma	1.90
6	Tomate	*Solanum lycopersicum*	Agbovi	Timanti	5.80
7	Gombo	*Abelmoschus esculentus*	Ninhou	Fétri	1.00
8	Concombre	*Cucumis sativus*	Concombre	Concombre	0.00
9	Pastèque	*Citrullus lanatus*	Watra	Watra	1.00
10	Tchiayo	*Ocimum gratissimum L*	Tchanmandido	Eslou/yandodo	0.00
11	Vernonia	*Vernonia galamensis*	Amanvivè	Aloman	1.90
12	Betterave	*Beta vulgaris L*			1.00

Source: Fieldwork results, April 2021

Atchanou, producers are more attracted to the production of crincrin, cabbage and, in equal proportions, chili pepper and tomato. In the arrondissement of Athiémé and Kpinnou, producers prefer to grow crincrin, cabbage and nightshade or gboma (*Solanum macrocarpon*). In the Dedekpoe zone, the production of crincrin, cabbage and chili peppers is more common (Figure 2).

Table 3 presents an inventory of the market garden products identified in the Commune. The results of the fieldwork allowed us to identify twelve (12) vegetables crops in the different farms surveyed. These crops are produced according to the preferences of each market gardener and the soil conditions of the plots. Thus, it appears that the cultivation of crincrin is the first preference of the producers, the production of chili pepper is the second and finally that of gboma is the third. The respondents gave the same reasons for their choice of crops that are high profitability, ease of marketing and food needs. In addition, the cultivation of crincrin, as the first crop, is linked to tradition in this area. It is therefore a traditional crop specific to the area. In addition, the relatively short harvest cycle of this crop (21 days after sowing) and the rapid availability of income help to solve financial problems.

Legend: Ba="Basil", Bet="Beetroot", Ch="Cabbage",



Cr'="Crin-crin", Go="Okra", GM="Grandmother", Ptq="Watermelon", Pi="Pepper", To="Tomato", Ver="Vernonia"

Figure 2. Main crops produced by district

Systems of Production

Most of the results of previous research consulted, in order to characterize production systems, refer to the mode of acquisition or mode of access to land, the type of labor, the work tools, the size of the farm, the water supply system, the sources of water supply, the cultivation operations, i.e., the types and means of fertilization, and the forms of phytosanitary treatment.

Cultural operations for soil preparation

The field surveys reveal a number of cultivation operations in the context of soil preparation. These include chemical clearing, which is a new form introduced, manual clearing, and manual or mechanical plowing. As for the cleaning of the soil, the producers proceed by incineration, by collection and/or burial and finish by transplanting (Figure 3).

Figure 3. Planting of greater nightshade in Ahoho (Shot: M. Mondé, 2020)

This transplanting session is done manually and is a sensitive step. When it is well done, the seedlings grow well. Otherwise, they can be asphyxiated or burned by the heat. The protection of these plants, especially for off-season crops, is done by several means available to each producer. For example, protection is provided by means of hedges made of palm branch stakes. Producers also sow maize to shade the crops one month after transplanting. Transplanting can also be done in banana plantations, but the latter practice increases the exposure of the crop to fungal diseases.

Mode of land acquisition and use of labor

Market gardeners get the land in several ways. This access depends on each district and the origin of the farmer. Figure 4 presents the different modes of acquisition of the farm units visited.

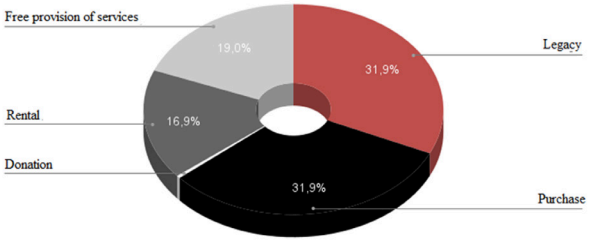


Figure 4. Methods of acquisition of farm units by market gardeners.
Source: Fieldwork results, December 2020

The analysis in Figure 2 shows that there are five modes of acquisition of market gardening farms in the Commune of Athiémé. The most developed methods are those of inheritance and purchase, which represent 31.9% of all methods. However, the donation of plots to be farmed is less developed and represents 3%. The practice of making land available free of charge is also well developed in the Commune (19.0%), thus allowing producers who do not have the means to purchase land to produce their products over a defined period. Within this system, there is also renting (16.9%), which mainly concerns foreigners from other Communes in the Departments of Mono and Couffo and neighboring Republic of Togo.

Fieldwork revealed that market gardeners use three types of labor (Figure 5): family labor, occasional hired labor and permanent hired labor.

Looking at Figure 4, it can be seen that family labor is highly used in vegetable farms (73.21%). This shows that market gardeners use family members more. However, they use permanent paid labor, which are people from the Commune. Also, the occasional salaried labor force (mostly made up of foreigners), is used by market gardeners. It should be noted that the use of salaried labor concerns market gardeners who have a relatively large financial power and size of operation.

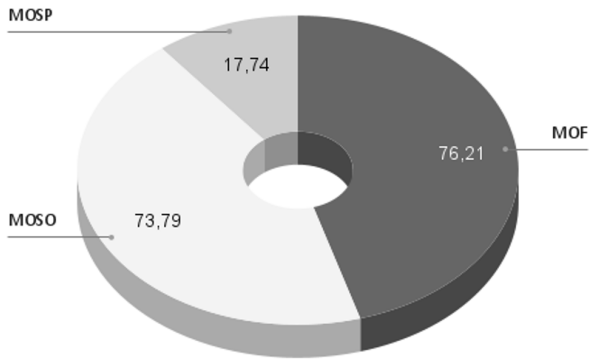


Figure 5. Proportions of labor use on vegetable farms (MOF=family labor; MOSO=casual hired labor; MOSP=permanent hired labor)
Source: Fieldwork results, December 2020

Areas farmed and equipment used on market garden farms

Land is a very important means of production in the farming system. In the Commune of Athiémé, depending on their financial means and social status, market gardeners have different portions of space to exploit. Figure 6 presents the size of the farm units allocated to market gardening in terms of the proportion of market gardeners.

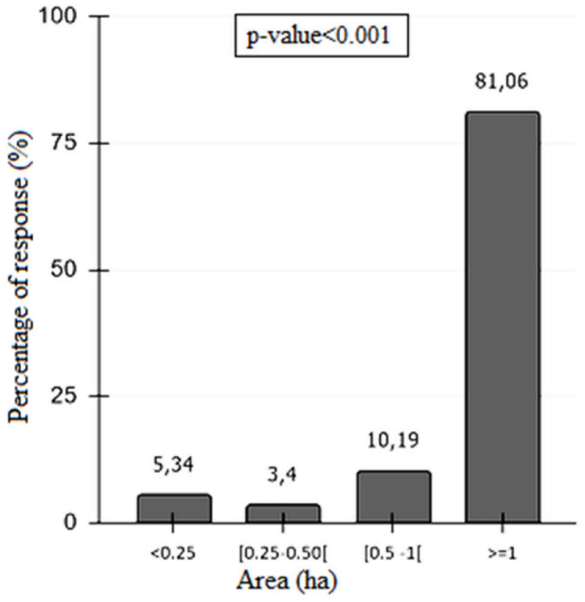


Figure 6. Areas farmed by market gardeners

Source: Fieldwork results, December 2021

Figure 5 shows a clear difference in terms of the amount of land farmed. Indeed, 81.06% of market gardeners have at least one hectare of land for market garden production. These issues indicate that the Commune of Athiémé is home to large market gardeners.

Irrigation systems

Field surveys revealed that in Athiémé, the dominant systems are those related to irrigation, rainfed and flood recession crops. In all five districts, rainfed crops are observed. In addition, the depressions are home to ponds, shallows and swamps and concern the Mono River valley, the Sazué and Saïdo rivers, and the Toho, Djèto and Whayè lakes. These rivers and bodies of water cross the villages of the various districts. From these river and lake networks, market gardeners organize various water supply systems for their crops. Others resort to drilling systems (Table 4).

Table 4. Water Distribution Equipment.

Equipment	Number (%)
Motor pumps	194 (33.66%)
Submersible pumps	15 (2.31%)
Perforated belts	45 (7.26%)
Turnstile	9 (1.65%)
Flexible hoses with sprinkler heads	60 (11.22%)
Displaceable hoses	162 (28.38%)
Watering can	72 (13.53%)
Drip tape	3 (0.66%)
Others	4 (1.32%)

Source: Field surveys, 2020

Examination of Table IV shows that the basic water distribution or irrigation equipment are motor pumps used at 33.66% by growers, submersible pumps used at 2.31%, perforated belts used at 7.26%, turnstiles used at 1.65% by market gardeners, flexible hoses with sprinkler heads used at 11.22%, movable piping at 28.38%, and drip waterers at 0.66% of surveyed market gardeners (Figure 7).

The water supply and distribution equipment and energy sources used by market gardeners are diverse. Figure 8 presents some of the energy sources identified in the research environment.

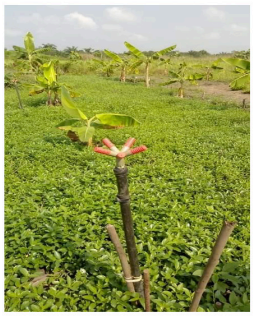
Figure 8 shows that efforts to modernize the pumping system are being made in the area. It is important to maximize this momentum and engage in the sustainable management of this equipment. According to field surveys, 93.57% of market gardeners use gasoline and 5.50% use diesel, not to mention photovoltaic energy.

In addition, other means are used on market garden farms. These are the tools, materials and machines used in the entire research sector. These means include the hoe and the cutter for all producers; rakes, tractors and accessories. Finally, work tools such as wheelbarrows, rope, rope for staking, decameters, hatchets and baskets are also noted.

Watering by apple and flexible pipes Djonougoui hamlet in Adjovè (Athiémé)

Irrigation system with 50 mm PVC movable pipes in Adjovè

Feeding by perforated bands in Adjovè



Feeding at the turnstile (Djonougoui in Adjovè)

Figure 7. Some water distribution equipment in Athiémé

Shot by M. Mondé, January 2020

Solar water pumping and treatment system for the Mono River (Aguidahoué to Adohoun)

Generator for water pumping

Figure 8. Energy sources for irrigation; Photo credit: M. Mondé, 2020

Fertilizer use and plant protection measures

Fertilizers

Several fertilizers (organic and chemical) are used to fertilize market gardens (Figure 9).

Soil fertilization is done in various ways and depends on the means available to market gardeners, particularly financial and human means. However, regardless of the type of operation, plants are amended either by chemical fertilizers or by organic matter or by both.

The analysis in Figure 6 shows that 80% of market gardeners use chemical fertilizers (NPK and urea). Only 11% use cow dung and poultry droppings. Others use liquid fertilizer, which is manufactured locally or imported.

Figure 10 shows the amendment of cabbage with urea (3.1) and the biological fertilization operation (3.2) of the plots.

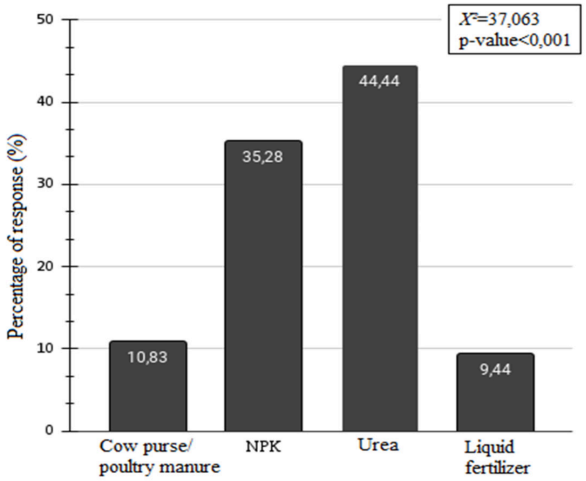


Figure 9. Proportion of farmers by type of fertilizer used

Source: Fieldwork results, December 2020

Urea amendment in Ahoho

Spreading organic fertilizer in Adjovè

Figure 10. Fertilizer products for Athiémé soil

Protection of the plants

In the Commune, the treatment of crops and the fight against pests are done in several ways. For the fight against pests, the producers resort to pesticides. The preparations that were the most recorded were the formulations of Isopropylamine, lambda-cyhalothrin, Emamectin benzoate, Abamectin, Haloxyfop-P-Methyl (Table 5).

The producers interviewed used pesticides, including herbicides, insecticides, fungicides and acaricides. The range of products identified includes 10 herbicides, 6 insecticides, 3 fungicides, 1 acaricide and 1 bactericide.

Protection measures taken by market gardeners during phytosanitary treatments

Phytosanitary treatment is a common practice in market gardening in the Commune of Athiémé. It is done by market gardeners without a minimum of personal protective measures. According to the surveys, 41.0% of market gardeners do not take any protective measures, although they are aware of the importance of wearing PPE.

Table 5. Chemical inputs used in the Commune.

Type of pesticide	Trade name	Active ingredients	Concentration	Chemical family
Herbicides	Finish 68 SG	Abamectine	18 g/L	Organophosphorous
	Malik 108 EC	Haloxyfop-R méthyl	104 g/l	Organophosphorous
	Force up	Glyphosate	360 g/L	Organophosphorous
	Terminator G4	Glyphosate Terbuthylazine Amitrole Oxyfluorfène	100 g/l 350 g/l 60 g/l 15 g/l	Organophosphorous
	Sunphosate 360 SL	Glyphosate	360 g/l	Organophosphorous
	Adwuma wura	Glyphosate sel d'isopropylamine	360 g/l	Organophosphorous
	Gallup super 360	Glyphosate	360 g/l	Organophosphorous
	Glyphader 360	Glyphosate	360 g/l	Organophosphorous
	Capizad	Haloxyfop-P-Méthyl acide éq. Haloxyfop-R-Ester méthylique EC	104 g/L 108 g/L	Propionate
	Sharp	Acétamipride	20 g/L	Néonicotinoïdes
Insecticides	Acarius 018 EC	Abamectine	18 g/L	Avermectines
	Emacot 050 WG	Emamectine benzoate	50 g/kg	Avermectines
	Pacha 25 EC	Acetamipride Lambda Cyhalothrine	10 g/l 15 g/l	Néonicotinoïdes Pyréthrinoïdes
	CYPERCAL 50 EC	Cyperme'thrine	50 g/L	Pyréthrinoïdes
	K-Optimal GHS 50.00	Lambda Cyhalothrine Acetamipride	15 g/L 20 g/L	Pyréthrinoïdes Néonicotinoïdes
	Sunpyrifos 48 EC	Chlorpyriphos-e'thyl	480 g/L	Organophosphorous
Fongicides	Acarius 018 EC	Abamectine	18 g/kg	Avermectines
	Idefix	Hydroxide of copper	65,6 g /100 g	Hydroxide of copper
	Coga 80 WP	Mancozeb	800 g/kg	Dithiocarbamates
Bactericides	Idefix	Hydroxide of copper	65,6 g /100 g	Hydroxide of copper
Acaricides	Acarius 018 EC	Abamectine	18 g/L	Avermectines

Source: Survey results

Figure 11 shows a producer spraying without protection.

Figure 11. Absence of PPE during spraying in Ahoho

The sensitivity of the chemical products requires, however, a protection by the use of the EPI for the sanitary safety of the producers.

DISCUSSION

Analysis of the foundations of the market gardening farms of the Commune of Athiémé has made it possible to appreciate certain specificities that should be underlined. Indeed, the market gardeners surveyed have an average level of education, the market gardeners are on average. 33.01% have primary school education. This finding is similar to the results obtained by Ouattara (2016) in Burkina Faso, where those with primary education are the most numerous (31.3%). The same observation is made by Ahouangninou (2013) who notes that in southern Benin, market gardeners for the most part do not have a high level of education.

The present study reveals that the most developed modes of access to land are those of inheritance and purchase, which represent an equal proportion of 31.9% of all modes. The opposite results exposed by Kasanda, (2016) in Lubumbashi in the Democratic Republic of Congo highlight that, access to land by inheritance, is

the least frequent mode in the study environment and represents 0.99%, or 1% of the study population. Those who have acquired the right to use the land by purchase represent 17.33% of the total population.

Renting is the most common mode of access in all the sites studied, and concerns 58.42% of farmers. In terms of land availability, the results of this research in Athiémé showed that 81% of market gardeners have more than one hectare of land under cultivation. These ending are in line with those of the study conducted by Dossou-Yovo (2019) in Sèmè-Podji, where 75% of producers farmed areas of more than 0.5 hectares. On the other hand, they contrast with those of Tori-Bossito, because the farmers in this Commune mostly farm small areas for their production activity. Only a few have areas larger than one hectare (Ahouangninou *et al.*, 2011).

Family labor is the most used 76.21% The present results allowed the identification of twelve (12) market gardening species in the different farms surveyed compared to nine (09) market gardening species identified in Grand-Popo in southern Benin by Adjatin *et al*., (2019).

The analysis of the results showed a high use of chemical fertilizers in the market garden farms (80% of the market gardeners use chemical fertilizer), organic fertilizers in a lesser proportion (11%). Going in the same direction, Mondé (2019) demonstrates that in the Commune of Tori-Bossito, to increase agricultural yields, producers use chemical fertilizers such as NPK and Urea.

In Athiémé, pest control is done with pesticides and a significant use of these products is noticed. According to the deductions of the survey, 21 commercial preparations were identified, including 10 herbicides, 6 insecticides, 3 fungicides, 1 acaricide and 1 bactericide. For weed control, 33.5% and 42.3% of producers use selective herbicides and total herbicides respectively. Only 24.2% of producers reported not using any herbicide and resorted to hand weeding to reduce crop vulnerability to weeds. These conclusions differ from those of Ahouangninou *et al*. (2011), who did not identify any herbicides, because people are more concerned with the control of insect pests and prefer manual weeding. The chemical preparations most commonly found in the study area were formulations of Methyl Isopropylamine, lambda-cyhalothrin, Emamectin benzoate, Abamectin, Haloxyfop-R methyl.

The same results regarding the use of phytosanitary products were obtained by Mondedji *et al*. (2015) in southern Togo, who showed that in developing countries, there is excessive and inappropriate use of pesticides but also failure to comply with the pre-harvest residual time of phytosanitary products. In terms of protection against the negative effects of the use of phytosanitary products, the results showed that market gardeners do not have PPE. The work of Ngakiama *et al*. (2019) in the town of Kinshasa showed similar results where no market gardeners have complete protective equipment such as gloves, boots, masks, dust covers, overalls, aprons, goggles. Only 36.9% of market gardeners use one or two pieces of protective equipment.

CONCLUSION

The research on the analysis of the foundations of market gardening in the Commune of Athiémé showed that market gardening is an activity carried out by a significant number of producers at all times of the year and in the five districts. A dozen market gardening activities were identified on the various farms visited. The dominant systems are those related to irrigation, rainfed and flooded crops. The distribution equipment and energy sources for the supply and distribution of water used by operators are diverse and efforts to modernize the pumping system are being made in the area. Plants are amended either by chemical fertilizers or by organic matter or by both. For pest control, producers use pesticides. The most common formulations were Isopropylamine, lambda-cyhalothrin, Emamectin benzoate, Abamectin, Haloxyfop-P-Methyl. In these farms, very few market gardeners use protective equipment during phytosanitary treatments. In view of the observations made from the analysis of the foundations of market gardening in Athiémé, it is urgent to deepen knowledge of current production methods in order to make this activity sustainable.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

REFERENCES

Adjatin, A. A., Bonou-Gbo Z., Boco A., Yédomonhan H., Dansi A. (2019). Diversité biologique et caractérisation de l'activité de maraîchage sur le site de Grand-Popo au Sud Bénin. International Journal of Biologie and Chemical Sciences 13(6): 2750-2764. https://dx.doi.org/10.4314/ijbcs.v13i6.26

Ahouangninou C. (2013). Durabilité de la production maraîchère au Sud-Bénin : un essai de l'approche écosystémique, Thèse de doctorat, Université d'Abomey-Calavi, Ecole doctorale pluridisciplinaire, Bénin. 344 pages.

Ahouangninou C, T Martin, S Bio-Bangana, J Huat, L Parrot, F Vidogbéna, D Medali, C Houssou, P Edorh, M Boko et B Fayomi, 2013. Characterization and diversity of the market-gardening production systems and theirs interactions with urban and peri urban environment in southern-Benin, West Africa. Continental Journal of Sustainable Development, 4(1): 24-38. https://doi.org/10.5707/cjsd.2013.4.1.24.38

Ahouangninou C., Fayomi B., Martin T. (2011). Évaluation des risques sanitaires et environnementaux des pratiques phytosanitaires des producteurs maraîchers dans la commune rurale de Tori-Bossito (Sud-Bénin). *Cah Agric* 20: 216-22. https://doi.org/10.1684/AGR.2011.0485

Alinsato A., Yagbedo U. (2018). « Analyse d'offre des produits maraîchers au Bénin », Université d'Abomey-Calavi, Bénin. 29 pages.

Atidegla C. S., Degbo H. E., Azonhè T., Agbossou Kossi E. (2017) Impacts socioéconomiques et sanitaires de l'exploitation agricole de la plaine inondable Todé Gbamè au Bénin. European Scientific, 13(18): 185-203 http://dx.doi.org/10.19044/esj.2017.v13n18p185

Dossou-Yovo S. (2019). Risques environnementaux et sanitaires liés à la pratique du maraîchage dans la commune de Sèmè-Podji sur le littoral du Bénin : évaluation de la contamination et propositions de stratégies de contrôles, Thèse de doctorat, Université d'Abomey-Calavi, 297 pages.

Kasanda Mukendi N., Mushagalusa Balasha A., Kitsali J. H., Nkulu Mwine Fyama J., Bogaert J. (2016). Maraichage périurbain à Lubumbashi : modes d'accès à la terre et gestion des superficies agricoles. International Journal of Innovation and Applied Studies ISSN 2028-9324 14 (1). 27-36.

Kpadenou C. C., Tama C., Dado Tossou B., Yabi A. J., (2019). Déterminants socio-économiques de l'adoption des pratiques agro-écologiques en production maraîchère dans la vallée du Niger au Bénin. International Journal of Biologie and Chemical Sciences 13(7): 3103-3118. https://dx.doi.org/10.4314/ijbcs.v13i7.11

Mondé M.-A. (2019). Evaluation des risques environnementaux de l'utilisation des intrants chimiques dans les cultures maraîchères de bas-fonds dans la Commune de Tori-Bossito. Mémoire de Master 2. Université d'Abomey-Calavi, Ecole doctorale pluridisciplinaire, Bénin, 72 pages.

Mondedji A., D., Nyamador W. S., Amevoin K., Adéoti R., Abbévi Abbey G., Koffivi Ketoh G., Glitho A. I. (2015). Analyse de quelques aspects du système de production légumière et perception des producteurs de l'utilisation d'extraits botaniques dans la gestion des insectes ravageurs des cultures maraîchères au Sud du Togo. International Journal of Biologie and Chemical Sciences 9(1): 98-107. https://doi.org/10.4314/ijbcs.v9i1.10

Ndiaye O., Diatta U., Abeudje A., Dramé M. (2021). Caractérisation des périmètres maraîchers institués par les groupements des femmes comme stratégie de résilience en zone post conflit (Casamance, Sénégal). European Scientific, 7431,17(13). https://doi.org/10.19044/esj.2021.v17n13p118

Ngakiama Ngweme G., Mbela Kiyombo G., Pole Sikulisimwa C., Kyela Mulaji C., Komanda Aloni J. (2019). Analyse des connaissances, attitudes et pratiques des maraîchers de la Ville de Kinshasa en rapport avec l'utilisation des pesticides et l'impact sur la santé humaine et sur l'environnement. Afrique International Journal of Innovation and Applied Studies ISSN 2028-9324, Vol. 26 No.2 345-356.

Ouattara Z. A. (2016). Caractérisation des systèmes de production maraichers et analyse des déterminants de la fertilité des sols sous cultures maraichères dans la province du Houet (Burkina Faso), Mémoire de fin de cycle, Université Polytechnique de Bobo-Dioulasso, 61 pages.

Projet d'Appui au Développement du Maraîchage. (2019). Manuel d'exécution revu du PADMAR, 151 pages.

Sossou C. H. (2015). Le financement de l'agriculture au Bénin : stratégies de gestion et d'adaptation des exploitations agricoles. Communauté française de Belgique, Université de Liège – Gembloux agro-Bio Tech, 199 pages.