



# Tomato Growers' Perception of Parasitic Wilt Diseases and the Impact of Cultural Practices on the Management of these Diseases in Côte d'Ivoire

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## Authors' contributions

*This work was carried out in collaboration among all authors. Author YK conceived the study, performed the statistical analysis, drafted the protocol and wrote the first draft of the manuscript. Author ALDGE participated in the study design, funding acquisition, and wrote. Authors TS, YYS and TGH contributed to the write and revision of the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** Analyze cultivation practices, grower's perception of parasitic wilt diseases to identify the limitations of current approaches and proposing sustainable agroecological alternatives.

**Study Design:** Tomatoes are one of the most important vegetable crops in Côte d'Ivoire and are widely consumed in daily meals. However, its production faces major constraints, notably parasitic wilt diseases, which limit its ability to meet the growing demand for this commodity.

**Place and Duration of Study:** Sample: the main tomato production zones, covering five agro-ecological zones (AEZs) in Côte d'Ivoire, between February and August 2024.

**Methodology:** A semi-structured questionnaire survey was carried out among 150 growers in the main tomato-growing areas of Côte d'Ivoire. The information gathered included farmers' socio-economic characteristics, crop practices, and perceptions related to parasitic wilt. These data were supplemented by field observations and then subjected to descriptive analysis and Hierarchical Ascending Classification (HAC) using R 4.4.1, in order to characterize production systems.

**Results:** The results revealed that 81.51% of growers, mostly men ( $p < 0,001$ ), recognized tomato wilt through symptoms such as thinning of the crown. Among them, 38.66% attributed its appearance to the practice of monoculture. Typological analysis enabled us to group production systems into four distinct categories. Although agroecological practices such as crop rotation and organic fertilization are crucial, they remain little, if at all, adopted by growers. Furthermore, the heavy reliance on chemical fertilizers and pesticides, combined with the lack of recourse to biological control, represents a major challenge for a transition to sustainable agroecological systems.

**Conclusion:** This study highlights the need for increased awareness among growers to recognize parasitic wilt and for technical support to promote sustainable practices, including the use of biocontrol agents, to improve productivity while preserving agriculture.

*Keywords: Socio-demographic characteristics; perceptions; cultural practices; tomato; Côte d'Ivoire.*

## 1. INTRODUCTION

The agricultural sector plays a crucial socio-economic role in Côte d'Ivoire. Historically, this sector has always occupied a central place in the country's economy and development, whether in terms of the agricultural workforce or its contribution to wealth creation in the country (Ducroquet et al., 2017). According to Kouakou (2017), agriculture accounts for 30-50% of GDP (Gross Domestic Product) and provides around 80% of the country's population with a source of income. Like other countries in the sub-region, food requirements are constantly increasing as the population grows. As a result, protein crops and truck farm produce are essential crops (FAO, 2009). The tomato (*Solanum lycopersicum* L.) is one of the world's most important vegetable crops due to its high nutritional value and its contribution to the food and economic security of rural populations (FAO, 2021). In Côte d'Ivoire, this crop plays a crucial role in diversifying farm incomes and improving livelihoods, particularly in peri-urban, urban, and rural areas. Indeed, it provides employment opportunities for thousands of families involved in the various stages of the value chain, from production to trade on local markets (Camara, 2021).

However, despite its economic and social importance, national production remains well below the country's growing needs, leading to heavy dependence on imports to make up the deficit (USDA, 2024). This situation is exacerbated by multiple constraints, including climate hazards, diseases, and pests. Among these major threats, parasitic wilt of fungal and bacterial origin considerably reduces yields, thus compromising the economic viability of farms (Ouattara et al., 2017). Indeed, according to these authors, these diseases can lead to incidence rates ranging from 40% to 60% depending on the region. At the same time, climatic hazards such as irregular rainfall, heat waves, droughts, and floods aggravate producers' difficulties. These phenomena lead to the appearance of diseases and shorten the production period.

These current challenges are aggravating yield losses, deteriorating soil fertility, and intensifying parasitic infestations, particularly of telluric origin. Moreover, research into the impact of cultural practices on the sustainable management of wilt diseases is still limited, particularly in tomatoes. In this context, it is essential to examine the socio-demographic factors and farm

characteristics influencing growers' resilience to these challenges. The general objective of this study is to analyze the management of wilt diseases in tomatoes in Côte d'Ivoire through the cultural practices adopted by growers despite these constraints. A better understanding of these dynamics will enable us to propose appropriate strategies aimed at improving the productivity and profitability of the tomato sector in Côte d'Ivoire.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was conducted in the main tomato production zones, covering five agro-ecological zones (AEZs) in Côte d'Ivoire (WDPA, 2018). This study area includes five regional capitals, one for each agro-ecological zone (Fig. 1). These study sites were chosen on the basis of the importance in terms of production and density of peripheral tomato-producing localities. Localities

in the regional capitals of Abidjan (AEZ I), Daloa (AEZ II), Yamoussoukro (AEZ IV), Bouaké (AEZ V), and Korhogo (AEZ VI) were selected as survey sites (Table 1).

### 2.2 Producer Sample Size and Data Collection

A sample of 150 growers was selected and divided into 30 active growers at each study site. Data were collected during the main vegetable production season, from February to August 2024. Surveys combined semi-structured interviews and direct field observations with resource growers heavily involved in tomato cultivation. The information gathered focused on the socio-demographic characteristics of producers (gender, age, ethnic group, level of education, etc.), their production resources (area-age, ecological site, mode of farm acquisition), their cultivation practices (pest control methods, watering, fertilization, etc.), and their perception of parasitic wilt.

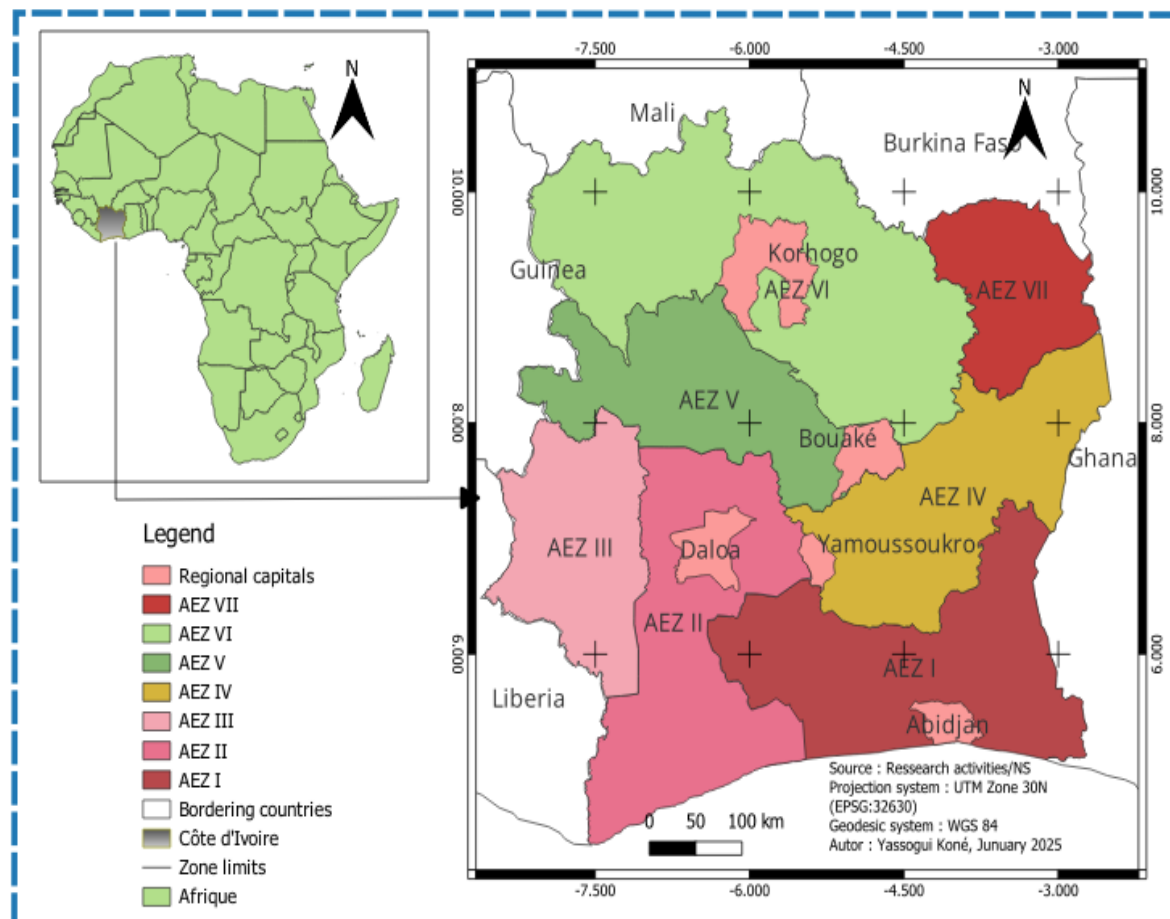


Fig. 1. Map of Côte d'Ivoire, showing the study area

**Table 1. Significance and characteristics of Côte d'Ivoire's agro-ecological zones (FAO, 2015; Fondio et al., 2016; Ducroquet et al., 2017; WDP, 2018)**

No	Names of AEZs	Climate type	Average Annual Rainfall (mm)
I	Equatorial coastal	Equatorial	1673
II	Forest transition zone	Subequatorial	1176
III	Forest zone	Hot and humid	1 775
IV	Guinean savannah zone	Tropical transition	1157
V	Savannah-forest transition Zone	Tropical de transition	1075
VI	Savannah zone	Tropical savannah	1204
VII	Sudano-guinean zone	Tropical Humid	1100

### 2.3 Statistical Analysis

Data were collected, centralized, entered in Excel, and then processed and analyzed using R (version 4.4.1). The Chi-Square test was used to test associations between growers' socio-demographic characteristics, cropping practices, and perception of wilt management. A multivariate analysis was also carried out (Hierarchical Ascending Classification (HAC) to establish a typology of production systems.

## 3. RESULTS

### 3.1 Socio-Demographic Characteristics of Tomato Growers and Farms

#### 3.1.1 Socio-demographic characteristics of tomato growers

Tomato production at the sites visited was predominantly carried out by men, with a proportion of 90% versus 10% by women ( $P = 0,001$ ). In this study, the average age of tomato growers was 37, corresponding to the 36-50 age bracket. This was the most represented category, accounting for 52.67% of growers, followed by those under 36 (41.33%) ( $P = 0,001$ ). Over 70% of growers are married, at least according to local custom. Ethnically, the Sénoufo and Baoulé groups are dominant, accounting for 36.67% and 32.67% of growers respectively (Table 2). Among the tomato growers surveyed, 46% were illiterate, 39% had primary education and 23% had secondary education (Table 3). In terms of experience and organization, 94% of growers had less than 11 years of farming experience and only 17.33% belonged to an agricultural cooperative.

#### 3.1.2 Characteristics of tomato farms

An analysis of farm characteristics revealed that most cultivated land and production activities are

located in rural areas, representing 78 % ( $P < 0,001$ ). The average size of tomato farms was 2351 m<sup>2</sup> and most farms covered areas of less than or equal to a quarter (1/4) hectare. Farms covering areas of between 1/4 and 1/2 ha and those larger than 1/2 ha, accounted for 15.33 %. On average, these farms have been in existence for 9 years. Plots less than 11 years old were the most common, accounting for 81,33 % of cases, followed by those between 11 and 20 years old. The majority (82,67 %) of tomato crops were planted on firm land, while 15,33 % were located in lowlands and 2% in soilless conditions. Plots were mainly acquired by rental (34,67 %) and inheritance (34,00 %), while loan (10,67 %) and purchase (2,67 %) were rarer modes of acquisition (Table 4).

### 3.2 Growers' Knowledge of the Symptoms and Origins of Parasitic Wilt in Tomatoes

#### 3.2.1 Symptomatology of parasitic wilt diseases

Of the growers surveyed, 79.33% claimed to be familiar with parasitic wilt (Fig. 2). The symptoms most frequently cited by these growers to identify this disease were thinning of the crown (20.55%), irreversible wilting (18.22%), presence of mycelium on stems, and yellowing of leaves (16.53%). A further 10.17% of growers mentioned the presence of sclerotia and 6.99% reported bulges on the stem. However, leaf curling and browning were the least frequently mentioned symptoms, each cited by 5.51% of growers (Table 5).

#### 3.2.2 Origin and events preceding the appearance of parasitic wilt diseases

Analysis of the results showed that over 81% of growers felt that parasitic wilt diseases were

closely linked to soil characteristics. On the other hand, a minority of 0.84% attributed the origin of the disease mainly to the water used to irrigate the plots (Fig. 3).

**Table 2. Socio-demographic characteristics of tomato growers in Côte d'Ivoire**

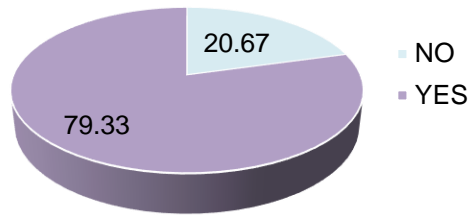
	<b>Modalities</b>	<b>Numbers</b>	<b>Percentage (%)</b>	<b>P-value</b>
Gender	Female	15	10,00	0,000
	Male	135	90,00	
Age(years)	< 36	62	41,33	0,000
	36-50	79	52,67	
	> 50	9	6,00	
Status	Single	44	29,33	0,000
	Married	106	70,67	
Ethnic groups	Baoulé	49	32,67	0,000
	Sénoufo	55	36,67	
	Foreign	24	16,00	
	Other	22	14,66	

**Table 3. Distribution of producers by level of education**

	<b>Modalities</b>	<b>Numbers</b>	<b>Percentage (%)</b>	<b>P-value</b>
Level of education	Primary	39	26,00	0,000
	Secondary	23	15,33	
	Higher	19	12,67	
	Illiterate	69	46,00	
Agricultural experience (years)	≤ 10	94	62,67	0,000
	11_20	31	20,67	
	≥ 20	18	12,00	
	No	7	4,67	
Cooperative membership	None	124	82,67	0,000
	Yes	26	17,33	

**Table 4. Distribution of producers according to production resources**

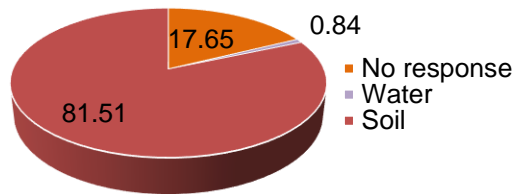
<b>Farm characteristics</b>	<b>Modalities</b>	<b>Numbers</b>	<b>Percentage (%)</b>	<b>P-value</b>
Production environment	Rural	117	78,00	0,000
	Urban	33	22,00	
Area	≤1/4ha	104	69,33	0,000
	1/4-1/2ha	23	15,33	
	>1/2ha	23	15,33	
Age of Farm	≤ 10	122	81,33	0,000
	11-20	21	14,00	
	≥ 21	7	4,67	
Ecological site of farms	Lowland	23	15,33	0,000
	Off-ground	3	2,00	
	Dry land	124	82,67	
Type of plot acquisition	Purchase	4	2,67	0,000
	Gift	27	18,00	
	Inheritance	51	34,00	
	Rental	52	34,67	
	Loan	16	10,67	



**Fig. 2. Proportion of growers recognizing parasitic wilt disease**

**Table 5. Symptoms of wilt recognition by growers**

Symptoms	Numbers	Percentage (%)	P-value
Leaf yellowing	78	16,53	0,000
Leaf browning	26	5,51	
Leaf incurvation	26	5,51	
Stem bulges	33	6,99	
Presence of mycelium on the plant	78	16,53	
Presence of sclerotia on crown	48	10,17	
Thinning of crown	97	20,55	
Irreversible wilting	86	18,22	



**Fig. 3. Origin of parasitic wilt**

Growers identified several factors to explain the appearance of parasitic wilt on tomato farms (Table 6). The majority considered that monoculture was the main cause of the disease, followed by variety change, with proportions of 35.61% and 31.30% respectively. In addition, 20.61% of growers reported the appearance of parasitic wilt after plot flooding or excess soil moisture. A minority of growers, 8.40% and 4.40%, respectively, associated wilting with weeding practices and the presence of insects in their plots.

### 3.3 Growers' Perceptions of the Impact of Agricultural Practices on the Management of Parasitic Wilt in Tomatoes

#### 3.3.1 Use of wilt-resistant varieties

The tomato variety most cultivated by growers was Cobra 26, with a proportion of 76%, followed

by IC (10%) ( $P = 0,000$ ). Other varieties, such as Amiral, Panthère, Patmate and Rajah F1, were marginal (Fig. 4). However, 93.28% of growers rated Cobra 26 as the most disease-tolerant variety compared with others. A small proportion of 4.2% of growers considered that there were no varieties resistant or tolerant to parasitic wilt, while 2.52% felt that the rajah F1 variety was the most tolerant (Fig. 5).

#### 3.3.2 Use of various agronomic methods against parasitic diseases

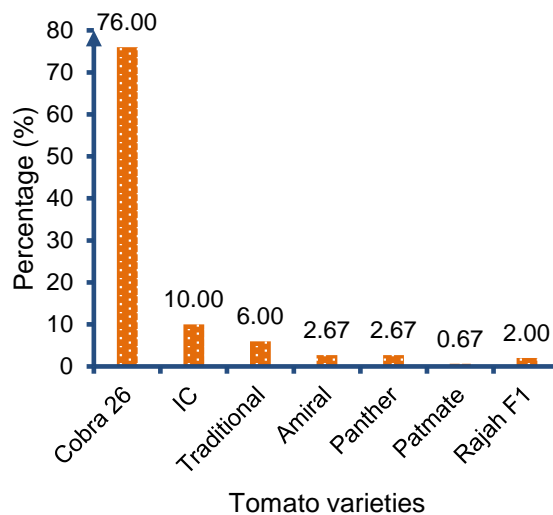
Table 7 shows the proportion of growers according to the cultivation practices adopted. To control parasitic wilt, 65.34% of growers opted mainly for systematic plant uprooting. However, 27.33% of growers did not implement any specific measures to manage infected plants. After harvesting, most growers (71.99%) left agricultural residues in place, while 15.33%

preferred to burn them and 12.6% collected them and deposited them outside the fields. Conversely, crop rotation was adopted by 56.67% of growers, while 43.33% practiced monoculture in terms of fertilization, a large majority (90.67%) of growers favored the use of chemical fertilizers ( $P < 0,001$ ). Organic fertilization, although less frequent, was used by

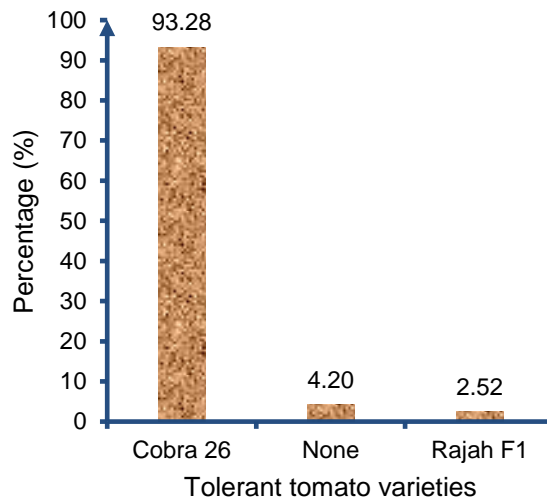
35.33% of growers, often in the form of beef or chicken droppings. With regard to crop protection against pests, 89.33% of growers used synthetic chemical pesticides, compared with 10.67% who did not. However, no biological control alternatives, such as the use of natural pesticides, were mentioned against tomato pests and diseases (Table 7).

**Table 6. Growers' perception of the causes of disease appearance**

Modalities	Numbers	Percentage (%)	P-value
Change of Variety	41	31,30	0,000
Presence of insects	6	4,40	
After weeding	11	8,40	
Monoculture	46	35,11	
Flooding	27	20,61	



**Fig. 4. Tomato varieties grown on farms**



**Fig. 5. Tomato varieties tolerant to parasitic wilt**

**Table 7. Proportion of growers according to cultivation practices adopted**

Cultivation practices	Modalities	Numbers	Percentage (%)	P-value
Management methods for infested plants	Uprooting	98	65,34	0,000
	None	41	27,33	
	Other	11	7,33	
Agricultural residue management methods	None	108	71,99	0,000
	Off-field	19	12,67	
	Burning	23	15,33	
Water supply mode	Manual watering	74	49,33	0,000
	Gravity irrigation	3	2,00	
	Rainfed	73	48,67	
Crop association	No	136	90,67	0,001
	Yes	14	9,33	
Crop rotation	No	65	43,33	0,10
	Yes	85	56,67	
Use of mineral fertilizer	No	4	2,67	0,000
	Yes	146	97,33	
Use of organic manure	No	97	64,67	0,000
	Yes	53	35,33	
Use of synthetic chemical	No	16	10,67	0,000
	Yes	134	89,33	

### 3.3.3 Use of synthetic chemical pesticides on tomato farms

#### a. Synthetic pesticides used against parasitic wilt

Regarding the means of controlling parasitic wilt by treatment, 86.56% of growers identified no curative treatment. However, some growers stated that the early use of products such as callicopper (13.44%) and maneb (7.56%) from the nursery reduced the rate of attack on seedlings in the plantation (Fig. 6).

#### b. Families and active substances of pesticides used against various tomato pests and parasites

Table 8 shows the families and active ingredients of pesticides used by growers. A total of 7 active ingredients of pesticides used in nurseries and six in plantations were identified. Of these, acetamiprid was the most commonly used in plantations (29.84%) and nurseries (21.05%). On the other hand, mancozeb and abamectin, used exclusively in plantations, were also very frequent, with proportions of 28.63 and 25.00% respectively. Cypermethrin (5.24%), metalaxyl-M (2.82%), and acetaminophen (1.21%) were specifically used in plantations, while fipronil (23.68%), lambda-cyhalothrin (13.16%),

deltamethrin (13.16%) and carbosulfan (18.42%) were reserved for nurseries. Copper oxychloride was used in both nurseries (5.24%) and plantations (10.53%). In general, the chemical families most in demand included neonicotinoids (28.67%), dithiocarbamates (24.83%), avermectin (21.68%) and pyrethroids (9.79%).

#### c. Targets for pesticides used on farms

On tomato farms, the phytosanitary products used by growers were mainly aimed at mites (33.53%) and fungi (27.19%). However, in nurseries, particularly for substrate disinfection, 66.67% of growers indicated that crop protection products were used mainly against insects, while 17.65% applied them to target nematodes. In nurseries and plantations, few growers use nematicides and bactericides (Table 9).

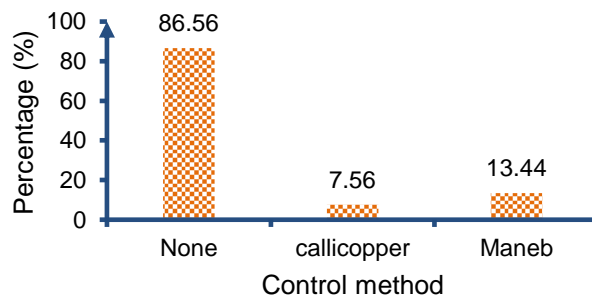
### 3.4 Typology of Tomato Farms According to Cultivation Practices

Fig. 7 shows the hierarchy ascending classification of the typology of tomato growers surveyed in this study. Four types of tomato farms were identified. Classes 1 and 4 were the most represented, accounting for 46.66% and 30.67% of growers, respectively ( $P < 0.001$ ). Classes 2 and 3, on the other hand, are the least

representative, comprising 10.00 and 12.67% of all growers surveyed. Table 10 presents the characteristics of each of the 4 classes or typologies of tomato production.

The first class is generally characterized by equal proportions (30.34%) of growers using chemical fertilizers and pesticides. Growers in this class cultivate the Cobra 26 variety at 24.78% and practice crop rotation to a lesser extent (14.35%). The second class includes growers who mainly use mineral fertilizers (62.5%). The use of Cobra

26 and crop rotation are not critical practices in this class. Intensive use of the Cobra 26 variety and of chemical inputs (pesticides and mineral fertilizers), is practiced in the same proportions (26.39%) by growers in the 3rd class. However, a minority of 9.72% of these growers apply associated organic fertilizers to their plots. The 4th class is characterized by growers using the Cobra 26 variety (16.5), mineral fertilizers (20.5%), combined organic fertilizers (23%), chemical pesticides (21.5%) and crop rotation (18.5%).



**Fig. 6. Synthetic chemical pesticides used by growers against parasitic wilt**

**Table 8. Families and actives substances of pesticides used by growers**

Produits phytosanitaire		Numbers		Percentage (%)		P-value
Families	Active ingredients	Plantation	Nursery	Plantation	Nursery	
Neonicotinoids	Acetamiprid	74	8	29,84	21,05	< 0,001
Dithiocarbomates	Mancozeb	71	0	28,63	0	
Avermectins	Abamectin	62	0	25,00	0	
Pyrethrinoids	Cypermethrin	13	0	5,24	0	
	Lambdacyhalothrin	0	5	0,00	13,16	
	Deltamethrin	0	5	0,00	13,16	
	Profenofos	5	0	2,02	0	
Acylamines	Metalaxyl-M	7	0	2,82	0	
Organophosphates	Acephate	3	0	1,21	0	
Copper oxychloride	Copper (II) oxychloride	13	4	5,24	10,53	
	Phenylpyrazoles	Fipronil	0	9	0,00	
Carbamates	Carbosulfan	0	7	0,00	18,42	

**Table 9. Proportion of tomato growers by pesticide target**

Product targets	Numbers		Percentage (%)		P-value
	Plantation	Nursery	Plantation	Nursery	
Mites	111	0	33,53	0,00	< 0,001
Bacteria	4	4	1,21	7,84	
Nematodes	9	9	2,72	17,65	
Fung	90	4	27,19	7,84	
Insects	117	34	35,35	66,67	

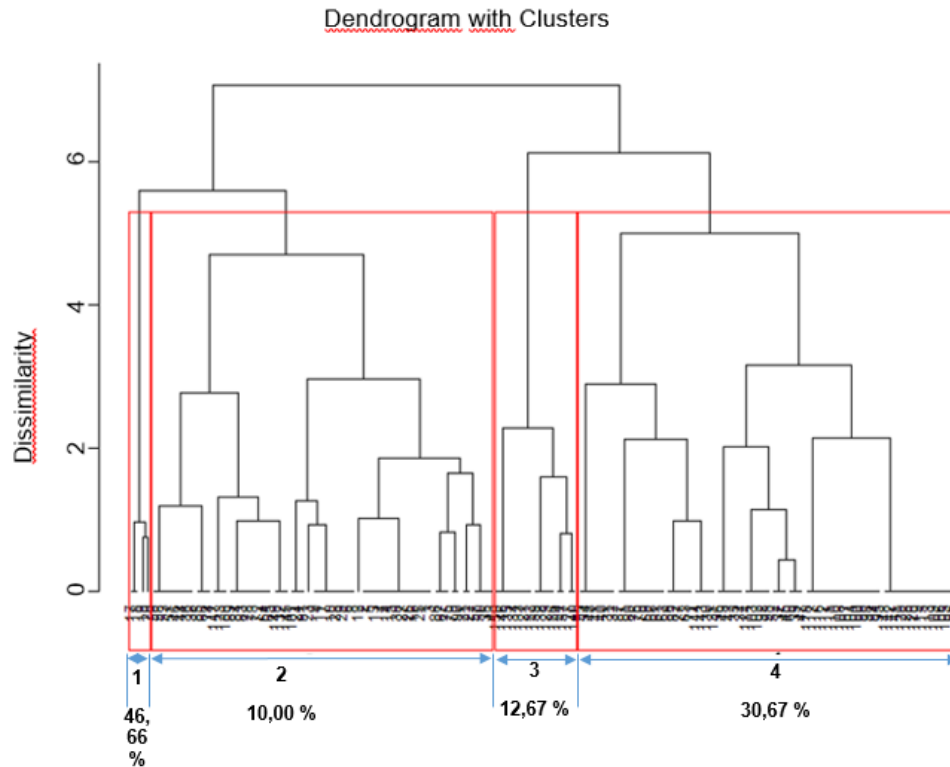


Fig. 7. Ascending hierarchical classification of the producer typology

Table 10. Characteristics of farm typologies according to producers

Classes	Cultivation practice	Numbers	Percentage (%)	P-value
Class 1	Use of Cobra 26	57	24,78	0,001
	Use of mineral fertilizer	70	30,43	
	Use of chemical pesticides	70	30,43	
	Crop rotation	33	14,35	
Class 2	Use of Cobra 26	4	16,67	0,010
	Use of mineral fertilizer	15	62,5	
	Crop rotation	5	20,83	
Class 3	Use of Cobra 26	19	26,39	0,02
	Use of mineral fertilizer	19	26,39	
	Use of organic fertilizer	7	9,72	
	Use of chemical pesticides	19	26,39	
	Crop rotation	8	11,11	
Class 4	Use of Cobra 26	33	16,5	0,627
	Use of mineral fertilizer	41	20,5	
	Use of organic fertilizer	46	23	
	Use of chemical pesticides	43	21,5	
	Crop rotation	37	18,5	

#### 4. DISCUSSION

The predominance of men in tomato production indicates that it is primarily a male activity. This could be explained by men's better access to land, resources, and the necessary credit (Son et al., 2017). In this study, producers acquired their

plots mainly through inheritance and rental, which contributes to this male dominance, as land is generally inherited by men or rented by those with sufficient financial means (Ouattara, 2017). Generally speaking, market gardening has always been a male-dominated activity. Several studies corroborate this finding

by highlighting the socio-demographic characteristics of market garden producers. For example, Ouattara (2017) revealed that in the province of Houet in Burkina Faso, market gardening is predominantly practiced by men. Similar results were obtained in Côte d'Ivoire, Bouaké (Yeo et al., 2022), and Mali, notably in Baguineda (Samake et al., 2022).

More than half the growers were aged between 36 and 50. This could be explained by the fact that at this age, growers have easier access to land and probably more credit. These results differ from those of Wognin et al (2013), who showed that 68.6% of market gardeners were aged 35 or younger. On the other hand, they concur with the findings of Békouanan (2018), according to which 53% of growers belong to this age bracket. Furthermore, this study revealed that 78% of tomato growers are based in rural areas, reflecting a strong migration of young people to urban centers, often motivated by lack of access to land or credit (Berté, 2016).

In terms of education, most growers (53%) are uneducated, although a significant proportion have a rudimentary level of education. This situation highlights the economic obstacles limiting access to adequate training faced by these producers. These results concur with those of Kouakou (2019), who found in the commune of Boundiali that market gardeners are, for the most part, illiterate, with a rate of 91% among women and 63% among men. According to the same author, this illiteracy can be explained by the fact that children, from an early age, are directed toward work in the fields, as the workforce is essentially family-based.

The high proportion of 69.33% of farms covered areas less than or equal to a quarter of a hectare. This reality illustrates the challenges faced by producers in expanding their farms, such as limited access to land, finance, and resources and probably the extent of biotic and abiotic constraints encountered (Jayne et al., 2014).

Parasitic wilt is a particularly devastating soil-borne disease of vegetable crops, especially tomatoes. The main symptoms mentioned by growers in the areas surveyed included leaf yellowing, crown rot, and the irreversible nature of the disease. These manifestations correspond to those described by Vakalounakis and Fragakiadakis (1999), who developed a rating scale to assess the symptoms of wilt caused by

*Sclerotium rolfsii*. These authors also identified the formation of secondary roots or bulges on the stem, a symptom cited by 27.73% of the growers surveyed. In addition, the presence of mycelium and sclerotia in the crown, characteristic of wilt caused by *S. rolfsii* (Bolou et al., 2015), was frequently reported by growers.

Analysis of growers' perceptions of the events preceding the onset of the disease revealed that monoculture and the introduction of varieties other than Cobra 26 were considered the main causes of the disease. These results could be explained by the fact that monoculture increases the incidence and severity of the disease, leading to more frequent visibility of symptoms by growers. In fact, monoculture and susceptible varieties can maintain a high level of inoculum in the cultivation soil, contributing to the infestation of subsequent crops. However, a recent study by Azandémè-Houmalon et al. (2024) on the development factors and distribution of wilt showed that 78.97% of growers were unable to accurately identify precursor events. Moreover, according to these authors, 4.103% of growers mentioned flooding as a triggering factor, an event also mentioned by 29.69% of growers in this study.

According to most growers (80%), parasitic wilt is attributed to soil-borne organisms. This perception is borne out by the soil-borne nature of the disease. Soil-borne pathogens such as *Ralstonia solanacearum* and *Sclerotium rolfsii* first colonize the root system before invading the vascular tissues, blocking the flow of water and nutrients through the xylem vessels, leading to tomato wilt (Lebas, 2010).

Growers' heavy reliance on the Cobra 26 variety is explained by its ability to deliver optimum production, even despite the constraints imposed by parasitic wilt. However, most growers interviewed stated that there is no effective curative control against these diseases. The use of resistant varieties is a strategy supported by several studies, including those by Sidikou et al. (2005), Fondio et al. (2013), and Ouédraogo (2016). These authors consider the adoption of resistant varieties one of the most effective approaches to controlling tomato bacterial wilt, as well as other bacterial crop diseases. Soulezelle (2017) corroborates this perspective, stating that in the absence of curative chemical solutions, wilt management relies primarily on preventive approaches. These include the use of resistant varieties, the implementation of

prophylactic measures, and the adoption of adapted cultural practices to limit the incidence of the disease. To limit infestations of telluric parasites, it is often advisable to disinfect the nursery substrate (Perpignan et al., 2018).

In the survey areas, over 65% of growers mentioned uprooting infected plants as a method for managing them. A small proportion burned the residue or collected it for disposal outside the field after harvesting. These practices are in line with the recommendations of Abo-Elyousr et al. (2009), Deberdt and Fernandes (2014), who stress the importance of prophylactic measures, such as uprooting and destroying contaminated plants (by burning), including infected weeds and cultivars, to reduce the infectious potential of the soil. Furthermore, Haougui et al. (2017) advocate crop rotation and association as effective practices for limiting the multiplication of telluric pathogens. These methods keep the pathogen population below a critical threshold, beyond which infestation could lead to a drastic drop in production, making the crop economically unviable. The majority of growers interviewed in this study practiced crop rotation. These results concur with those of [Azandémè-Houmalon et al. \(2024\)](#) who reported that 52% of tomato growers surveyed adopted crop rotation.

Chemical fertilization and the use of chemically synthesized pesticides were the main soil fertility management and pest control methods adopted by growers. However, 35.33% also included organic fertilization in their practices. This finding concurs with the observations of Ouédraogo (2004), who pointed out that fertilization on market-garden farms in Burkina Faso was based on a combination of mineral and organic manure. Similarly, Ouattara (2014) demonstrated that 92% of market gardeners in the Bobo-Dioulasso region combined organic substrates with mineral fertilizers. The heavy use of synthetic chemical pesticides by growers is explained by the considerable pressure exerted by pests and parasites on market garden crops. A review carried out by Dosso et al (2023) on diseases and pests of the main vegetables in Côte d'Ivoire, particularly in the main vegetable production zones, revealed a wide diversity of pests affecting these crops. This dependence on chemically-synthesized pesticides is also seen in Benin, where, according to Ahouangninou (2013), market gardeners use these products almost exclusively to ensure profitable vegetable production. The synthetic chemical pesticides most used by growers are mainly insecticides,

fungicides, and acaricides. These results are in line with the work of Ouédraogo et al. (2019), who revealed that market gardeners in the Bobo-Dioulasso region of Burkina Faso systematically used insecticides and acaricides. Similarly, according to Dosso (2021), 65% of market gardeners in the autonomous district of Yamoussoukro mainly used insecticides, followed by fungicides (27%). This predominance of insecticides can be explained by the pressure exerted by insects, identified as the main constraint to vegetable farming by Mondedji (2010). According to Mano et al. (2019), most local tomato varieties are sensitive to insect attacks, which can cause up to 85% of yield losses, which would also explain the high use of insecticides.

Analysis of phytosanitary practices in particular the diversity of families and active substances of chemically-synthesized pesticides by growers revealed widespread use of various families, with a predominance of neonicotinoids, dithiocarbamates, and pyrethroids. These results are similar to those of Son (2018), who showed that pesticides belonging to the neonicotinoid and pyrethroid families with active substances such as acetamide and cypermethrin were among the products most used by tomato growers in Burkina Faso. In Bouaké (central Côte d'Ivoire), a large proportion of market gardeners used pesticides containing lambda-cyathalothrin and acetamiprid (Yéo et al., 2022). The dominance of the neonicotinoid families, pyrethroids of an insecticidal nature, and dithiocarbamates of a fungicidal nature reflects the need for market gardeners to manage the destructive effects of insects and fungi, which represent major threats to their farms.

## 5. CONCLUSION

Parasitic wilt appears to be well known to most growers. However, management practices for these diseases remain inadequate to ensure sustainable management, particularly on farms where the use of synthetic pesticides and systematic recourse to mineral fertilization are constant. Although modestly adopted by growers, practices such as crop rotation, cultural associations, and organic fertilization represent significant advances toward an agroecological transition of tomato production systems in Côte d'Ivoire.

The typology enabled us to distinguish four categories of farms based on tomato production

practices. The first category is mainly characterized by intensive use of chemicals, and the second by heavy use of mineral fertilizers. The fourth category characterizes tomato farms where the nursery substrate is disinfected, and the last identifies farms where mineral fertilizer is combined with organic manure. The last two categories appear to be further along in the agroecological transition than the others. However, each faces its own set of challenges if it is to achieve its full potential. These challenges include promoting integrated pest management, reducing the use of chemical inputs, and adopting practices such as crop rotation and association that would encourage better expression of the potential of antagonistic agents.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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