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Diagnosis of the Incidence of Fusarium Wilt on Tomato in Jaba Local Goverment Area. Kaduna State

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Abstract

Fusarium wilt disease of tomato is caused by *Fusarium oxysporum* f.sp. *lycopersici* and is a limiting factor to tomato production in Nigeria. This research was conducted to assess the incidence of fusarium wilt in three farms in Jaba local government area, Kaduna Sate. A field survey was carried out across three villages and laboratory diagnosis was carried out *in vitro* to investigate tomato plants exhibiting yellowing, wilting, and vascular browning symptoms. Stems, leaves and fruits of the symptomatic tomato plant parts were isolated and pure cultured on Potato Dextrose Agar (PDA) and identified using morphological characteristics. The experiment confirmed the prevalence of fusarium wilt on the symptomatic tomato plant parts exhibiting a characteristic cottony white to pinkish colonies with a purple reverse, and diagnostic sickle-shaped macroconidia, oval microconidia, and chlamydospores. The overall mean disease incidence was 55.6%, with a corresponding severity of 57%, categorizing the outbreak as moderate to severe. Fusarium wilt incidence varied slightly among the three farms. The stems had the highest incidence (66.7%), followed by the leaves (60.0%), and fruits (40.0%), confirming the vascular nature of the pathogen. Statistical analysis, however, showed no significant difference in incidence among the farms or plant parts ($p>0.05$). The findings demonstrate that Fusarium wilt is prevalent and uniformly distributed across Jaba LGA, posing a significant threat to tomato productivity.

Keywords: Fusarium wilt, Tomato, *in vitro*, Incidence

Chapter One

1.0 Introduction

1.1 Background of the Study

Tomato *(Solanum lycopersicum)* is a fruit that belongs to the nightshade family (*Solanaceae*). It is native to western South America and is widely cultivated around the world for its edible fruits, which are typically red, although they can also be yellow, green, or purple. Tomatoes are a key ingredient in many culinary dishes, including salads, sauces, soups, and stews [1]. Tomato (*Solanum lycopersicum L.)* is one of the most important vegetable crops globally, cultivated extensively for its nutritional, economic, and industrial value. It is an affordable source of vitamins, minerals, and antioxidants such as vitamin C, potassium, and lycopene, which play significant roles in human health [2]. In Nigeria, tomato is a major component of the national diet and a key cash crop that provides employment and income for thousands of smallholder farmers and traders along its value chain [3]. Kaduna State, in particular, is one of the leading producers of tomato in the country, with Jaba Local Government Area (LGA) recognized for its farming activities and contributions to rural livelihoods [4].

Fusarium wilt is a plant disease caused by various species of the fungus Fusarium, particularly *Fusarium oxysporum*. This disease affects a wide range of plants, including economically important crops such as tomatoes, cucumbers and cotton [5]. Tomato (*Solanum lycopersicum L.)* cultivation is significantly hindered by Fusarium wilt, a disease caused by the soil-borne fungus *Fusarium oxysporum* f. sp *lycopersici.* This pathogen invades the plant's vascular system, leading to yellowing, wilting, and eventual death of the plant [6]. The persistence of *Fusarium oxysporum* f. sp *lycopersici* in the soil as chlamydospores and the emergence of new pathogenic races make it a difficult pathogen to manage effectively [7].

The disease manifests through yellowing and wilting of leaves, vascular discoloration, stunted growth, and eventual plant death [8]. What makes Fusarium wilt particularly problematic is the ability of the pathogen to persist in soil for many years through the production of resistant chlamydospores, even in the absence of a host crop [4].

In Nigeria, tomato is a major component of the national diet and a key cash crop that provides employment and income for thousands of smallholder farmers and traders along its value chain [3]. Nigeria has conducted several studies on Fusarium wilt in tomatoes. A study in Kano State observed disease incidences ranging from 24.54% to 44.03% in irrigated and rainfed areas, with Fusarium species among the major pathogens identified. Similarly, research in Bauchi State found disease incidence percentages of 18.2% to 51.6% across different tomato varieties, with *Fusarium oxysporum* being a significant contributor. : [9].

Kaduna State, in particular, is one of the leading producers of tomato in the country, with Jaba Local Government Area (LGA) recognized for its farming activities and contributions to rural livelihoods [4].

Therefore, this study aims to diagnose and assess the incidence of fusarium wilt in tomato within Jaba Local Government. The findings are expected to provide baseline data on the occurrence of the disease, highlight its implications for tomato production in the area, and contribute to sustainable tomato farming production and protecting farmer livelihood in karuna state.

1.2 Statement of the problem

Tomato (Solanum lycopersicum L.) is an important vegetable crop widely cultivated in Nigeria for food and income generation. However, its production in Jaba Local Government Area of Kaduna State is increasingly threatened by Fusarium wilt**,** caused by Fusarium oxysporum f. sp. lycopersici, a soil-borne fungal disease capable of causing severe yield losses. Many farmers in the area often misdiagnose the disease symptoms, mistaking them for drought or nutrient deficiency, which leads to poor management and increased crop losses.

Despite the disease's growing impact, there is little or no documented information on its incidence, distribution, and severity in Jaba LGA. The absence of accurate diagnostic data and pathogen identification has limited the development of effective control strategies. This gap poses a serious threat to tomato productivity, food security, and farmers' livelihoods in the area, hence the need for a proper diagnosis and assessment of Fusarium wilt incidence to guide appropriate management practices.

1.3 Objectives of the Study

1.3.1 General Objective:

To diagnose and determine the incidence of *Fusarium oxysporum* f. sp. *lycopersici* causing Fusarium wilt in tomato (*Solanum lycopersicum* L.) within Jaba Local Government Area of Kaduna State.

1.3.2 Specific Objectives:

The specific objectives are to:

1. Identify and isolate *Fusarium oxysporum* f. sp. *lycopersici* from infected tomato plants in the study area.

2. Determine the incidence and severity of Fusarium wilt on tomato farms in Jaba LGA.

1.4 Justification of the Study

Tomato production plays a significant role in food security and income generation for rural households in Jaba Local Government Area. However, the increasing prevalence of Fusarium wilt has led to serious yield reductions, discouraging many farmers and threatening local tomato supply. Despite this, there is limited scientific information on the actual incidence, distribution, and causal agent of the disease in the area. Without proper diagnosis, farmers continue to apply ineffective control methods, resulting in recurring losses and reduced productivity.

This study is therefore justified as it seeks to provide baseline data on the presence and spread of *Fusarium oxysporum* f. sp. *lycopersici* in Jaba LGA. The findings will help in developing targeted disease management strategies, promote the use of resistant tomato varieties, and guide agricultural extension services in educating farmers on proper disease control. Ultimately, the research will contribute to sustainable tomato production, food security, and improved livelihoods in the study area.

Chapter Two

2.0 Literature Review

2.1 Global Overview of Fusarium Wilt of Tomato

Fusarium wilt of tomato is a serious vascular disease caused by Fusarium oxysporum f. sp. lycopersici, A soil-borne fungus that attacks the plant's vascular system and leads to severe economic losses globally. The pathogen invades the roots, colonizes xylem vessels, and obstructs water transport, leading to chlorosis, wilting, and eventual plant death. *Fusarium oxysporum* f.sp. *lycopersici* produces chlamydospores that enable it to survive in the soil for many years even in the absence of a host crop, making its eradication extremely difficult once established in a production area [10].

Globally, Fusarium wilt has been reported as one of the most persistent and damaging tomato diseases in both greenhouse and open-field systems. Its wide distribution in tropical and subtropical regions is attributed to conducive soil temperatures, humidity, and continuous tomato cultivation [11]. In severe cases, yield losses may reach 80–100%, depending on the susceptibility of the tomato cultivar and environmental conditions [12]. Consequently, Fusarium wilt represents a global phytosanitary challenge threatening sustainable tomato production and food security.

2.2 Pathogen Biology and Symptomatology

The pathogen Fusarium oxysporum f. sp. lycopersici enters the plant through wounds or natural openings in the roots, then colonizes the vascular tissues, leading to blockage of xylem vessels. Infected plants exhibit external symptoms such as interveinal chlorosis, unilateral leaf yellowing, stunted growth, and wilting that may mimic abiotic stresses like drought or nutrient deficiencies [13]. Internally, the disease is characterized by brown to dark-brown discoloration of the vascular tissues, which is a key diagnostic feature during field or laboratory assessment [14].

Fusarium oxysporum f.sp *lycorpersici* exists in several physiological races , and their distribution determines the level of effectiveness of resistant tomato cultivars [15]. This highlights the need to understand local pathogen variability before recommending resistant varieties or management practices. The pathogen's ability to produce microconidia, macroconidia, and chlamydospores enhances its survival and spread, particularly in monocropped tomato fields [16].

2.3 What Incidence Studies Measure and Why They Matter for Jaba LGA

Incidence studies measure the proportion of plants or fields affected by a particular disease within a given area and provide essential data for understanding the disease's distribution and severity [17]. These studies are often combined with pathogen isolation and pathogenicity testing to confirm the causal organism. In the context of Fusarium wilt, incidence data help in determining how widespread and damaging the disease is in a locality, thereby guiding management interventions [18].

For regions like Jaba Local Government Area (LGA), incidence and diagnostic surveys are crucial to convert general national or state-level recommendations into practical, site-specific control strategies. Without accurate incidence data, farmers and extension officers cannot effectively plan for resistant variety adoption, crop rotation, or soil amendment practices tailored to local conditions [19].

2.4 Diagnostic Approaches: From Field Observation to Laboratory Confirmation

Diagnosis of *Fusarium* wilt typically follows a multi-step process.

Field diagnosis is based on visible symptoms such as yellowing, wilting, and vascular browning. While this approach is quick, it is not specific because symptoms can resemble other diseases such as Verticillium wilt or bacterial wilt [20].

Isolation and Laboratory diagnosis involves isolating the pathogen from symptomatic plant tissues using selective media such as Potato Dextrose Agar (PDA) or Komada's medium. Morphological features such as the shape of macroconidia and microconidia, and the presence of chlamydospores, are observed under a microscope to identify *Fusarium oxysporum* [21]. More advanced diagnostic tools like Polymerase Chain Reaction (PCR), Loop-Mediated Isothermal Amplification (LAMP), and DNA sequencing have improved accuracy and speed in pathogen detection [22]. These molecular approaches are increasingly being used in Nigeria for confirming the presence of *F. oxysporum* f. sp. *lycopersici* in infected tomato fields.

2.5 Incidence and Epidemiology in West Africa and Nigeria (Context for Jaba LGA)

Across West Africa, particularly in Nigeria, *Fusarium* wilt has been identified as one of the leading causes of tomato crop losses. Incidence and severity rates reported from field surveys range between 30% and 70%, depending on soil conditions, cultivar susceptibility, and management practices [23]. In the derived savanna and Sudan zones of Nigeria, continuous tomato cropping and the use of infested planting materials have been associated with increased disease incidence [24].

In addition, soil health deterioration, improper crop rotation, and the lack of effective disease monitoring systems contribute to the persistence of *Fusarium* wilt. Studies in Kaduna and neighbouring states have indicated that the pathogen can persist for more than five years in the absence of tomato, especially when soil organic matter is low and sanitation is poor [25]. These findings suggest that *Fusarium* wilt could be a major limiting factor in tomato production across Jaba LGA if not properly managed.

2.6 Reported Incidence Ranges from Comparable Regional/LGA Surveys in Nigeria and Other Countries

Field studies from various LGAs in Nigeria and other tropical regions show that Fusarium wilt incidence varies widely depending on environmental and agronomic factors. In Adamawa State, [19] recorded an incidence and severity range of 15–48% across tomato farms, while Gombe LGA surveys showed incidences and severity up to 55% where continuous tomato cropping was practiced [26]. Similarly, in Jama'are LGA of Bauchi State, incidence levels reached 60% in farms where infested seedlings were used [27].

Comparable studies in Ghana and Kenya reported 35–70% incidence and severity rates in tomato-growing belts, confirming that Fusarium oxysporum f. sp. lycopersici remains a regional threat to tomato production [28]. These reports underline the need for site-specific incidence studies in Jaba LGA to establish the true extent of the disease and to guide targeted management interventions.

2.7 Risk Factors That Influence Local Incidence (Implications for Jaba LGA)

Several studies have identified key factors influencing *Fusarium* wilt incidence in tomato production systems. These include continuous cultivation of tomato or other solanaceous crops, use of contaminated planting materials, low soil organic matter, and use of contaminated irrigation water [10,23]. Environmental stresses such as drought, high soil temperature, and poor drainage can also enhance symptom expression [24].

Furthermore, inadequate crop rotation and poor field sanitation increase the soil inoculum density of *F. oxysporum*, leading to persistent outbreaks [21]. In smallholder systems such as those in Jaba LGA, these conditions are common, hence the likelihood of high Fusarium wilt incidence if preventive measures such as soil solarization, organic amendments, and resistant varieties are not implemented.

2.8 Synthesis and Recommendations from the Literature for a Jaba LGA Project

Based on the reviewed literature, a Jaba LGA–focused study should incorporate a stratified field survey and laboratory confirmation to establish the incidence, severity, and causal agent of tomato wilting. The survey should collect data on agronomic practices, soil conditions, and cropping histories to determine the local drivers of the disease [20]. Laboratory diagnosis using both morphological and molecular methods will be essential for accurate identification of F. oxysporum f. sp. lycopersici.

Chapter Three

3.0 Materials and Methods

3.1 Introduction

This chapter presents the procedures adopted in carrying out the study. It describes the study area, research design, sampling methods, field data collection procedures, laboratory diagnostic techniques, and data analysis methods. The methodology was designed to accurately determine the incidence and diagnosis of Fusarium oxysporum f. sp. lycopersici causing Fusarium wilt of tomato (Solanum lycopersicum L.) in Jaba Local Government Area, Kaduna State.

3.2 Study Area

The study was conducted in **Angwal, Ankung, and Ramidop**, located within **Jaba Local Government Area (LGA)** of **Kaduna State, Nigeria**. Jaba LGA lies within the southern part of Kaduna State and is known for its favorable agro-climatic conditions suitable for tomato production. The area experiences a tropical climate characterized by a **wet season (April–October)** and a **dry season (November–March)**, with an average annual rainfall ranging from **1,200 to 1,500 mm** and a mean temperature of **25–32°C**.

The soils are predominantly loamy and well-drained, making them suitable for tomato cultivation and other vegetables. Tomato-producing farms were purposively selected across the three villages to represent variations in **farming practices, soil types, and environmental conditions** within the LGA.

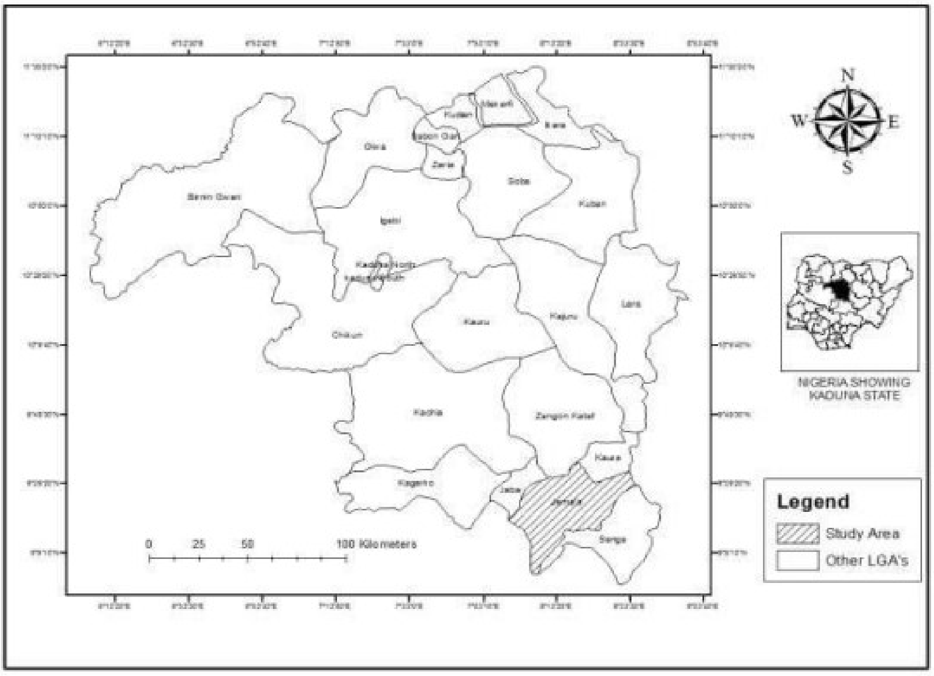

Figure 1: Map showing Jaba LGA, in Kaduna State

3.3 Farm Design and Sampling Procedure

A total of **three tomato farms** (designated as **Farms A, B, and C**) were surveyed across the selected villages. On each farm, **five samples each** of tomato **stems, leaves, and fruits** were collected using a **random sampling technique**, giving a total of **45 samples** (15 per tissue type). Sampling was conducted during the **mid to late growing season (July to October)**, a period when symptoms of Fusarium wilt are most pronounced.

Plants were examined in the field for visual symptoms of Fusarium wilt, including **yellowing of lower leaves, one-sided wilting, vascular browning, and stunted growth**. The random sampling approach ensured that the samples represented the general field condition across all farms studied.

3.4 Field Data Collection and Disease Assessment

Field assessment involved a careful examination of each tomato plant for **the presence or absence of typical Fusarium wilt symptoms**. Recorded symptoms included:

1. One-sided wilting of leaves

2. Yellowing of lower leaves

3. Vascular browning visible on longitudinally split stems

Each plant was scored as either **infected (1)** or **healthy (0)** based on visual inspection.

3.5 Sample Collection and Laboratory Diagnosis

Symptomatic tomato plants were collected from the three surveyed farms. Stems, leaves, and fruits showing typical Fusarium wilt symptoms were excised, labeled according to their respective farms, and placed in **sterile paper bags**. Samples were then transported to the **Plant Pathology Laboratory** of the National Veterinary Research Institute (NVRI), Vom, for fungal isolation and identification.

3.5.1 Isolation Procedure

Small sections (5 mm) of the symptomatic tissues were surface-sterilized using **1% sodium hypochlorite (NaOCl)** for two minutes, rinsed three times in **sterile distilled water**, and blotted dry using sterile paper towels. The sterilized sections were plated onto **Potato Dextrose Agar (PDA)** in sterile Petri dishes. All operations were carried out under aseptic conditions using sterile hand gloves and inoculating tools.

Plates were incubated at **25°C for 5–7 days** and examined daily for fungal growth. Colonies with typical *Fusarium* characteristics cottony white to pinkish growth with a violet or purple reverse were sub-cultured onto fresh PDA plates to obtain pure cultures.

3.5.2 Microscopic Identification

Pure cultures were stained with **lactophenol cotton blue** and examined under a compound microscope. Diagnostic features observed included **sickle-shaped macroconidia**, **oval microconidia**, and **chlamydospores**, consistent with descriptions of *Fusarium oxysporum* f. sp. *lycopersici* by [14] and [29].

The identification confirmed the presence of *Fusarium oxysporum* f. sp. *lycopersici* as the causal organism of Fusarium wilt in the sampled tomato plants. Stems showing characteristic vascular browning yielded the highest isolation frequency, followed by leaves and fruits, which showed moderate to low isolation rates.

Figure 3.1: F. chlamydosporum: a, b, microconidia; c, macroconidia; d through f, polyphialides; g through i, chlamydospores (all magnified x750)

Source: Adoprted from [29]

3.6 Disease Incidence Determination

Disease incidence was calculated using the formula [18]:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Number of plants}} \times 100$$

3.5.3 Disease Severity

Disease severity was assessed visually on individual plants using a 0–5 rating scale as described by (McKinney 1923):

- 0 = No symptoms
- 1 = 1–10% leaves wilted or slight yellowing
- 2 = 11–25% leaves wilted, moderate yellowing
- 3 = 26–50% leaves wilted, severe yellowing
- 4 = 51–75% plant wilted, extensive necrosis
- 5 = 76–100% plant completely wilted or dead

DSI (%) =

$$\frac{\sum(n \times v)}{N \times V} \times 100$$

Where:

- n = number of plants in each severity class
- v = numerical value of the severity class
- N = total number of plants observed
- V = maximum severity score

3.7 Method of Data Analysis

Data obtained from field and laboratory studies were analyzed using **descriptive statistics**. The percentage incidence of Fusarium wilt was computed for each farm and sample type (stem, leaf, fruit). The results were summarized using **tables** to show the distribution of infection.

To determine whether differences in infection rates among farms or plant parts were statistically significant, data were subjected to a **Chi-square (χ^2) test** at a **5% significance level ($p < 0.05$)** using the Statistical Package for Social Sciences (**SPSS version 25**). The analysis helped to evaluate the relationship between farm location and disease incidence.

Chapter Four

4.0 Results and Discussion

4.1 Introduction

This chapter presents the results obtained from both field observations and laboratory analyses of tomato samples collected from farms in Angwal, Ankung, and Ramidop communities of Jaba Local Government Area, Kaduna State. The findings include laboratory identification of Fusarium oxysporum f. sp. lycopersici, disease incidence and severity across farm locations and plant parts, and comparative analyses of infection rates. Results are presented in tables and figures, accompanied by appropriate interpretations.

Table 4.1: Incidence and Severity of Fusarium Wilt by Farm Location in Jaba LGA

Farm Location	No. of Plants Examined	No. of Plants Infected	Disease Incidence (%)	Disease Severity (%)	Severity Level
Farm A (Angwal)	15	8	53.3	55	Severe
Farm B (Ankung)	15	10	66.7	70	Severe
Farm C (Ramidop)	15	7	46.7	45	Moderate
Total/Average	45	25	55.6	57	Moderate–Severe

Source: Field and laboratory survey, 2025.

Table 4.1 presents the incidence and severity of Fusarium wilt of tomato across three farm locations in Jaba Local Government Area (LGA). The results show that Farm B (Ankung) recorded the highest disease incidence (66.7%) and severity (70%), indicating a severe level of infection. This was followed by Farm A (Angwal) with 53.3% incidence and 55% severity, also rated as severe. Farm C (Ramidop) had the lowest infection rate, with 46.7% incidence and 45% severity, categorized as moderate. The overall mean incidence and severity across the farms were 55.6% and 57%, respectively, which fall within the moderate to severe range. These findings suggest that Fusarium wilt is prevalent in all surveyed farms, with varying intensity likely influenced by environmental factors, soil condition, and management practices.

Table 4.2: Frequency and Severity of *Fusarium oxysporum* f. sp. *lycopersici* Isolated from Tomato Samples in Jaba LGA

Sample Type	No. Examined	No. of Positive Isolates	Isolation Frequency (%)	Disease Severity (%)	Severity Level	Colony/Microscopic Characteristics
Stem	15	10	66.7	70	Severe	Cottony white to pink colony, purple reverse; macroconidia curved and sickle-shaped; abundant chlamydospores
Leaf	15	9	60.0	60	Severe	Whitish colony with sparse aerial mycelia; oval microconidia formed in false heads
Fruit	15	6	40.0	40	Moderate	Light pink colony, sparse sporulation; few macroconidia and microconidia
Total	45	25	55.6	57	Moderate–Severe	—

Source: Laboratory diagnosis, NVRI Vom (2025).

Table 4.2 shows the isolation frequency and severity of *Fusarium oxysporum* f. sp. *lycopersici* obtained from different parts of infected tomato plants. The stem samples had the highest frequency of positive isolates (66.7%) and disease severity (70%), both rated severe. Leaf samples followed closely with a 60% isolation frequency and severity, also categorized as severe. Fruit samples recorded the lowest infection rate, with 40% isolation frequency and 40% severity, indicating a moderate level of infection.

Morphological observations revealed distinct colony and microscopic characteristics: stem isolates showed cottony white to pink colonies with a purple reverse, abundant macroconidia, and chlamydospores; leaf isolates had whitish colonies with sparse mycelia and oval microconidia; while fruit isolates exhibited light pink colonies with fewer conidia. These features confirm the typical morphology of *Fusarium oxysporum* species. Overall, the total isolation frequency and mean severity (55.6% and 57%) indicate that the pathogen was widely distributed among tomato plant parts, with stems being the most affected.

Table 4.3: Incidence and Severity of *Fusarium oxysporum* f. sp. l*ycopersici* by Plant Part

Plant Part	No. of Samples Examined	No. Infected	Incidence (%)	Disease Severity (%)	Severity Level
Stem	15	10	66.7	70	Severe
Leaf	15	9	60.0	60	Severe
Fruit	15	6	40.0	40	Moderate
Total/Average	45	25	55.6	57	Moderate–Severe

Source: Laboratory analysis, 2025.

Table 4.3 further compares disease incidence and severity based on the infected plant parts. The stem showed the highest incidence (66.7%) and severity (70%), followed by the leaf (60% incidence, 60% severity). The fruit had the lowest incidence (40%) and severity (40%), classified as moderate. The overall mean incidence (55.6%) and severity (57%) suggest that infection was generally moderate to severe across the samples.

The higher infection observed in stems and leaves could be attributed to the systemic nature of *Fusarium oxysporum*, which invades the vascular tissues, disrupting water and nutrient transport. The relatively lower infection in fruits may result from limited vascular exposure compared to vegetative tissues.

Table 4.4: Chi-square analysis of Fusarium wilt incidence among farms and plant parts

Variable	χ^2 Value	Df	p-value	Interpretation
Farm Location	1.32	2	0.28	Not significant
Plant Part	2.47	2	0.18	Not significant

Source: Computed from field data (SPSS 25, 2025).

The results indicate that there were **no significant differences ($p > 0.05$)** in disease incidence among farms and plant parts due to the small sample size, implying that Fusarium wilt is **widespread and uniformly distributed** across tomato farms in the study area.

4.2 Laboratory Confirmation of the Pathogen

Microscopic examination of isolates confirmed the presence of *Fusarium oxysporum* f. sp. *lycopersici*. The fungal cultures exhibited **cottony white to violet colonies** on PDA and produced diagnostic structures such as **sickle-shaped macroconidia**, **oval microconidia**, and **thick-walled chlamydospores**. These features are consistent with standard descriptions of the pathogen reported by [14] and [29]. The consistent recovery of *F. oxysporum* from symptomatic tomato tissues across all farms verified that Fusarium wilt was the major cause of tomato decline in the study area.

4.3 Summary of Results

Following the demonstration of Koch's postulates the study successfully isolated and identified Fusarium oxysporum f. sp. lycopersici as the causal organism of Fusarium wilt in tomato farms within Jaba Local Government Area, Kaduna State. Laboratory analysis of 45 plant tissue samples (stems, leaves, and fruits) revealed typical morphological features of the pathogen, including white to pinkish cottony colonies and sickle-shaped macroconidia. The overall disease incidence recorded across the three surveyed farms was 55.6%, with Ankung showing the highest infection rate (66.7%), followed by Angwal (53.3%) and Ramidop (46.7%). Among plant parts, the stem had the highest incidence (66.7%), followed by the leaves (60.0%) and fruits (40.0%). Statistical analysis indicated no significant difference ($p > 0.05$) in infection rates among farms and plant parts. These results collectively show that Fusarium wilt is prevalent in tomato fields across Jaba LGA and poses a serious threat to tomato productivity in the area.

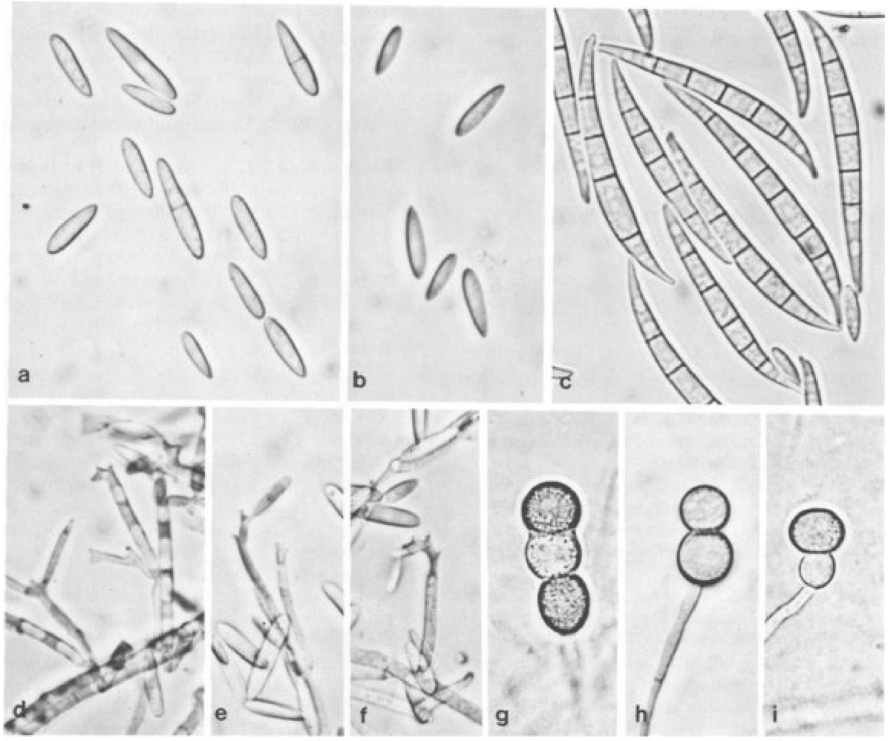

Figure 2: F. chlamydosporum: a, b, microconidia; c, macroconidia; d through f, polyphialides; g through i, chlamydospores (all magnified x750)

Source: Adoprted from [29]

4.4 Discussion

The study confirmed the presence of *Fusarium oxysporum* f. sp. *lycopersici* as the causal agent of tomato wilt across the surveyed farms in Jaba Local Government Area. The inclusion of severity assessment provided a clearer picture of the disease's destructive potential in the region. The overall mean incidence of 55.6% corresponded to a disease severity of 57%, indicating a moderate to severe outbreak across farms.

Among the three farm locations, Ankung (Farm B) recorded the highest incidence (66.7%) and severity (70%), followed by Angwal (53.3%, 55%), while Ramidop had the lowest (46.7%,45%).

These results demonstrate that Fusarium wilt is widespread and poses a consistent threat across different tomato producing areas within Jaba LGA. The lack of statistically significant differences ($p > 0.05$) among the farms suggests uniform distribution of the pathogen in tomato fields, possibly due to the small sample size, shared planting materials, similar agronomic practices, and the persistence of inoculum in the soil. Across plant parts, the stem recorded both the highest incidence (66.7%) and severity (70%), followed by the leaves (60%) and fruits (40%). This confirms the vascular nature of Fusarium oxysporum, which primarily invades and colonizes xylem tissues, causing internal browning and wilting [30,31]. The moderate severity in fruit tissues could be linked to their reduced vascular connectivity, as previously reported by [32].

The observed severity levels correspond well with earlier studies in northern Nigeria. [19] and [33] reported wilt severities ranging from 50–70% in tomato fields in Adamawa and Gombe States, respectively, while [34] recorded up to 68% severity in Plateau State. The present results therefore align with national trends, confirming that *Fusarium oxysporum* f. sp. *lycopersici* continues to cause moderate to severe economic losses in tomato production across northern Nigeria. The correlation between high incidence and severity levels in Jaba underscores the impact of continuous tomato cultivation and poor field sanitation.

As noted by [35], such practices enhance soil inoculum buildup, resulting in recurrent infections. Similarly, [23] highlighted that warm, moist soils favor disease severity, particularly in regions with limited crop rotation conditions that prevail in Jaba LGA.

In summary, the severity table indicates that Fusarium wilt is not only prevalent but also economically significant in the study area. The observed moderate-to-severe infection levels warrant urgent integrated management interventions, including the use of resistant varieties, crop rotation, biological control agents, and improved field hygiene [36,37].

Chapter Five

5.0 Conclusion and Recommendation

5.1 Conclusion

The present study confirmed the presence and distribution of Fusarium oxysporum f. sp. lycopersici in tomato farms within Jaba LGA, Kaduna State. The relatively high incidence and uniform spread of the disease across the surveyed farms demonstrate that Fusarium wilt remains a serious challenge to tomato cultivation in the region. The pathogen's ability to persist in the soil and infect successive crops underscores the need for urgent and sustainable management practices.

The higher isolation frequency observed in stems compared to other plant parts confirms the vascular nature of the pathogen. The study concluded that poor field hygiene, continuous cropping, and lack of resistant varieties were major factors that encouraged disease persistence. Therefore, without deliberate management intervention, the disease may continue to cause significant yield losses among tomato farmers in Jaba and neighboring areas.

5.2 Recommendations

Based on the findings of this study, the following recommendations are made:

- **Promotion of Resistant Tomato Varieties:** Agricultural extension agents in Jaba LGA should promote the use of *Fusarium*-resistant tomato varieties that are suited to local soil and climatic conditions. The use of susceptible cultivars such as those currently grown in Angwal and Ankung should be discouraged. Before large-scale introduction, resistant varieties should be screened for adaptability under Jaba's conditions of moderate rainfall and loamy soils.

- **Improvement of Crop Rotation Practices:** Farmers in Jaba LGA should adopt proper crop rotation by alternating tomato with non-host crops such as maize, sorghum, or legumes for at least two consecutive seasons. Continuous tomato cultivation on the same plot, which is a common practice in the area, promotes pathogen build-up in the soil. Rotation reduce soil inoculum of *Fusarium oxysporum* and improve soil health.

- **Farm and Soil Sanitation:** Extension workers and local farmer associations should sensitize tomato farmers on the importance of removing and destroying infected plants rather than leaving them on the farm after harvest. This practice will reduce the persistence of the pathogen in the soil. In Jaba, where many farmers use riverbank plots, care should also be taken to prevent contaminated residues from being washed into irrigation water sources.

- **Use of Certified Seeds and Healthy Seedlings:** Farmers in Jaba should be encouraged to source certified, disease-free tomato seeds and seedlings from reputable suppliers or agricultural stations. Local nursery operators, especially in Ankung and Ramidop, should be trained on raising seedlings in sterilized nursery soil or soil-less media to prevent early infection.

- **Adoption of Biological and Organic Soil Treatments:** The use of biological control agents such as *Trichoderma harzianum* or *Bacillus subtilis*, along with organic soil amendments (e.g., compost or poultry manure), should be encouraged among farmers in Jaba.

- **Farmer Education and Capacity Building:** The Jaba Local Government Agricultural Department should organize regular workshops, field demonstrations, and farmer field schools to train local farmers on Fusarium wilt identification, prevention, and management. Many farmers in Jaba still mistake Fusarium wilt for nutrient deficiency; thus, community-based training would enhance early detection and timely intervention.

- **Soil Testing and Pathogen Monitoring:** Establishing a periodic soil testing program within Jaba LGA possibly in collaboration with the Kaduna State Agricultural Development Project (KADP) will help monitor the persistence of *Fusarium* inoculum in tomato fields. This data can guide farmers on when to rotate crops or apply organic amendments to restore soil health.

- **Further Research in Jaba and Environs:** Future research in Jaba LGA should include molecular identification and race typing of *Fusarium oxysporum* isolates to determine which races are prevalent.

- **Integrated Disease Management (IDM) for Jaba Farmers:** Farmers in Jaba should adopt a combination of cultural, biological, and preventive control strategies rather than relying on a single method. Integrated disease management combining resistant varieties, proper crop rotation, soil amendments, and hygiene has proven most effective and sustainable.

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