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Research Article

Pathogenicity Assessment of Five *Fusarium* Species from Onion (*Allium cepa* L.) on Four Tomato (*Solanum lycopersicum* L.) Varieties in Burkina Faso

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ABSTRACT

Fusarium species are among the most destructive plant pathogens, causing significant yield losses in many crops, including tomato. Their wide host range raises concerns about cross-pathogenicity between crops commonly grown in market gardening systems, such as onion and tomato. The present study evaluated the pathogenicity and aggressiveness of *Fusarium* strains isolated from onion on four tomato varieties (UC82B, Cobra 34 F1, Mongal F1, and Petomech) under controlled conditions. Disease incidence (DI) was assessed at 21, 28, and 35 days after inoculation (DAI). Results demonstrated significant variation in aggressiveness among the tested species. *Fusarium oxysporum* was the most virulent, reaching 85 ± 10% DI in UC82B at 35 DAI. *F. proliferatum* and *F. falciforme* also induced severe infections, with DI of 78.33 ± 16.67% in Cobra 34 F1 and 70.83 ± 5% in Petomech, respectively. *F. solani* and *F. acutatum* were comparatively less aggressive but still caused substantial disease in certain varieties. Varietal responses revealed that UC82B was the most susceptible, recording DI values exceeding 80% for multiple species, while Mongal F1 and Cobra 26 F1 exhibited moderate resistance, and Petomech showed intermediate susceptibility. Control treatments remained symptom-free, confirming *Fusarium* as the causal agent. Re-isolation and morphological characterization of the fungi fulfilled Koch's postulates, confirming the identity of *F. acutatum*, *F. solani*, *F. proliferatum*, *F. oxysporum*, and *F. falciforme*. These findings demonstrate strong cross-pathogenicity of onion-derived *Fusarium* strains on tomato, highlighting the importance of resistant cultivars and integrated management strategies to limit disease spread in intensive vegetable cropping systems.

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Introduction

The *Fusarium* genus comprises numerous fungal species that are widespread and notorious for their economic impact on agriculture, collectively affecting more than 100 plant species worldwide. These fungi are commonly present in cultivated soils, where they persist as chlamydospores and hyphae, infecting a wide range of host plants and causing significant yield losses (Gupta et al., 2020). Among the affected crops, onions (*Allium cepa*) and tomatoes (*Solanum lycopersicum*) hold particular

importance due to their high economic and nutritional value. In West Africa, especially in Burkina Faso, these crops are staple commodities that contribute substantially to food security and local economies. They serve as primary income sources for smallholder farmers and are integral to regional diets, providing essential vitamins and nutrients (FAO, 2024). However, their production is highly vulnerable to fungal pathogens, with *Fusarium* species ranking among the most destructive due to their ability to cause root rot, wilting, and other severe diseases, leading to yield losses of up to 40% in affected fields and thereby aggravating food insecurity in vulnerable regions (Brandi et al., 2007; Nucci and Anaissie, 2007; Gupta and Tuohy, 2019).

The capacity of *Fusarium* species to infect multiple hosts presents additional challenges for sustainable crop management. Although some isolates are known to infect different crops under certain conditions, the extent to which isolates from onions can infect other hosts, such as tomatoes, remains poorly understood, particularly in West African agro-ecological systems. To address this knowledge gap, the present study provides the first understandings about *Fusarium* cross-pathogenicity in onion and tomato production. Previous research has shown that environmental conditions, crop rotation practices, intercropping systems, and genetic variability among *Fusarium* isolates can influence cross-host pathogenicity, emphasizing the importance of region-specific investigations (Palmero et al., 2010; Singha et al., 2011). Understanding these interactions is critical; without this knowledge, farmers may unintentionally facilitate the spread of pathogens between crops, thereby increasing disease prevalence and reducing crop resilience (Zhang et al., 2006).

In Burkina Faso, the limited understanding of pathogen dynamics constrains the development of regionally adapted management strategies, as the behavior of local *Fusarium* strains may differ significantly from that of non-local populations. Therefore, this study aims to evaluate the pathogenicity of five *Fusarium* species isolated from onions on four tomato varieties. The objective is to determine the potential for cross-infection under similar environmental conditions and to assess its implications for disease management. Addressing this research gap will enable the development of tailored management strategies for local farmers, reduce the risk of cross-crop infections, and promote sustainable approaches to mitigate *Fusarium*-related threats. Furthermore, targeted strategies will provide farmers with practical, locally relevant tools to limit disease spread, reduce reliance on costly chemical inputs, and enhance agroecological sustainability. In the long term, this research will contribute to strengthening the resilience of agricultural sector of Burkina Faso, thereby improving food security and economic stability for communities dependent on onion and tomato production.

Materials and Methods

Tomato varieties and nursery establishment

Four tomato varieties were used in the study, including two hybrids (Mongal F1 and Cobra 26 F1) and two open-pollinated varieties (Petomeh and UC82B). These are early-maturing varieties, with the first harvest obtained 65 days after planting (DAP) for the hybrids and 75 DAP for the fixed varieties. The varieties were selected based on seed availability and fruit quality, which are highly valued by local consumers, as reported by Kabore (2022). Although widely cultivated in the country, all these varieties are susceptible to *Fusarium* infection.

The nursery was established in a greenhouse using rectangular trays (100 cm × 43 cm × 8 cm). A potting mixture, prepared from equal proportions of fine sand and silty-sandy soil, was autoclaved at 100°C for 30 min to ensure sterilization. The trays were then filled with the sterilized soil mixture, and furrows spaced 5 cm apart were made on the surface for sowing the seeds. After sowing, neem leaves (*Azadirachta indica*) were used to cover the soil surface due to their pest-repellent properties. Watering was performed twice daily: in the morning between 8:00-9:00 a.m. and in the evening between 5:00-6:00 p.m. Neem leaves were removed once seed germination occurred. During the nursery period, the greenhouse temperature ranged between 29-34°C, relative humidity was maintained at 50-67%, and natural photoperiod lasted 12-14 h.

Fusarium species and inoculum preparation

One isolate from each of five *Fusarium* species, *F. proliferatum*, *F. acutatum*, *F. oxysporum*, *F. solani*, and *F. falciforme*, was used. These isolates were obtained from diseased onions collected in Burkina Faso and previously characterized by Sogoba (2022).

For inoculum preparation, a 1 mm diameter mycelial plug from a 7-14-day-old culture of each isolate was transferred onto potato dextrose agar (PDA) plates and incubated at 28 ± 2°C under a 12 h light/12 h dark cycle. After 10 days of incubation, 5 ml of sterile distilled water

was added to each plate, and the mycelium along with conidia was gently scraped using a sterile scalpel. The resulting suspension was filtered, and a conidial suspension was prepared and adjusted to a concentration of 1×10^6 conidia/ml using a Neubauer hemocytometer.

Seedling inoculation and transplanting

Seedling inoculation was performed on the 28th day after sowing, following the method of Nabahat (2014) and Kumar (2017). For each *Fusarium* strain, 12 seedlings of each tomato variety were carefully uprooted, and their roots were trimmed just below the crown using sterilized scissors. The seedlings were then immersed in 20 ml of the conidial suspension (1×10^6 conidia/ml) for 30 min. Subsequently, they were transplanted into 10-liter pots (30 cm depth) filled with sterilized potting soil and compost, with three plants per pot.

For control treatments, seedling roots were trimmed and immersed in sterile distilled water before transplanting. The experiment followed a split-plot design with four replications (Figure 1). Pots were spaced 15 cm apart, with 20 cm between replicates, and plants within pots were maintained at a 15 cm spacing. Throughout the experimental period, the greenhouse conditions were maintained at 29-34°C, 50-67% relative humidity, and a 12-14 h photoperiod.

Reisolation and identification of Fusarium species from inoculated seedlings

Three weeks after transplanting, both inoculated and control seedlings were carefully uprooted. Fragments of roots, collar, stem, and leaves were washed with distilled water and subsequently immersed in 1% sodium hypochlorite (bleach) solution for 3-5 min to eliminate surface saprophytes and contaminants. The fragments were then rinsed twice with sterile distilled water and placed in Petri dishes containing blotting paper moistened with distilled water. After two weeks of incubation, the plant tissues were examined under a stereomicroscope and later under a compound microscope to observe the morphological characteristics of the fungi. Finally, mycelial fragments were sub-cultured on PDA medium to re-isolate *Fusarium* strains from the inoculated seedlings, which were then compared morphologically with the original isolates.

Data collection

Inoculated plants were monitored to evaluate the pathogenicity of each *Fusarium* strain on different host varieties. Disease severity was assessed using the six-point rating scale (0-5) described by Pandey et al. (2003), where each score corresponds to a specific level of disease intensity. Assessments were conducted at 21, 28, and 35 days after transplanting. Based on these severity ratings (Symptom Assessment Scale), disease incidence (DI) was calculated following the formula of Song et al. (2004).

$$DI\ (\%) = \frac{\sum(\text{Values} \times \text{Number of infedted plants})}{(\text{Highest value} \times \text{Total number of plants}} \times 100$$

DI (%) represents disease incidence expressed as a percentage, quantifying the proportion of infected plants within the tested population.

The numerator accounts for the total severity of infection across all evaluated plants.

The denominator normalizes this value against the maximum possible severity for the entire plant population.

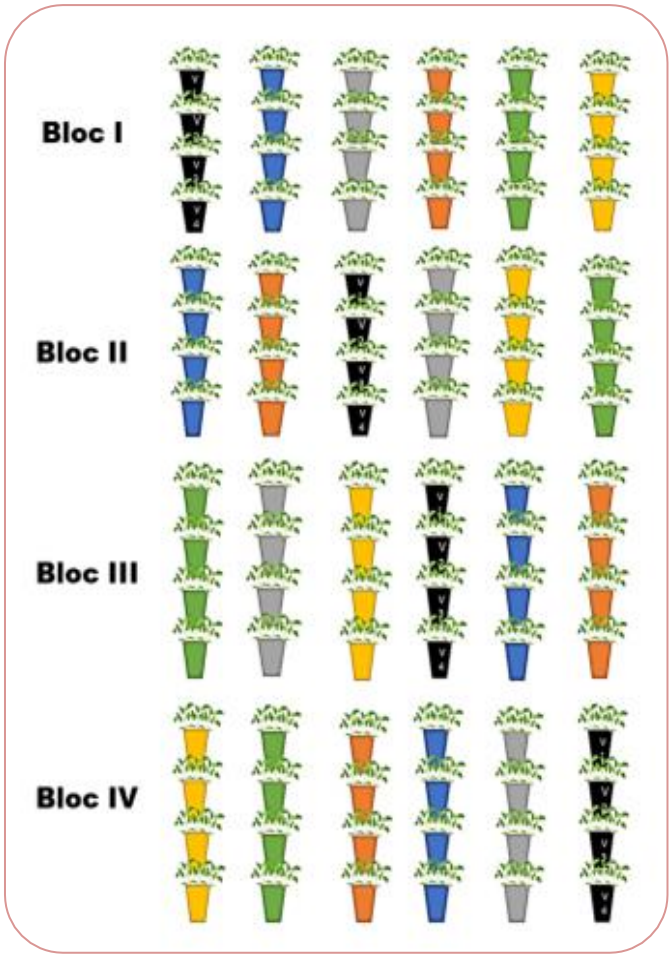

Figure 1. Experimental setup for the pathogenicity test. Each color represents a different tomato variety combined with the respective strains, while black indicates the control.

Data analysis

All statistical analyses were performed using R software (version 4.2.2). Analysis of variance (ANOVA) was used to determine significant treatment effects, and mean separation was carried out using the Student-Newman-Keuls (SNK) test at a 5% probability level ($p \leq 0.05$).

Results

***Fusarium* aggressiveness**

The results (Table I) revealed a significant increase in disease incidence (DI) among the tested tomato varieties, influenced by *Fusarium* species and observation periods (21, 28, and 35 DAI). *F. oxysporum* exhibited the highest aggressiveness, with disease incidence peaking at 85 ± 10% in the UC82B variety at 35 DAI, making it the most virulent species.

F. proliferatum and *F. falciforme* also caused severe infections, reaching 78.33 ± 16.67% in Cobra 34 F1 and 70.83 ± 5% in Petomech, respectively. Although *F. solani* showed comparatively lower aggressiveness, it still produced considerable disease incidence in some varieties. *F. acutatum* induced relatively lower incidence than the other species but still caused significant infection in Mongal F1 and Cobra 34 F1.

Prevalence of *Fusarium* species on tomato varieties

Varietal responses indicated distinct levels of susceptibility. UC82B was the most vulnerable, exhibiting high incidence levels of *F. oxysporum* and *F. proliferatum* as early as 28 DAI, with DI exceeding 80% for multiple *Fusarium* species by 35 DAI, suggesting strong genetic susceptibility.

Mongal F1 and Cobra 26 F1 displayed moderate resistance, particularly against *F. acutatum* and *F. falciforme*, with DI values generally remaining below 50% at 28 and 35 DAI, though incidence increased with time. Petomech showed intermediate susceptibility, with DI values lower than UC82B but higher than the relatively resistant varieties.

In all control treatments (uT, mT, cT, pT), disease incidence remained negligible (~0%), confirming that *Fusarium* species were the primary cause of disease development.

Table 1. Degree of infection by *Fusarium* species in tomato varieties.

Tomato Variety	*Fusarium* Species	Disease Incidence (%)		
		21 DAI	28 DAI	35 DAI
Cobra	*F. oxysporum*	26.6 ± 9.4a	56.6 ± 9a	80 ± 21a
	F. acutatum	11.6 ± 4.8abc	50 ± 12.8abcd	51.4 ± 14.8abc
	F. falciforme	13.4 ± 5.4abc	25 ± 8.4cdef	48.4 ± 22abc
	F. proliferatum	11.6 ± 4.8abc	45 ± 14abcd	78.4 ± 16.6a
	F. solani	13.4 ± 5.4abc	41.6 ± 13abcd	56.6 ± 19.2a
	Control	0.0 ± 0.0c	0.0 ± 0.0ef	0.0 ± 0.0bc
Mongal	*F. oxysporum*	25 ± 11.4a	66.6 ± 9.8a	76.6 ± 3.8a
	F. acutatum	10 ± 3.8abc	31.6 ± 10.2bcdef	55 ± 13.8ab
	F. falciforme	11.6 ± 4.2abc	23.4 ± 13cdef	50 ± 8.6abc
	F. proliferatum	8.4 ± 2.4abc	26.6 ± 7.6cdef	61.6 ± 20a
	F. solani	10 ± 4.8abc	50 ± 20abcd	50 ± 13abc
	Control	0.0 ± 0.0c	0.0 ± 0.0f	0.0 ± 0.0bc
Petomech	*F. oxysporum*	23.4 ± 11.2ab	51.6 ± 10.8abcd	63.4 ± 21a
	F. acutatum	16.6 ± 12.6abc	38.4 ± 6.6abcde	60 ± 16a
	F. falciforme	8.4 ± 6.4abc	38.4 ± 9.6abcde	63.4 ± 11.6a
	F. proliferatum	16.6 ± 8.4abc	45 ± 10.8abcd	68.4 ± 9.6a
	F. solani	21.6 ± 12.8abc	45 ± 20abcd	63.4 ± 20.8a
	Control	0.0 ± 0.0bc	0.0 ± 0.0ef	0.0 ± 0.0bc
UC 82B	*F. oxysporum*	26.6 ± 9.4a	58.4 ± 2ab	85 ± 10a
	F. acutatum	11.6 ± 3.2abc	41.6 ± 10.2abcd	60 ± 8.6a
	F. falciforme	13.4 ± 2.4abc	25 ± 6.6bcdef	58.4 ± 12.8abc
	F. proliferatum	10 ± 3.8abc	40 ± 10abcd	60 ± 15.6a
	F. solani	11.6 ± 2.8abc	36.6 ± 10.2bcde	58.4 ± 9abc
	Control	0.0 ± 0.0c	0.0 ± 0.0f	0.0 ± 0.0bc

Numbers followed by different letters in the same column are statistically different at the 5% significance level according to the SNK test. R^2 = coefficient of determination, DAI = days after inoculation.

Statistical analyses revealed highly significant effects across all observation periods (P ≤ 0.000) (Table 2). The model demonstrated strong explanatory power, with R^2 values of 51.23% at 21 DAI, 70.98% at 28 DAI, and 73.52% at 35 DAI, indicating that the experimental design accounted for a substantial proportion of variation in DI, which increased as the disease progressed.

Table 2. Annova of disease incidence according to the date after inoculation

	Disease incidence (%)		
	21 DAI	28 DAI	35 DAI
P-value	≤ $6{,}08.10^{-5}$	≤ $1{,}2.10^{-11}$	≤ $6{,}29.10^{-13}$
Meaning	VHS	VHS	VHS
R^2	51,23%	70,98%	73,52%

R^2 = Coefficient of determination; DAI = Days after Inoculation; VHS = Very Highly Significant.

Description of *Fusarium* isolates re-isolated from inoculated tomato plants according to Koch's postulates

The cultural characteristics and microscopic features of the mycelia and conidia of fungi re-isolated from inoculated plants were consistent with those of *Fusarium* spp. Accordingly, *F. acutatum*, *F. solani*, *F. proliferatum*, *F. oxysporum*, and *F. falciforme* were identified, as shown in Figures 1A, 1B, 1C, 1D, and 1E.

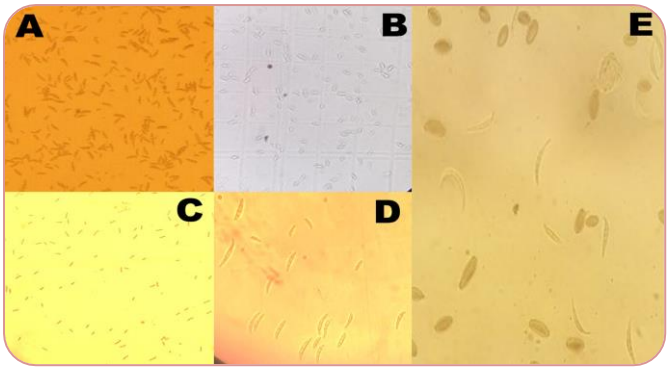

Figure 2. Microscopic characteristics of mycelia and conidia of *Fusarium* species re-isolated from inoculated plants. Magnification: 10 × 40; Scale bar: 10 µm. (A) *Fusarium acutatum*; (B) *F. solani*; (C) *F. proliferatum*; (D) *F. oxysporum*; (E) *F. falciforme*).

Discussion

The significant variation in DI among *Fusarium* species highlights their differences in virulence factors. *F. oxysporum* emerged as the most aggressive, consistent with its recognition as a major plant pathogen (Gupta et al., 2020). This can be explained by the fact that *F. oxysporum* f. sp. *lycopersici* (FOL) is a highly destructive soil-borne pathogen responsible for *Fusarium* wilt, one of the most prevalent and economically damaging diseases of tomato worldwide. Its wide geographical distribution makes it a persistent challenge for both breeders and farmers (Singh et al., 2020). Moreover, *F. oxysporum* exhibits high host specificity, with formae speciales targeting particular hosts. The pathogen has evolved into different races, each overcoming specific resistance genes in tomato. Its adaptability to diverse soil types, along with its capacity to spread via irrigation water, contaminated tools, and infected plant material, further aggravates its impact (Jones et al., 2018). Field studies in Burkina Faso confirmed that *F. oxysporum* is the predominant pathogen in tomato production areas, causing losses of up to 60-80% in some market garden sites (Tiendrebeogo et al., 2023). Similarly, Si Mohammed (2017) demonstrated, after strain characterization, that *F. oxysporum* was the most frequently detected species in tomato.

The moderate aggressiveness of *F. acutatum* and *F. solani* highlights the need for species-specific management strategies. Although *F. acutatum* is less frequently associated with tomato wilt than *F. oxysporum*, it has been reported to cause root rot in solanaceous crops, including tomato. Its pathogenic role in tomato remains under investigation, as virulence varies by region and environmental conditions (Geiser et al., 2021). Pathogenicity tests conducted by Khamas et al. (2021) confirmed the virulence of *F. acutatum*, causing 58% yellowing and wilting of tomato leaves. *F. solani* has a broader host range and environmental adaptability. It is particularly destructive in seedlings, where it causes damping-off, and in mature plants, where it induces root rot, making it a significant concern for tomato breeders focused on early-stage disease resistance (Gordon, 2017).

Although primarily associated with maize and other cereals, *F. proliferatum* has increasingly been reported in tomato, where it causes fruit rot and plant decline. This raises concerns about cross-species infection and mycotoxin accumulation in tomato fruits (Logrieco et al., 2007; Simões and de Andrade, 2023). Meanwhile, *F. falciforme* is relatively new as a reported tomato pathogen. It shares pathogenic traits with *F. solani* and is often studied as part of the *F. solani* species complex.

The high DI values observed in UC82B and Petomech indicate weak genetic resistance, particularly against *F. oxysporum* and *F. proliferatum*. By contrast, Mongal F1 and Cobra 26 F1 displayed relatively stronger resistance,

suggesting the presence of genetic traits mitigating *Fusarium* infection. However, this resistance may break down under high *Fusarium* pressure. These findings support earlier studies emphasizing the importance of host-pathogen interactions in shaping disease severity (Smith et al., 2018). The progressive increase in DI over time, reflected in rising R^2 values, illustrates the aggressive colonization and spread of *Fusarium* pathogens in tomato. This emphasizes the necessity of early-stage control measures to prevent the severe infections observed at 35 days after inoculation (DAI). The highly significant P-values and strong R^2 values confirm the reliability of these findings and their relevance for practical applications. Enhancing the resistance of varieties such as Mongal F1 and Cobra 26 F1 could help reduce yield losses. In addition, integrated pest management (IPM) strategies, combining resistant varieties, early detection, fungicide application, and crop rotation, remain critical for mitigating *Fusarium* outbreaks.

Re-isolation of the pathogens from symptomatic inoculated plants, followed by microscopic comparison of the re-isolated spores with the original inoculum, confirmed their identity. This verified the causal role of the fungi and fulfilled Koch's postulates.

Conclusion

The current study emphasizes the critical threat posed by *Fusarium* species, particularly *F. oxysporum* and *F. proliferatum*, to tomato cultivation in West Africa. Although varieties such as Mongal F1 and Cobra 34 F1 demonstrated reduced susceptibility, targeted breeding programs are essential to strengthen resistance across tomato cultivars. The highly significant P-values and increasing R^2 values validate the robustness of the results, supporting their application in breeding and management strategies. Integrating knowledge gained from *Fusarium* research in other crops, such as onion, into tomato breeding could provide a broader framework for managing *Fusarium* diseases. For instance, insights from onion breeding programs against *F. oxysporum* f. sp. *cepae* may inform strategies to counter *F. oxysporum* f. sp. *lycopersici* in tomato. This interdisciplinary approach highlights the importance of cross-host research, pathogen monitoring, and shared resistance breeding efforts to address yield losses and safeguard food security. Leveraging research across crops will be vital for developing holistic, sustainable, and effective solutions for managing *Fusarium* in tomato production.

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Authors' Contributions

MS and KHS collected the data; MS, KHS and HS managed laboratory works; AO helps to analyze the data; TAN drafted and corrected the manuscript; KK supervised all the work.

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Conflict of Interest

All authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 12: Responsible Consumption and Production

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