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Identification and Characterization of Market Garden Crops Grown Near Landfills in Abidjan District

Harding Charlemagne Assy ^{a*},
Ghislaine Chépo Dan ^a,
Désiré Yapi Assoi Yapi ^a
and Ohouo Régina Antoinette Don ^a

^a *Department of Food Sciences and Technology, University Nangui Abrogoua (UNA),
Abidjan, Côte d'Ivoire.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Abstract: Market garden crops constitutes an important source of food and is one of the most income-generating activities in Côte d'Ivoire. In the Abidjan district, several market gardening sites are located near illegal landfill sites, therefore representing a danger for consumers.

Aims: This study was carried out to map these different sites, inventory the plant species cultivated and characterize the cultivation practices with a view to highlighting the constraints and identifying prospects for improvement.

Methodology: Semi-structured individual interviews were carried out in 4 communes of Abidjan (Abobo, Bingerville, Cocody and Port-bouët) to collect information from 400 residents including 280

*Corresponding author: Email: charlemagne.harding@gmail.com;

men and 120 women. The statistical analysis of the survey results was carried out using Google Form and Excel software.

Results: The results revealed six (6) market garden sites with landfills distributed in four (4) different communes (Abobo - Akeikoi village; Bingerville - Bingerack city; Cocody - M'pouto village and M'badon village; Port-bouët - 4th bima and Mafiblé village). Thirteen (13) market garden species which are divided into eight families. Lettuce and basil are grown on all identified sites and represent the most cultivated species (40%). Market garden crops is practiced by young people aged 10 to 30 (70%) with a relatively low level of education. Pests (insects, rodents, fungi) and heavy metals from illegal dumps constitute the main obstacles to production and are vectors of frequent diseases.

Conclusion: It would be wise to adopt an integration policy for market gardening, in urban development plans, and to combat the proliferation of uncontrolled landfill sites, this will help to improve the quality and yield of market garden crops in Abidjan.

Keywords: *Market garden crops; uncontrolled landfills; leafy vegetables; unsanitary conditions; security alimentary.*

1. INTRODUCTION

The urban population of sub-Saharan Africa will rise from 1 billion 94 million in 2020 to over 1 billion 200 million in 2025. With a growth rate that is already 3.7% per year [1]. Despite the efforts of some governments to curb the rural exodus in all southern countries, the urbanization process is accelerating [2]. Urban food security will therefore become a crucial issue for decision-makers [3].

Although agriculture is one of the main sectors of activity contributing to the socio-economic development of populations. This sector employs more than 40% of the world's working population, including more than 52% in Africa [4,5]. In the agricultural sector, market garden crops play an important role in human nutrition, and are an effective response to urban food demand [6].

However, the income generated by market gardening enables several hundred families to meet their daily needs, contributing to the integration and poverty reduction of rural populations [7].

In Côte d'Ivoire, market garden crops are characterized by a diversification of cultivated species, for which demand continues to grow [8]. The consumption of fruit and vegetables is recommended in several countries as a means of protecting against diseases such as obesity, cancer and cardiovascular disease, and the benefits of their fiber are also recognized for their contribution to the balance of intestinal flora [9].

One of the world's most popular and widely consumed vegetables is lettuce (*Lactuca sativa*), which has become an integral part of the Abidjan

(Côte d'Ivoire) diet [10]. This being said, market garden crops face enormous constraints, including those linked to land tenure (precarious rental status, scarcity of available land), the precariousness and vulnerability of production systems [11], insect attacks and pathologies affecting the qualitative and quantitative yield of produce [12], the marketing of agricultural produce and, above all, insalubrity and pollution due to the presence of uncontrolled landfill sites on market garden crop sites.

To this end, the popularization of this activity needs to be accompanied by a database to predict how it might contribute to food security. However, data on certain market gardening sites are insufficient or sometimes non-existent. The present work is an introduction to the study of urban agriculture in Côte d'Ivoire.

The principal objective of this study is to inventory cultivated plant species and characterize agricultural practices, then to identify production sites at risk (sites with uncontrolled landfills on which market garden produce is grown).

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study area is the district of Abidjan, the economic capital of Côte d'Ivoire, which comprises ten communes and three sub-prefectures. The city of Abidjan is located on the coast along the Ebrié lagoon. It covers an area of 58,000 ha, including 9,000 ha of lagoons (16%) and 49,000 ha of dry land (84%). It lies between 4°10 and 5°30 north latitude and 3°50 and 4°10 west longitude [13]. It is covered by a climate of

two rainy seasons and two dry seasons, driving leachate deep into the soil via infiltration. Climatic forecasts for the first rainy season, from March to June 2023, indicate a 45% chance that seasonal accumulations will be surplus (rainfall amounts will range from 417 to 865 millimeters over the period March to July 2023). Temperatures range from 23 to 32°C [14]. The hydromorphic soils in the south are permeable and contain a lot of water. Between 1998 and 2021, the population of Abidjan rose from 312,5090 to 6,321,012. The growth rate is 2.9% [15]. Easy access to water makes the city of Abidjan ideal for market garden production, supplying the population with fresh vegetables [16]. The present study consisted of a multiple-choice survey of 400 market gardeners and took place at six (6) market garden sites in the Abidjan district (site 1: Abobo - Akeikoi village, site 2: Bingerville - Bingerack city, site 3: Cocody - M'pouto village, site 4: Cocody - M'badon village, site 5: Port-bouët - 4ème bima and site 6: Port-Bouët - Mafiblè village). The choice of these locations was based on the following criteria: ease of access to the population, importance of market gardening activities, diversity of market garden produce on the sites and uncontrolled landfill on or near the sites.

2.2 Data Collection

A total of 400 market garden producers from the six study sites were interviewed.

The study itself was suitably preceded by an exploratory phase to list the sites of major market-garden crop production and nearby uncontrolled landfill sites over a 12-month period (from January 2021 to January 2022). This enabled us to draw up a survey sheet. These six (6) sites were selected because of the importance of their market garden production and the omnipresent insalubrity on these sites. All the plots under cultivation and their proximity to uncontrolled landfill sites were inspected several times [4]. At each farm site, the survey questionnaire was sent to the farm manager or his representative. This approach provides a better understanding of the knowledge, attitudes, practices and perceptions of the individuals targeted in relation to the questions asked [16]. The various data collected concerned the socio-demographic characteristics of the growers (nationality, gender, age, level of education, type of training, number of years' experience, living environment, waste disposal method), the

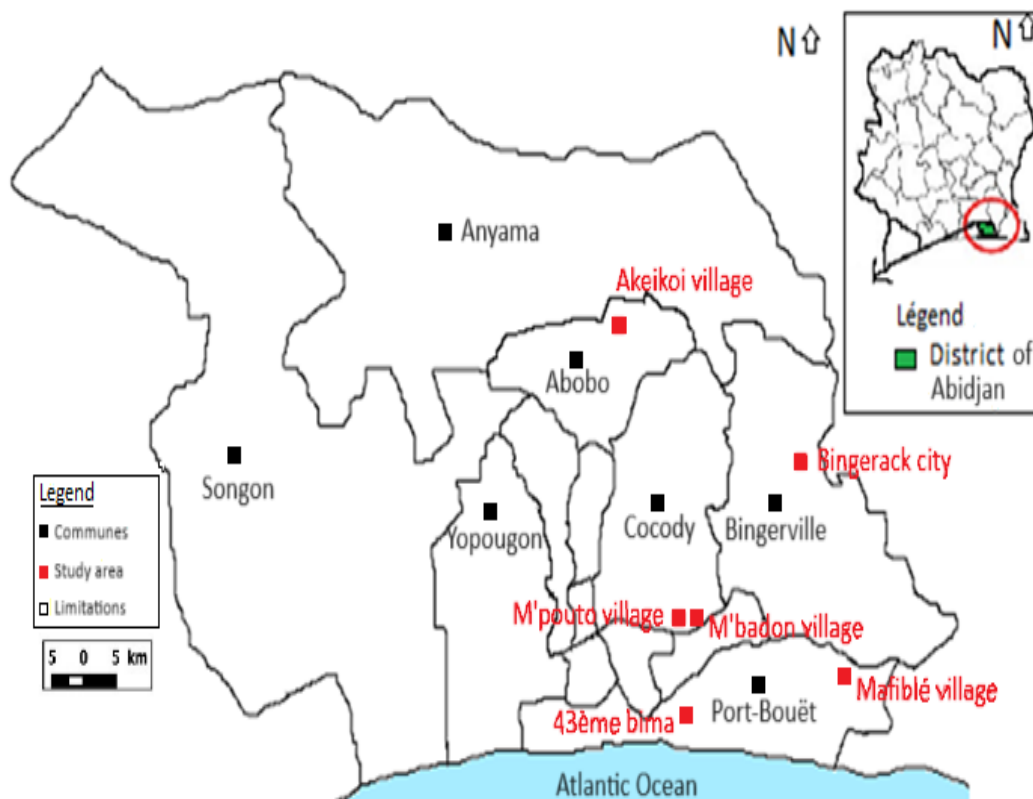


Fig. 1. Map illustrating the six (6) study areas identified in the Abidjan district (Côte d'Ivoire)

characteristics of the various farms (diversity of vegetables grown, cultivation techniques, cropping calendars, quantity produced), the nuisance caused by uncontrolled landfill (illnesses and diseases, frequency of illnesses and diseases and quality of market garden produce).

2.3 Data Collection Tool

The survey covered a total of 400 individuals, which corresponds to the sample size obtained using a formula developed by Dagnelie [17]. This mathematical formula is as follows :

$$n = z^2 \times p (1 - p) / m^2 \quad (1)$$

Where :

sample size = n, confidence level according to the reduced centered normal distribution = z (for a confidence level of 95 % in this study, $z = 1.96$; for a confidence level of 99 %, $z = 2.575$), estimated proportion of the population with the characteristic = p (when p is unknown, $p = 0.5$ is used, which corresponds to the worst case or widest spread), tolerated margin of error = m (in this study, we want to know the real proportion to within 5 %).

This formula determines the number of people n to be questioned as a function of the margin of error m that can be tolerated on a proportion of responses p.

The proportions of the various characteristics in this study were calculated using the percentage formula in Excel. The formula is as follows

$$p = (e / et) \times 100 \quad (2)$$

Where :

proportion of the characteristic (%) = p,
number of people for the characteristic = e,
total number of people surveyed = et,
percentage coefficient = 100

This number was allocated as follows: 280 men, 120 women, including 92 Ivorians and 308 foreigners. In addition, this choice took into account the quotas of statistical data on the populations of the sites identified in the district of Abidjan.

2.4 Statistical Processing of Data

The use of Google Maps software enabled us to locate and position our sites in order to map

them. The survey forms were analyzed using Google Forms and Excel for the quantitative survey. The first stage involved the use of Google Forms. In the second stage, using Excel, the results were presented in the form of sectors and histograms. For the qualitative survey, the semi-structured interviews were transcribed. The survey data were supplemented by direct observations of the crops on the beds, the scientific names of which were determined according to the nomenclature in [18].

3. RESULTS

3.1 Socio-Demographic Characteristics

The socio-demographic results of the market gardeners surveyed show that 77% of the market gardeners are foreigners (mostly of Burkina Faso and Mali nationality). Only 23% of the growers surveyed were natives (Table 1). The 20-30 age group is the most represented with 46%, followed by the 10-20 age group with 24%. These two age groups (10-20 and 20-30) alone account for 70% of market gardeners. Table 1 also shows that market gardening is predominantly practiced by men (70%), compared with only (30%) of women. Up to 62% of market gardeners are illiterate. However, 38% of growers claim to have attended school, albeit at a very low level (Table 1). Most growers are therefore unaware of the risks of contamination caused by market garden crops grown near uncontrolled landfill sites.

3.2 Diversity of Market Garden Crops Cultivated

Table 2 shows that the market garden crops produced are made up of seven species of leafy vegetables (basil, cabbage, vegetable cornet, spinach, onion leaf, lettuce, parsley), which are the most abundant (68%), and six species of fruiting vegetables (carrot, aubergine, chilli, pepper, turnip, tomato), which are less abundant (32%). These thirteen species in total come from eight different families. The Solanaceae family is the most represented, with four species, or 50% of all families. These species are all fruiting vegetables (representing 2/3 of fruiting vegetables) (Fig. 2.). In short, lettuce production accounts for 22% of crops on the different sites, because of its high profitability, especially during the rainy season. Next come basil, aubergine and onion leaf, with proportions of 18%, 12% and 10% respectively. These crops alone account for 62% of market garden production at all the sites

identified. Other crops such as cabbage, peppers and tomatoes accounted for only 2% each.

3.3 Cultivation Characteristics

Table 3 shows that the number of crops produced varies from 1 to 5, depending on the grower and given the limited financial resources and access to land at the various sites. The crops have cycles ranging from 21 to 70 days, with the exception of carrots and tomatoes, which have cycles of 80 and 120 days respectively. The results of the survey also revealed three cropping systems: crop association (which consists of associating species or varieties grown on the same area), crop rotation (successive and alternating cropping methods on the same plot of land to conserve soil fertility) and monoculture (growing a single plant and a single product). They are practiced according to the species grown. According to Table 3, almost all the species grown are in monoculture and crop rotation, with only basil grown in association, either with onion leaf, lettuce or parsley. Cabbage, vegetable marrow and spinach are only grown in rotation with lettuce [2]. The only means of watering crops observed during the field survey was the use of dug wells.

3.4 Nuisances and Illnesses Linked to Uncontrolled Landfill Sites

The results of the study show that the local population, consumers and market gardeners are strongly affected by the presence of uncontrolled landfill sites, which have a negative impact on the living environment, product quality, market garden production and, consequently, on the health of the population. Indeed, these populations are exposed to foul smells emanating from dumps [19], and to diseases and symptoms associated with the microbiological composition of urban waste (acute diarrhea, typhoid fever, malaria, cholera, conjunctivitis, pulmonary infections). There are also mosquitoes, rodents, insects and flies that shuttle back and forth between unauthorized dumps, residents' homes and market gardens. According to the field survey, the populations living near and consuming market garden produce from the various sites identified (exposed populations) have a higher incidence of illness than unexposed populations. Seventy per cent of the exposed population said they felt ill after consuming market garden produce from the identified sites. 60% said they fell ill more than twice a month.

Table 1. Socio-demographic characteristics of market garden producers surveyed

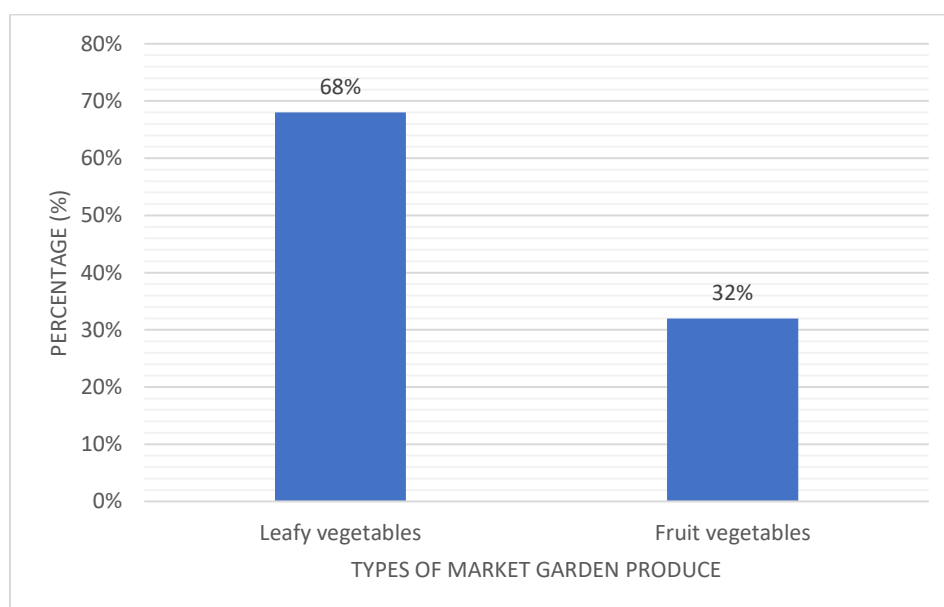
Characteristics	Headcount	Proportion (%)
Sex		
Men	280	70
Women	120	30
Total	400	100
Age		
10-20 years old	96	24
20-30 years old	184	46
30-40 years old	84	21
> à 40 years old	36	09
Total	400	100
Nationality		
Ivorians	92	23
Foreigners	308	77
Total	400	100
Level of study		
Primary	112	28
Secondary	36	9
Higher	4	1
No schooling	248	62
Total	400	100

% : Percentage

Table 2. Market garden products inventoried at the different sites

Organ consumed	Common name	Scientific name	Family	Site	Fréquency (%)
Leaves	Basil	<i>Ocimum basilicum</i>	Lamiaceae	All sites	18 %
	Cabbage	<i>Brassica oleracea</i>	Brassicaceae	Port-Bouët – 43rd Bima	2 %
	Vegetable cortea	<i>Corchorus olitorius</i>	Malvaceae	Port-Bouët – 43rd Bima Bingerville	4 %
	Spinach	<i>Spinacia oleracea</i>	Chenopodiaceae	Port-Bouët – 43rd Bima Cocody – M'badon	6 %
	Onion leaf	<i>Allium fistulosum</i>	Alliaceae	All sites	10 %
	Lettuce	<i>Lactuca sativa</i>	Asteraceae	All sites	22 %
	Parsley	<i>Petroselinum crispum</i>	Apiaceae	Port-Bouët – 43rd Bima Cocody - M'pouto	6 %
Fruits	Carrot	<i>Daucus carota</i>	Apiaceae	Port-Bouët – 43rd Bima Abobo	4 %
	Aubergine	<i>Solanum. melongena</i>	Solanaceae	Abobo Port-Bouët – 43rd Bima Cocody - M'pouto Cocody - M'badon	12 %
	Chilli	<i>Capsicum annum</i>	Solanaceae	Port-Bouët – 43rd Bima Port-Bouët - Mafiblé	6 %
	Sweet pepper	<i>Capsicum</i>	Solanaceae	Port-Bouët – 43rd Bima	2 %
	Turnip	<i>Brassica rapa</i>	Brassicaceae	Port-Bouët – 43rd Bima Port-Bouët - Mafiblé	6 %
	Tomato	<i>Solanum Lycopersicon</i>	Solanaceae	Port-Bouët – 43rd Bima	2 %

% : Percentage

**Fig. 2. Repair of market garden produce by type of product**

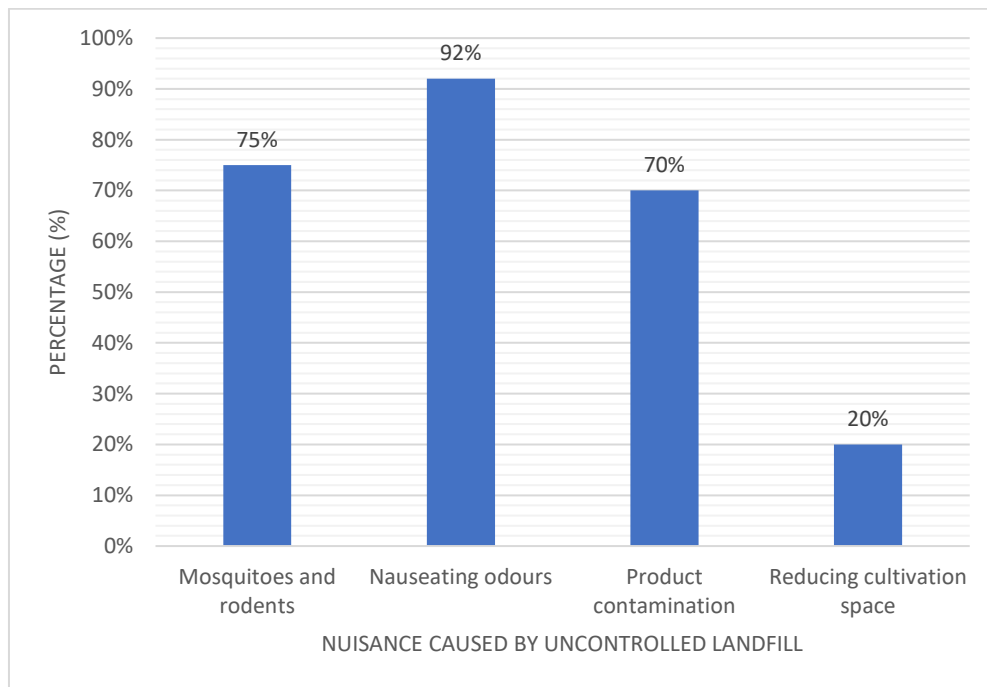


Fig. 3. Nuisance caused by uncontrolled landfill on cultivation sites

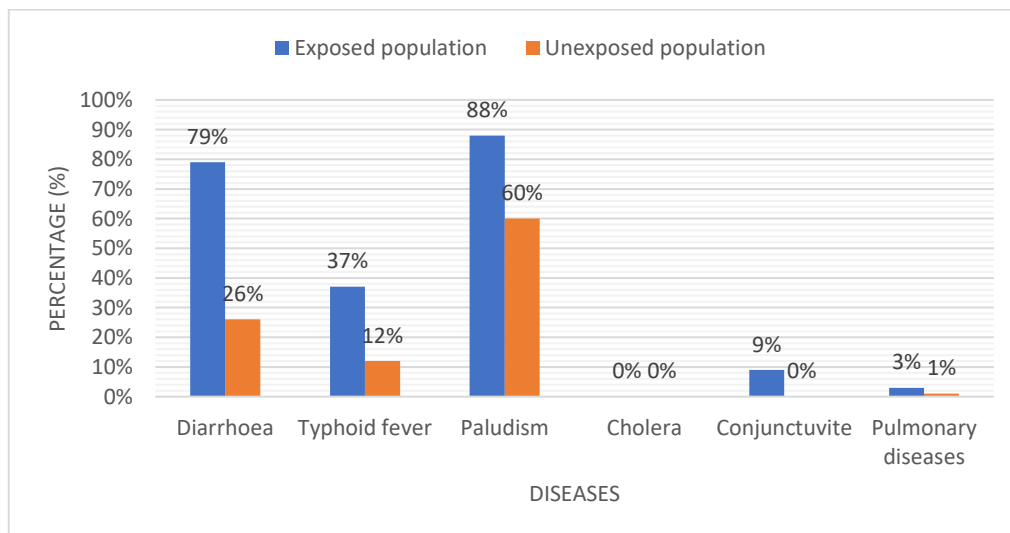


Fig. 4. Frequency of diseases depending on the populations surrounding and consuming them

4. DISCUSSION

4.1 Socio-Demographic Characteristics

The practice of market garden crops in the district of Abidjan contributes in an urban environment to the fight against poverty and environmental sanitation by increasing the sources of income of poor populations living in precarious neighborhoods. This finding is compatible with that of several authors who have

confirmed that market garden crops largely dominate agricultural activities in urban areas because of their major contribution to improving people's living conditions, given their important role in socio-economic life [20, 21]. In the 6 market garden sites identified, 400 market gardeners, regardless of sex or age, were interviewed on the basis of their availability. Of these, 280 were men and only 120 women, representing proportions of 70 % and 30 % respectively. The arduous practice of irrigation,

dominated by manual work, justifies the low representation of women in market garden practice. In Baguineda, Mali, 76.19 % of men grow market garden crops, compared with 23.8 % of women [22]. These results corroborate those of another study carried out in Abidjan, where 77.98 % of market gardeners were men and 22.02 % were women [23]. The greater presence of men could be explained by the existence of men's market garden groups from neighboring countries in Abidjan since the 1990s.

In all 6 sites, 70 % of market gardeners were between 10 and 30 years old (the most dominant age bracket). Similarly, the results of Bancal et al [23] in Côte d'Ivoire and Samake et al [22] in Mali showed that 68.6 % of market gardeners were aged between 15 and 35, and 41.7 % were aged 35 or under (the most dominant age category). The predominance of young people in the activity can be explained by their return to the land due to the lack of work paying monthly wages.

Surveys revealed that 77 % of market gardeners are non-Ivorians, the majority of whom are from Burkina Faso, compared with only 23 % who are Ivorians. This is due to the migration of young foreigners who come specially to practice this activity in the city of Abidjan. In this sense, Hien et al [24] confirm that in Abidjan, market garden crops are mainly grown by foreigners, especially Burkinabés and Malians, who account for around 65 % of the total. The large number of foreigners working in this activity is justified by the fact that they were originally agricultural producers [25].

The low level of education among market gardeners in Abidjan could be due to the fact that

market garden crops do not require any particular qualifications. In Senegal and Abidjan, market garden crops are grown predominantly by people from immigrant backgrounds who have no other vocational qualifications [24, 26].

4.2 Diversity of Market Garden Crops Cultivated

The survey results show a diversity of cultivated species, with 13 market garden products listed, divided into 2 genera and 8 families. This diversity is linked to massive consumer demand, and in particular to the great diversity of cultural communities [27]. The diversity of vegetable species is also explained by the diversity of organs sought for their nutritional and therapeutic qualities [28]. The fact that market garden crops are dominated by lettuce and basil is partly due to Abidjan's favorable climate, which means that these leafy vegetables have to be grown and are therefore profitable on the market, and partly due to the facility of production associated with their short cycle time. Moreover, leafy vegetables are the most cultivated, given the predominance of eating leafy foods among most people in Côte d'Ivoire and West Africa in general [2]. Furthermore, the low production of these crops (cabbage, sweet pepper, tomato, etc.) is due to the fact that they are mainly in demand only during the festive periods. In fact, the percentage occupied by each crop varies according to the time of year. In addition, the type and number of crops vary from one farmer to another, depending on financial resources and access to land.

Table 3. Cropping system and cycle length of market garden produce

Market garden product	Cropping system	Cycle length (days)
Basil	Association	21 days
Cabbage	Crop rotation	38 à 70 days
Vegetable cortea	Crop rotation	60 à 70 days
Spinach	Crop rotation	60 à 70 days
Onion leaf	Association- Crop rotation-Monoculture	21 days
Lettuce	Association- Crop rotation-Monoculture	21 à 45 days
Parsley	Association-Crop rotation-Monoculture	21 days
Carrot	Crop rotation -Monoculture	60 à 80 days
Aubergine	Crop rotation -Monoculture	60 days
Chilli	Crop rotation -Monoculture	60 days
Sweet pepper	Crop rotation -Monoculture	60 days
Turnip	Crop rotation -Monoculture	60 days
Tomato	Crop rotation -Monoculture	60 à 120 days

4.3 Cultivation Characteristics

However, an analysis of growers' practices on market garden sites in the Abidjan district reveals behaviors that are not without consequences for city populations. Growers' increased use of untreated wastewater and pesticides exposes the entire chain to many health risks, like skin irritation, headaches, coughing, dizziness, respiratory problems, diarrhea and so on. The high level of analphabetism and the absence of training programs on good urban farming practices could explain the behavior of producers [29]. They are unaware of the risks of contamination due to market garden practices and therefore of their responsibility in the chain of health risks [30]. Market gardeners refuse to accept a possible link between the use of waste water, dangerous pesticides, pollutants from uncontrolled landfill sites and certain diseases [31]. However, those who are conscious of the potential risks to public health underestimate them and prioritizes the economic benefits [32].

4.4 Nuisances and Illnesses Linked to Uncontrolled Landfill Sites

The major constraints on market garden production (caused mainly by the presence of uncontrolled landfill sites) are insects, nematodes, pathogens, including fungi, and above all heavy metals. The latter are very dangerous and are known to accumulate in leafy vegetables. These comments are supported by Yehouenou et al [33] in their study of market garden crops grown on the Houéyiho compost site in Benin, who assert that market garden produce grown on the Houéyiho market garden site is contaminated by heavy metals because the soils on which the various market garden crops are planted are heavily contaminated by the heavy metals contained in the compost used on the site. Work by Yehouenou et al [34] on the same site showed high concentrations of heavy metals in the soil due to the storage of household waste on the site by market gardeners to extract organic fertilizers.

According to the WHO [35], 600 million people - almost one in 10 worldwide - fall ill each year after eating contaminated food, 420,000 die and 33 million healthy years of life are lost as a result. Unsafe food costs low- and middle-income countries around \$110 billion a year in lost productivity and health costs. Food-borne diseases hamper socio-economic development by placing heavy demands on healthcare

systems, and by damaging national economies, tourism and trade. That said, eliminating uncontrolled landfill sites, combining certain farming practices such as crop rotation, physical protection (insect netting) and the use of pesticide plants (any plant whose chemical properties can be used to combat organisms considered harmful and therefore likely to significantly reduce the pressure of bio-aggressors and the need for synthetic pesticides) can also help to increase market garden yields and protect people's health.

5. CONCLUSION

This work made it possible to map the market garden sites and uncontrolled landfill sites, to make an inventory of the market garden species grown on these different sites and to identify production constraints. Market garden production is dominated by leafy vegetables (lettuce, basil) at all the sites identified, and not only ensures food security but also provides a source of cash for the local population. Nevertheless, it faces a number of difficulties, the main ones being attacks by insects, rodents, nematodes, fungi and the accumulation of heavy metals from uncontrolled landfill sites. Chemical control is still the most common method of combating these problems. To promote market garden crops, to enable urban or peri-urban agriculture to achieve its objectives and to ensure the health of the population, it is important to act as quickly as possible on these constraints.

CONSENT

All market garden producers gave their informed consent before participating in the study and completed the questionnaires on the study survey form.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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