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Incidence and Severity of Fusarium Wilt Disease on Tomato (*Solanum lycopersicum* L.) in Dormaa Central Municipality, Ghana

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Abstract
Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *lycopersici*, is among the most economically damaging soil-borne diseases threatening tomato (*Solanum lycopersicum* L.) production. This study assessed the incidence and severity of Fusarium wilt disease across three major tomato-producing communities in Dormaa Central Municipality, Ghana. It characterised the causal pathogen using morphological methods and Koch's postulates. A stratified sampling design was applied, with four farms selected per community (Benekrom, Babianiha, and Duasidan). Disease incidence was assessed on 100 plant stands per farm, and severity was scored on 50 plants per farm using the CSIR-Crop Research Institute five-point rating scale. The pathogen was isolated on potato dextrose agar (PDA) and identified based on cultural and microscopic characteristics. Benekrom recorded the highest mean disease incidence (67.25%) and severity score (1.21), followed by Babianiha (43.75%; 0.61) and Duasidan (39.75%; 0.44). Disease incidence and severity in Benekrom were significantly higher than in the other two communities ($p < 0.05$), whereas Babianiha and Duasidan did not differ significantly from each other. The isolate exhibited white to dirty-white fluffy mycelium, microconidia measuring 5.3–10.0 μm, and chlamydospores forming in chains, consistent with *F. oxysporum*. Pathogenicity tests reproduced field symptoms, fulfilling Koch's postulates. These findings confirm the pervasive and damaging presence of Fusarium wilt in the municipality and highlight the urgent need for integrated disease management interventions.

Keywords
Fusarium wilt; *Solanum lycopersicum*; disease incidence; disease severity; *Fusarium oxysporum*; plant pathology; Ghana

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Contents

1. Introduction

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae, which encompasses several economically important vegetable and fruit crops, including potato, eggplant, and pepper (Peralta et al., 2008). The crop is widely consumed globally for its nutritional richness, providing minerals such as calcium, iron, and phosphorus; vitamins A and C; essential amino acids; dietary fibre; and citric acid (Naika et al., 2005; Ramya & Patel, 2019; Ali et al., 2020). Its culinary versatility, spanning salads, sauces, soups, and juices, further underpins its commercial importance (Kumar et al., 2022). Global tomato production has grown from approximately 31 million tonnes in 2017 to 34.2 million tonnes in 2023, with projections of 37.2 million tonnes by 2027 (Tomato News, 2023; FAO, 2021). Despite this trajectory, production is constrained by pests and diseases, high input costs, and unfavourable climatic conditions (Gatahi, 2020; Litskas et al., 2019; Biratu, 2018).

Numerous fungal, bacterial, viral, and nematode pathogens cause economically significant damage to tomato crops worldwide (García-Estrada et al., 2022; Rodrigues & Furlong, 2022; Panno et al., 2021; Blancard, 2012). In Ghana and other tropical regions, documented fungal diseases include early blight, late blight, septoria leaf spot, fusarium wilt, crown rot, collar rot, sclerotium rot, and damping-off (Okorley et al., 2024; Opoku et al., 2021; Lucas, 2009; Holliday, 1995). Among these, Fusarium wilt, caused by the soil-borne pathogen Fusarium oxysporum f. sp. lycopersici, is considered one of the most economically devastating (Bawa, 2016; Worku & Sahe, 2018).

Fusarium oxysporum f. sp. *lycopersici* penetrates plant roots and colonises the xylem vascular tissues, physically obstructing water and nutrient translocation. The resulting symptoms include progressive wilting, interveinal leaf yellowing, stunted growth, vascular discolouration, and plant death (Sanoubar & Barbanti, 2017). The pathogen is highly persistent in soil, surviving in the absence of a host for extended periods through chlamydospore formation, which makes cultural control measures alone insufficient (Joshi, 2018; Jiménez-Díaz & Jiménez-Gasco, 2011). Yield losses from Fusarium wilt are reported to range from 20% to 100% depending on cultivar susceptibility, soil conditions, and environmental factors (Bawa, 2016; Worku & Sahe, 2018).

Tomato farming is a critical livelihood activity in the Dormaa Central Municipality, Bono Region of Ghana (Rongai et al., 2017; Ahmed et al., 2016). However, persistent reports of Fusarium wilt have resulted in significant crop losses, undermining household incomes, reducing market supply, and contributing to local food insecurity. Despite these impacts, no systematic baseline study of Fusarium wilt incidence and severity had been conducted in this municipality prior to this study. This research was therefore conducted to: (1) determine the incidence and severity of Fusarium wilt disease across three major tomato-producing communities in Dormaa Central Municipality; (2) isolate and morphologically characterise the causal pathogen; and (3) confirm pathogenicity through Koch's postulates.

2. Materials and Methods

2.1 Study Area

The study was conducted in Dormaa Central Municipality, located in the Bono Region of Ghana (latitude 7°N, longitude 3°W). The municipality is bordered to the north by Jaman North Municipality, to the east by Dormaa East Municipal District, to the south and southeast by Asunafo North Municipality and Asutifi North District, to the southwest by Dormaa West, and to the west and northwest by La Côte d'Ivoire (Figure 1). The municipality covers a total land area of 1,210.28 km², accounting for approximately 3.1% of the Bono Region's total area, and had a population of 112,702 as of the 2021 Population and Housing Census (Ghana Statistical Service, 2022). The area experiences a wet semi-equatorial climate with a bimodal rainfall regime. Mean annual rainfall ranges between 1,250 mm and 1,750 mm. The major rainy season extends from May to June, with peak rainfall in June, while the minor rainy season occurs from September to October. The main dry season runs from late November to February. These climatic conditions, particularly the periods of high humidity and rainfall, are conducive to the development and spread of soil-borne fungal diseases (Opoku et al., 2021).

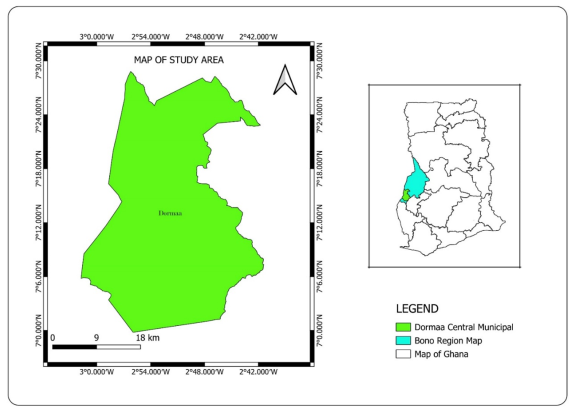

Figure 1. Map of the study area showing Dormaa Central Municipality, Bono Region, Ghana, and the locations of the three surveyed tomato-producing communities.

2.2 Symptoms Description of Fusarium Wilt

Fusarium wilt symptoms on tomato were documented during field surveys. Infected plants exhibited stunted growth, yellowing and premature dropping of leaves, wilting and necrosis of stems, and browning of vascular tissue when stems were cross-sectioned (Figure 2). Deterioration of the root system and the basal portion of the stem was also observed, consistent with descriptions reported for *F. oxysporum* f. sp. *lycopersici* (Sanoubar & Barbanti, 2017; Bawa, 2016). Reduced photosynthetic leaf area and decreased fruit set were recorded as secondary consequences of infection.

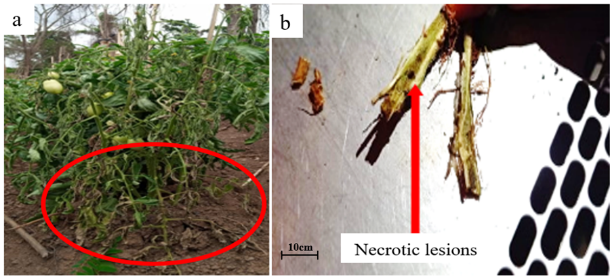

Figure 2. Symptoms of Fusarium wilt disease on tomato (*Solanum lycopersicum* L.) in Dormaa Central Municipality. (a) Wilted plant with characteristic yellowing and stunting; (b) Necrotic vascular discolouration in the stem cross-section.

2.3 Sample Collection and Pathogen Isolation

Farm selection was based on reports of Fusarium wilt incidence compiled by the Ministry of Food and Agriculture (MoFA), Dormaa-Ahenkro. A stratified sampling approach was adopted to ensure equal representation across communities (Uribeetxebarria et al., 2019). Four farms were selected from each of the three surveyed communities: Babianiha, Duasidan, and Benekrom (Table 1). From each farm, 12 diseased plant samples were randomly collected for laboratory analysis at the University of Energy and Natural Resources Mini-Laboratory in Dormaa-Ahenkro, yielding a total of 36 samples (Table 1).

Table 1. Tomato-producing communities surveyed and samples collected in Dormaa Central Municipality, Ghana.

Community	No. of Farms Selected	No. of Samples Collected
Babianiha	4	12
Duasidan	4	12
Benekrom	4	12
Total	**12**	**36**

Source: Field survey, 2022–2023

Pathogen isolation was conducted under aseptic conditions in a laminar airflow chamber. Diseased tissue segments were excised at the junction of visibly infected and adjacent healthy tissue. Tissue pieces were surface-sterilised in 70% ethanol for 60 seconds, rinsed three times in sterile distilled water, blotted dry on Whatman No. 1 filter paper, and plated in triplicate at equidistant positions on potato dextrose agar (PDA) amended with chloramphenicol (100 mg/L) to suppress bacterial contamination (Omuketi, 2020; Muntala et al., 2020). Plates were incubated at 28°C for three to seven days and examined daily for fungal growth.

2.4 Morphological Characterisation of the Pathogen

Hyphal-tip subcultures from each primary isolation were transferred to freshly prepared PDA and incubated at 28°C $\pm$ 2°C for 10–15 days to obtain pure cultures (Muntala et al., 2020). Morphological identification was conducted under a ZEISS Axiolab 5 compound microscope and a binocular microscope. Colonial characteristics (colour, texture, growth pattern) and microscopic features (conidial shape, size, and septation; presence of chlamydospores) were recorded and compared against established identification keys for Fusarium species (Kale et al., 2023; Khan et al., 2021).

2.5 Disease Incidence and Severity Assessment

Disease incidence and severity were assessed across all 12 farms (4 per community). One hundred (100) plant stands per farm were scored for incidence, and 50 plants per farm were scored for severity. Disease incidence was calculated as:

$$DiseaseIncidence(\%) = \frac{Numberofinfectedplants}{Totalplantsscored} \times 100$$

Disease severity was assessed using the five-point rating scale recommended by the CSIR-Crop Research Institute (2014), described in Table 2.

Table 2. Disease severity rating scale used to assess Fusarium wilt on tomato (Source: CSIR-Crop Research Institute, 2014)

Rating Score	Description of Symptom Severity
1	No disease symptoms are visible on the tomato plant.
2	Disease symptoms cover 5–25% of the total leaf area.
3	Disease symptoms cover 25–50% of the total leaf area.
4	Disease symptoms cover 50–75% of the total leaf area.
5	Disease symptoms cover 75–100% of the total leaf area, resulting in complete plant death with no recovery or yield.

Final disease severity per farm was calculated as:

Disease Severity $= \frac{\sum(n \times v)}{N}$

where n = number of plants scored at each rating value, v = the corresponding rating value, and N = total number of plants scored per farm.

2.6 Radial Growth Measurement

Five replicate Petri dishes inoculated with pure *F. oxysporum* culture on PDA were used to monitor radial mycelial growth. Diameters were measured daily along two perpendicular axes for eight consecutive days using a digital Vernier calliper, and mean radial growth (mm) was recorded for each dish per day.

2.7 Pathogenicity Test (Koch's Postulates)

Pathogenicity was confirmed by inoculating healthy tomato seedlings (14 days old) with a conidial suspension (1×10^6 conidia/mL) prepared from a seven-day-old PDA culture. Roots were dipped in the suspension for 30 minutes prior to transplanting into sterilised soil. Control seedlings were treated with sterile distilled water. Plants were maintained in a greenhouse at 28°C ± 2°C and monitored for 21 days. The pathogen was re-isolated from symptomatic inoculated plants and compared morphologically with the original isolate.

2.8 Statistical Analysis

All data were analysed using the GenStat statistical software package (11th edition, VSN International). A one-way analysis of variance (ANOVA) was performed to test for significant differences in disease incidence and severity among the three communities. Tukey's honestly significant difference (HSD) post hoc test was used to separate treatment means at the 5% probability level ($p < 0.05$). Values were reported as means with standard errors.

3. Results and Discussion

3.1 Disease Incidence and Severity

Fusarium wilt disease was detected on all farms surveyed across the three communities, confirming its widespread prevalence in the municipality and consistent with reports from MoFA-Dormaa Ahenkro. Benekrom recorded the highest mean disease incidence (67.25%), followed by Babianiha (43.75%) and Duasidan (39.75%) (Figure 3; Table 3). Tukey's HSD test showed that disease incidence in Benekrom was significantly higher than in both Babianiha and Duasidan ($p < 0.05$), while no significant difference was detected between Babianiha and Duasidan. These results are consistent with Opoku et al. (2021), who recorded a mean Fusarium wilt incidence of 45.2% in the Asante Akim North District of Ghana, suggesting that this disease is a widespread concern across the country's forest-transitional zones.

The high incidence in Benekrom is likely attributable to several interacting agronomic and ecological factors. Field interviews with farmers indicated that the majority obtained planting materials, including seeds and seedlings, from neighbouring farmers rather than certified sources. Continuous use of farm-saved planting material is a well-documented pathway for the dissemination of soilborne pathogens, including *F. oxysporum*, as infected material introduces the pathogen to new fields and maintains inoculum pressure across seasons (Gupta & Kumar, 2020; Joshi, 2018). Furthermore, continuous tomato monoculture in Benekrom over successive seasons likely contributed to the buildup of soilborne inoculum, as *F. oxysporum* chlamydospores persist in soil for extended periods (Jiménez-Díaz & Jiménez-Gasco, 2011).

Disease severity scores followed the same community ranking as incidence: Benekrom (1.21) > Babianiha (0.61) > Duasidan (0.44) (Figure 4; Table 3). Benekrom's severity was significantly higher than that of the other two communities ($p < 0.05$), whereas Babianiha and Duasidan were not significantly different from each other. The severity scores, although relatively low on the five-point scale, indicate that disease pressure is sufficient to cause

Table 3. Mean Fusarium wilt disease incidence and severity recorded across three communities in Dormaa Central Municipality, Ghana.

Community	Mean Incidence (%)	Mean Severity Score	p-value
Benekrom	67.25 a	1.21 a	$p < 0.05$
Babianiha	43.75 b	0.61 b	$p < 0.05$
Duasidan	39.75 b	0.44 b	$p < 0.05$

Means followed by different letters within a column are significantly different at $p < 0.05$ (Tukey's HSD test). Source: Field survey and laboratory analysis, 2022–2023.

measurable yield depression, particularly in Benekrom. Jiménez-Díaz and Jiménez-Gasco (2011) established that even moderate disease incidence, when left uncontrolled, progressively reduces productivity across crop development stages, a conclusion reinforced by Joshi (2018), who documented the progressive dynamics of vascular colonisation by *F. oxysporum* that render infected plants unable to recover.

All three communities fall within the transitional agro-ecological zone, which is characterised by high rainfall, elevated humidity, and moderate temperatures. These conditions are optimal for Fusarium spore germination, root infection, and disease spread (Opoku et al., 2021; Fitt et al., 1989; Golan & Pringle, 2017). Rainfall in particular facilitates the splash dispersal of macroconidia and the movement of inoculum-laden soil particles across farms (Fitt et al., 1989). The higher disease pressure in Benekrom may also reflect differences in local land-use history, drainage patterns, and the intensity of tomato cultivation compared with the other two communities.

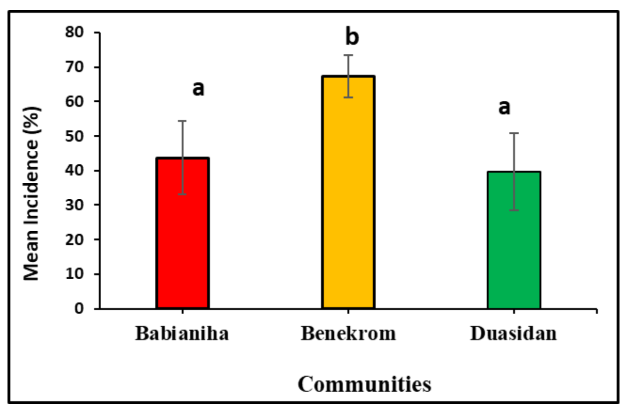

Figure 3. Mean Fusarium wilt disease incidence (%) on tomato (*Solanum lycopersicum* L.) across three surveyed communities in Dormaa Central Municipality, Ghana. Different letters above bars indicate significant differences ($p < 0.05$; Tukey's HSD test).

Farmers in the study area reported routine fungicide application; however, severity continued to increase over time. This discrepancy is consistent with observations by Moumouni et al. (2021), who attributed suboptimal fungicide efficacy in smallholder systems to under-dosage linked to the high cost of agrochemicals. Aworh (2021) further noted that health and environmental concerns have prompted some farmers in sub-Saharan Africa to reduce chemical inputs voluntarily. This factor may also be operating in this context.

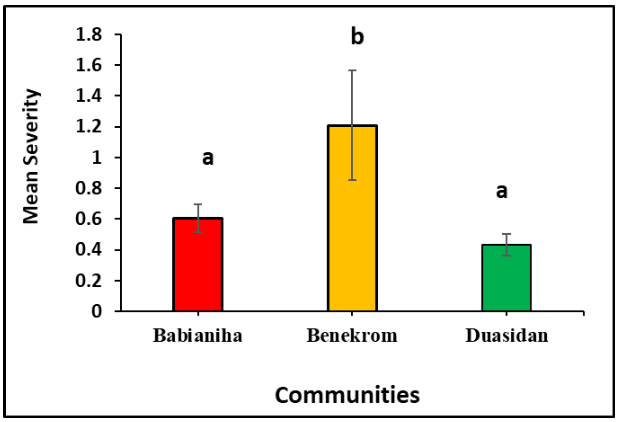

Figure 4. Mean Fusarium wilt disease severity scores on tomato (*Solanum lycopersicum* L.) across three surveyed communities in Dormaa Central Municipality, Ghana. Different letters above bars indicate significant differences ($p < 0.05$; Tukey's HSD test).

Figure 5. Colony morphology of *Fusarium oxysporum* isolated from wilted tomato plants in Dormaa Central Municipality on potato dextrose agar (PDA) after 7 days of incubation at 28°C. (Obverse view shown.)

3.2 Morphological Identification of the Pathogen

After seven days of incubation on PDA at 28°C, fungal colonies exhibited white to dirty-white fluffy aerial mycelium with a slightly yellowish pigmentation on the reverse side of the plate (Figure 5). Microscopic examination confirmed the presence of two conidial types. Microconidia were oval to ellipsoid or kidney-shaped, measuring 5.3–10.0 µm in length, with a single septum. Macroconidia were three-celled, with a slightly curved, tapering shape. Chlamydospores were observed forming terminally and intercalarily, frequently in chains (Figure 6). These morphological characteristics are diagnostic of *Fusarium oxysporum*. They are consistent with descriptions by Khan et al. (2021), who characterised the same species from cotton wilt in Pakistan and Joshi (2018), who documented comparable conidial sizes and chlamydospore morphology.

Colony morphology and spore dimensions recorded in this study conform to the taxonomic description of *F. oxysporum* f. sp. *lycopersici*, the established causal agent of tomato Fusarium wilt (Bawa, 2016; Sanoubar & Barbanti, 2017). The identification was further corroborated by the results of the pathogenicity test described below.

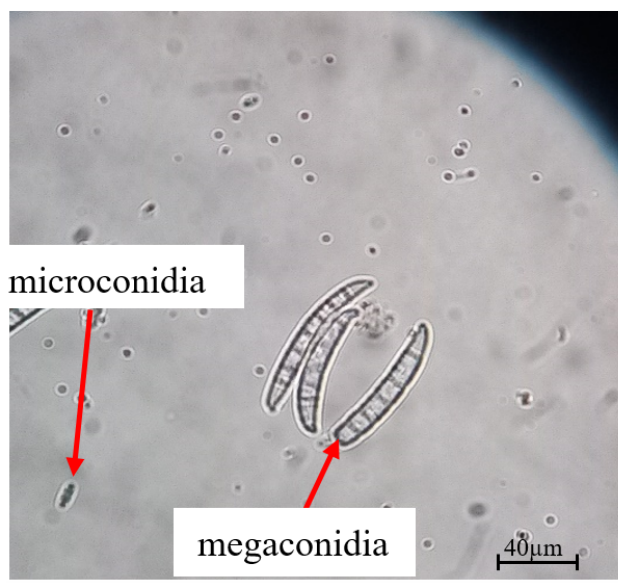

Figure 6. Microscopic morphology of *Fusarium oxysporum* isolated from tomato plants in Dormaa Central Municipality. Microconidia (oval to kidney-shaped, 5.3–10.0 µm), macroconidia (three-celled), and chlamydospores forming in chains are visible (ZEISS Axiolab 5; scale bar = 40 μm).

3.3 Radial (Mycelial) Growth

Mycelial radial growth on PDA at 28°C showed consistent progression across all five Petri dishes (P1–P5), reaching a maximum diameter of 25 mm (full plate coverage, stationary phase) within eight days (Figure 7; Table 4). Petri dish P2 reached the stationary phase earliest, on Day 5, while P4 and P5 attained full growth by Day 6, P3 by Day 7, and P1 by Day 8. Variation in growth rate across dishes likely reflects minor differences in initial inoculum density or position of the plug.

These results confirm that PDA at 28°C provides a favourable medium and temperature for maximum mycelial development of *F. oxysporum*, as reported by Chaudhary et al. (2023), who found that PDA and Richards's agar supported optimal growth of *F. udum*. Desai et al. (2016) established that the optimal growth temperature for *F. oxysporum* f. sp. *lycopersici* is between 25°C and 28°C, a range consistent with the incubation conditions used in this study. Poorvasandhya et al. (2020) similarly confirmed that PDA outperforms other culture media for Fusarium species under in vitro conditions.

Table 4. Radial mycelial growth (mm) of *Fusarium oxysporum* on PDA at 28°C across eight days (Day 2 to Day 8). Values marked with * indicate attainment of the stationary phase (full plate coverage = 25 mm).

Petri Dish	D2	D3	D4	D5	D6	D7	D8
P1	5	8	12	16	20	23	25
P2	7	11	15	25*	25*	25*	25*
P3	6	10	14	18	22	25*	25*
P4	7	11	15	19	25*	25*	25*
P5	6	10	14	18	25*	25*	25*

3.4 Pathogenicity Test

Inoculated tomato seedlings developed Fusarium wilt symptoms within 14–18 days post-inoculation, including wilting, yellowing of lower leaves, vascular discolouration, and, in severely affected plants, plant death. Control plants remained healthy throughout the observation period. Re-isolation from symptomatic inoculated plants yielded cultures morphologically identical to the original isolate, thereby fulfilling all requirements of Koch's postulates. This confirms that *F. oxysporum* f. sp. *lycopersici* is the causal agent of the wilt disease observed in the surveyed farms (Bawa, 2016; Sanoubar & Barbanti, 2017; Worku & Sahe, 2018).

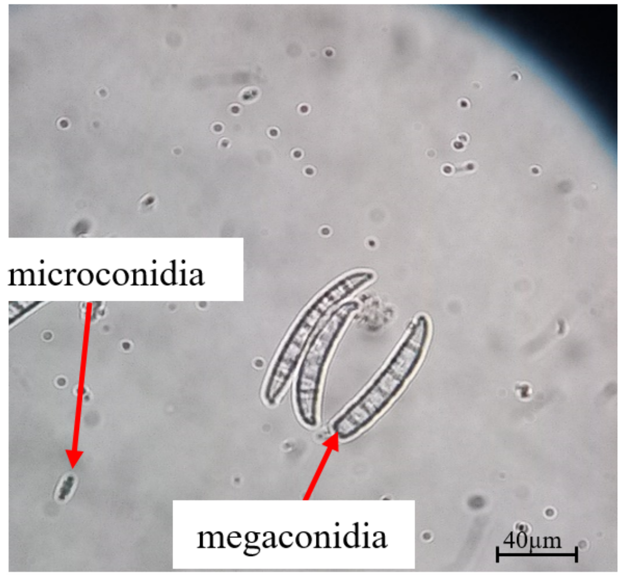

Figure 7. Radial mycelial growth (mm) of *Fusarium oxysporum* on potato dextrose agar (PDA) at 28°C over eight days. P1–P5 represent five replicate Petri dishes. The dotted horizontal line at 25 mm indicates full plate coverage (stationary phase).

4. Conclusion

Fusarium wilt disease, caused by *Fusarium oxysporum* f. sp. *lycopersici*, is confirmed to be widespread across all three surveyed tomato-producing communities in Dormaa Central Municipality, Ghana. Disease incidence and severity were highest in Benekrom (67.25% and 1.21, respectively), significantly exceeding those recorded in Babianiha (43.75% and 0.61) and Duasidan (39.75% and 0.44). The pathogen was morphologically identified as *F. oxysporum*, and pathogenicity was demonstrated through Koch's postulates. Continuous tomato monoculture, use of unverified planting material from infected sources, and prevailing warm, humid conditions in the transitional agro-ecological zone are the primary factors driving the observed high disease pressure. The findings underscore the need for integrated disease management strategies in the municipality, including promoting certified, disease-free planting material, crop rotation, adopting resistant cultivars, and applying targeted fungicides as part of a broader integrated pest management framework.

5. Acknowledgments

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6. Author Contributions

All authors participated in conceptualisation, research design, field data collection, laboratory analyses, statistical analyses, manuscript writing, and critical revision. All authors read and approved the final manuscript.

7. Declaration of Competing Interest

The authors declare that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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