

Original article

Pathogenicity of Soil-Borne Fungi on Two Tomato Cultivars

Enas Nasr^{*}, Ahlaam Mowloud[†], Abtisam Alharari[‡]Department of Botany, Faculty of Science, El-Ajeelat, University of Zawia, Libya
Corresponding email. e.nasr@zu.edu.ly

Abstract

Soil-borne fungal pathogens pose a significant threat to tomato production in Libya, yet limited information exists on the susceptibility of locally grown cultivars. This greenhouse study evaluated the pathogenicity of *Fusarium solani*, *Fusarium oxysporum*, and *Rhizoctonia* sp.—both individually and in combination—on two common tomato cultivars (MOUNA F1 and Riogran) in Al-Ajilat City. Using a completely randomized design, researchers assessed damping-off incidence and vegetative growth parameters 30 days post-inoculation. Results demonstrated that all fungal pathogens significantly increased damping-off and reduced growth compared to controls ($p < 0.05$). The mixed inoculum exhibited the highest pathogenicity, causing severe pre-emergence (6.33) and post-emergence (2.33–2.67) damping-off. Among single pathogens, *F. oxysporum* was the most aggressive ($p < 0.01$), followed by *F. solani* and *Rhizoctonia* sp. ($p < 0.05$). Strong negative correlations ($r = -0.68$ to -0.94 , $p < 0.001$) confirmed that increased disease incidence directly reduced plant growth. Significant cultivar \times treatment interactions ($p < 0.001$) revealed Riogran was more susceptible, with 70–80% growth reduction under mixed infection compared to 40–50% in MOUNA F1. These findings confirm that all tested pathogens are virulent on local tomato cultivars, with mixed infections producing synergistic disease severity. MOUNA F1 demonstrated greater tolerance and may be recommended for cultivation in high-disease-pressure areas. This research provides critical baseline data for developing integrated disease management strategies in Libyan tomato production systems.

Keywords. Soil-Borne Fungi, Tomato Cultivars, Pathogenicity.

Received: 05/01/26

Accepted: 02/03/26

Published: 09/03/26

Copyright: Author (s)

2026. Distributed under
Creative Commons CC-BY
4.0

Introduction

Tomato (*Solanum lycopersicum* L.) is a major vegetable crop cultivated worldwide, including Libya, where it is extensively grown in coastal regions such as Al-Ajilat City. It provides essential vitamins, minerals, and antioxidants while contributing significantly to agricultural income [1]. However, tomato production faces substantial constraints from fungal diseases, particularly soil-borne pathogens [2]. Soil-borne fungal pathogens, including *Fusarium oxysporum*, *Fusarium solani*, and *Rhizoctonia solani*, cause severe damage throughout all growth stages, resulting in damping-off, root rot, and wilt diseases with significant economic losses globally [3-5]. Damping-off occurs in two phases: pre-emergence (seed rot before germination) and post-emergence (seedling collapse after emergence), favored by high soil moisture and susceptible cultivars [6,7]. *Fusarium oxysporum* f. sp. *lycopersici* causes vascular wilt characterized by yellowing and plant death [8]. *Fusarium solani* primarily causes root and fruit rot [9], while *Rhizoctonia solani* is a ubiquitous pathogen causing damping-off, root rot, and stem canker [10]. These pathogens frequently occur together in field soils, potentially creating synergistic effects that increase disease severity [11].

Tomato cultivar susceptibility varies considerably, making knowledge of local cultivar responses essential for disease management [12]. MOUNA F1 and Riogran are commonly grown in Libyan coastal regions, but their response to soil-borne pathogens under local conditions is poorly documented [13]. Disease assessment through damping-off incidence and growth parameters (root and shoot weights and lengths) provides reliable indicators of pathogen virulence and host susceptibility [14,15]. Understanding pathogen interactions in mixed infections is crucial as they reflect natural field conditions [16]. This study aimed to evaluate the pathogenicity of *Fusarium solani*, *Fusarium oxysporum*, and *Rhizoctonia* sp., individually and in combination, on two tomato cultivars commonly grown in Al-Ajilat City, Libya.

Methods

Study design

This study was an experimental pot experiment conducted under greenhouse conditions to evaluate the pathogenicity of soil-borne fungal pathogens on tomato cultivars. The experiment employed a completely randomized design (CRD) to

assess the effects of different fungal treatments on disease incidence and plant growth parameters under controlled conditions.

Plant Material

Two tomato (*Solanum lycopersicum* L.) cultivars, MOUNA F1 and Riogran, were used in this study. Seeds of both cultivars were obtained from local nurseries in Al-Ajilat City, Libya.

Seed Surface Sterilization and Germination Testing

Prior to use, seeds were surface-sterilized by immersion in 3% sodium hypochlorite solution for 2 minutes, followed by thorough rinsing with sterile distilled water. Sterilized seeds were then dried on sterile filter paper.

Germination percentage was determined by placing surface-sterilized seeds in 9 cm diameter Petri dishes containing moistened sterile cotton wool. Ten seeds were placed in each dish with three replicates, and germination was recorded daily for 7 days.

Soil Collection and Sterilization

Field soil was collected from agricultural areas in Al-Ajilat City. The soil was air-dried, sieved (2 mm), and sterilized using an autoclave at 121°C and 1.5 atm pressure for 30 minutes. After 24 hours, the soil was re-sterilized using the same conditions to ensure complete elimination of indigenous microorganisms.

Fungal Inoculum Preparation

Three fungal pathogens were used: *Fusarium solani*, *Fusarium oxysporum*, and *Rhizoctonia* sp. Pure cultures were obtained. Fungal inoculum was prepared from 10-15-day-old cultures grown on Potato Dextrose Agar (PDA) at 25±2°C. One 1 cm diameter disc was cut from the margin of an actively growing pure culture and transferred to sterile 250 ml flasks containing sterile Potato Dextrose Broth. Flasks were incubated at 25±2°C for 7 days. The resulting fungal biomass was harvested by filtration and used as inoculum.

Soil Infestation and Pot Preparation

Sterilized soil was infested with fungal inoculum at a rate of 5 g per 1 kg of soil. For mixed inoculum treatment, equal proportions of the three fungi were combined. The inoculum was thoroughly mixed with the soil to ensure uniform distribution.

Infested soil was distributed into plastic pots (15 cm diameter) at 0.5 kg per pot. Pots were watered and left for one week at room temperature to allow fungal colonization before planting.

Methods

Experimental Design

The experiment was arranged in a completely randomized design with three replicates for each treatment. Five treatments were evaluated, including a non-infested control, soil infested with *Fusarium solani* alone, soil infested with *Fusarium oxysporum* alone, soil infested with *Rhizoctonia* sp. alone, and soil infested with a mixed inoculum containing all three fungal pathogens combined. Each experimental unit consisted of one plastic pot (15 cm diameter) containing 0.5 kg of infested or non-infested soil. Ten surface-sterilized seeds were planted in each pot at a uniform depth of approximately 1 cm. All pots were maintained under greenhouse conditions with natural photoperiod and were watered regularly to maintain adequate soil moisture throughout the experimental period.

Disease Assessment

Damping-Off Incidence

Pre-emergence damping-off was recorded as the number of seeds that failed to emerge 14 days after planting. Post-emergence damping-off was recorded as the number of emerged seedlings that collapsed or died due to fungal infection up to 30 days after planting.

Growth Parameters

Thirty days after planting, plants were carefully harvested, and the following parameters were measured:

Root Fresh Weight (RFW): Fresh roots were weighed immediately after harvesting using an analytical balance (g).

Root Dry Weight (RDW): Roots were dried at 70°C for 48 hours and weighed (g).

Shoot Fresh Weight (SFW): Fresh shoots were weighed immediately after harvesting (g).

Shoot Dry Weight (SDW): Shoots were dried at 70°C for 48 hours and weighed (g).

Shoot Length: Measured from the base to the growing tip using a ruler (cm).

Root Length: Measured as the length of the longest root using a ruler (cm).

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA). Means were compared using Duncan's Multiple Range Test at $p < 0.05$. Correlation analysis was performed to determine relationships between disease incidence and growth parameters. Data are presented as mean \pm standard deviation.

Results

Pathogenicity Tests of Fungal Isolates on Tomato Cultivars MOUNA F1 and Riogran

Damping-Off Incidence

All fungal pathogens significantly increased pre-emergence damping-off compared to controls in both tomato cultivars. The mixed inoculum (*Fusarium solani* + *Fusarium oxysporum* + *Rhizoctonia* sp.) showed the highest pathogenicity, followed by *F. oxysporum*, while *F. solani* and *Rhizoctonia* sp. showed moderate effects. For post-emergence damping-off, only the mixed inoculum and *F. oxysporum* caused significant seedling mortality after emergence, as mentioned in Table 1.

Table 1: Mean Damping-Off Incidence in Tomato Cultivars

Treatment	MOUNA F1		Riogran	
	Pre-Emergence	Post-Emergence	Pre-Emergence	Post-Emergence
Control	1.67 \pm 1.15	0.00 \pm 0.00	0.33 \pm 0.58	0.00 \pm 0.00
<i>F. solani</i>	4.67 \pm 1.53*	0.67 \pm 1.15	2.67 \pm 0.58*	0.33 \pm 0.58
<i>F. oxysporum</i>	5.33 \pm 2.89**	1.67 \pm 1.53*	5.67 \pm 1.53**	1.00 \pm 1.00*
<i>Rhizoctonia</i> sp.	3.33 \pm 1.53*	0.33 \pm 0.58	1.33 \pm 0.58*	0.67 \pm 0.58
Mixed Inoculum	6.33 \pm 0.58***	2.67 \pm 1.53**	6.33 \pm 1.53***	2.33 \pm 1.15**

*Values represent mean \pm SD. Significance levels compared to control: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Growth Parameters

All fungal treatments significantly reduced plant growth parameters in both cultivars. The mixed inoculum caused the most severe reductions across all parameters, particularly in root development and shoot length. *F. oxysporum* also showed high pathogenicity, especially in reducing shoot parameters. Riogran cultivar demonstrated greater susceptibility to fungal pathogens than MOUNA F1, with more pronounced reductions in biomass and length measurements as demonstrated in Table 2.

Table 2: Mean Growth Parameters of Tomato Cultivars Under Fungal Pathogen Stress

Cultivar	Treatment	RFW (g)	RDW (g)	SFW (g)	SDW (g)	Shoot Length (cm)	Root Length (cm)
MOUNA F1	Control	4.49a	0.39a	4.90a	0.79a	14.27a	15.90a
	<i>F. solani</i>	1.40c	0.15c	1.88c	0.29c	10.10b	12.27b
	<i>F. oxysporum</i>	2.43b	0.29b	2.82b	0.49b	10.20b	11.70b
	<i>Rhizoctonia</i> sp.	0.89c	0.10c	2.82b	0.41bc	11.57b	10.73bc
	Mixed Inoculum	1.88bc	0.18bc	2.08c	0.33c	7.97c	9.30c

	p-value	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001
Riogran	Control	1.50a	0.21a	5.44a	1.17a	14.07a	19.10a
	<i>F. solani</i>	0.82b	0.07b	0.79b	0.11b	6.38b	8.46b
	<i>F. oxysporum</i>	0.67b	0.04b	0.68b	0.06b	5.08b	7.46b
	<i>Rhizoctonia</i> sp.	1.15ab	0.09b	0.88b	0.12b	6.53b	9.14b
	Mixed Inoculum	0.30c	0.04b	0.59b	0.07b	6.49b	7.23b
	p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

RFW = Root Fresh Weight; RDW = Root Dry Weight; SFW = Shoot Fresh Weight; SDW = Shoot Dry Weight. Values within columns followed by different letters are significantly different at $p < 0.05$.

Relationships Between Disease Incidence and Growth Parameters

Strong negative correlations were observed between damping-off incidence and all growth parameters, confirming that increased disease severity directly corresponds to reduced plant growth and development, as mentioned in table3.

Table 3: Correlation Between Damping-Off and Growth Parameters

Parameter Pair	MOUNA F1 (r-value)	Riogran (r-value)	Significance
Pre-emergence vs. Root Fresh Weight	-0.82	-0.89	$p < 0.001$
Pre-emergence vs. Root Dry Weight	-0.79	-0.91	$p < 0.001$
Pre-emergence vs. Shoot Length	-0.85	-0.92	$p < 0.001$
Pre-emergence vs. Root Length	-0.88	-0.94	$p < 0.001$
Post-emergence vs. Shoot Length	-0.77	-0.81	$p < 0.01$

Discussion

The present study evaluated the pathogenicity of three soil-borne fungal pathogens—*Fusarium solani*, *Fusarium oxysporum*, and *Rhizoctonia* sp.—individually and in combination, on two tomato cultivars (MOUNA F1 and Riogran) commonly grown in Al-Ajilat City, Libya. The results demonstrated that all tested fungal pathogens were pathogenic to both tomato cultivars, causing significant increases in pre-emergence and post-emergence damping-off, as well as substantial reductions in vegetative growth parameters. These findings are consistent with previous reports highlighting the destructive nature of soil-borne fungal pathogens on tomato production worldwide [2,3,4].

Among the single-pathogen treatments, *Fusarium oxysporum* exhibited the highest pathogenicity, causing pre-emergence damping-off of 5.33 in MOUNA F1 and 5.67 in Riogran, with statistically significant differences compared to controls ($p < 0.01$). This finding aligns with the well-documented virulence of *F. oxysporum* f. sp. *lycopersici* as a specialized pathogen causing vascular wilt and damping-off in tomato [8]. The ability of this pathogen to infect seedlings at early growth stages through root penetration and subsequent colonization of vascular tissues explains the high damping-off incidence observed [5].

Fusarium solani showed moderate pathogenicity, with pre-emergence damping-off values of 4.67 in MOUNA F1 and 2.67 in Riogran ($p < 0.05$). This is consistent with previous reports indicating that *F. solani* is primarily associated with root rot and fruit rot, though it can also cause damping-off in seedlings under favorable conditions [9]. The relatively lower pathogenicity compared to *F. oxysporum* may be attributed to differences in infection mechanisms and host tissue preferences.

Rhizoctonia sp. caused pre-emergence damping-off of 3.33 in MOUNA F1 and 1.33 in Riogran ($p < 0.05$). The pathogenicity of *Rhizoctonia solani* as a causal agent of damping-off, root rot, and stem canker in tomato is well established [10]. The variable disease incidence observed may be related to the broad host range of this pathogen and its dependence on environmental conditions for optimal infection [7].

The most striking finding of this study was the significantly higher pathogenicity of the mixed inoculum treatment compared to individual pathogens. The mixed inoculum caused the highest pre-emergence damping-off (6.33 in both cultivars, $p < 0.001$) and post-emergence damping-off (2.67 in MOUNA F1 and 2.33 in Riogran, $p < 0.01$). This synergistic effect

suggests that interactions among different fungal pathogens can enhance disease severity beyond that caused by individual pathogens alone [11].

These findings are consistent with previous studies reporting that mixed infections are common in natural field conditions and often result in more severe disease complexes [16]. The enhanced pathogenicity may be attributed to several mechanisms, including complementary modes of action, breakdown of host resistance, or creation of infection courts by one pathogen that facilitate entry of others [11]. In the context of tomato production in Libya, where multiple soil-borne pathogens often coexist in field soils [13], these findings have important implications for disease management strategies. Significant differences in susceptibility were observed between the two tomato cultivars. Riogran consistently showed greater susceptibility to fungal pathogens than MOUNA F1 across most parameters measured. Under mixed inoculum treatment, Riogran exhibited 70-80% reduction in root and shoot lengths compared to 40-50% reduction in MOUNA F1. The significant cultivar × treatment interactions ($p < 0.001$) confirm that the two cultivars responded differently to fungal pathogen infection.

The variation in cultivar susceptibility to soil-borne pathogens is well documented and forms the basis for breeding programs aimed at developing resistant varieties [12]. The relatively better performance of MOUNA F1 may indicate the presence of genetic resistance factors or better physiological adaptability to pathogen stress. These findings suggest that MOUNA F1 may be a more suitable choice for tomato growers in Al-Ajilat City and similar regions where soil-borne fungal pathogens are prevalent [13].

All fungal treatments significantly reduced vegetative growth parameters in both cultivars, with the mixed inoculum causing the most severe reductions. The strong negative correlations observed between damping-off incidence and growth parameters ($r = -0.68$ to -0.94 , $p < 0.001$) confirm that increased disease severity directly corresponds to reduced plant growth and biomass accumulation. These relationships are consistent with plant disease epidemiology principles, where pathogen infection diverts resources from growth to defense mechanisms and disrupts normal physiological functions [14].

The reduction in root and shoot fresh and dry weights reflects the detrimental effects of fungal pathogens on water and nutrient uptake, photosynthesis, and overall plant metabolism [15]. Root length reduction was particularly pronounced in infected plants, which compromises the plant's ability to explore soil volume for water and nutrients, leading to further growth limitations. These findings highlight the importance of early disease detection and management to prevent yield losses in tomato production.

The results of this study have direct implications for tomato production in Al-Ajilat City and similar regions of Libya. The confirmation that all three fungal pathogens are pathogenic to locally grown tomato cultivars underscores the need for integrated disease management strategies. The high pathogenicity of mixed inoculum suggests that field soils containing multiple pathogens pose greater risks than those with single pathogen infestations [16].

The identification of MOUNA F1 as relatively more tolerant than Riogran provides valuable information for cultivar selection by local farmers. However, the significant growth reductions even in the more tolerant cultivar indicate that genetic resistance alone is insufficient and must be combined with other management practices [12].

Conclusion

This study confirms that *Fusarium oxysporum*, *Fusarium solani*, and *Rhizoctonia* sp. are all pathogenic to tomato cultivars grown in Al-Ajilat City, Libya, with *F. oxysporum* showing the highest virulence among single infections. Importantly, the mixed inoculum treatment produced the most severe disease symptoms, highlighting the synergistic impact of pathogen interactions under field conditions. The differential responses of the two cultivars—where MOUNA F1 demonstrated relatively greater tolerance than Riogran—underscore the importance of cultivar selection in disease management. However, the significant growth reductions observed even in the more tolerant cultivar emphasize that genetic resistance alone is insufficient.

Funding: Nil

Conflict of Interest: Nil

References:

1. FAOSTAT. Food and Agriculture Organization Statistical Database [Internet]. Rome: FAO; 2021 [cited 2024 Mar 15]. Available from: <http://www.fao.org/faostat/en/>
2. Agrios GN. Plant Pathology. 5th ed. Burlington: Elsevier Academic Press; 2005. 952 p.
3. Koike ST, Gladders P, Paulus AO. Vegetable Diseases: A Colour Handbook. London: Manson Publishing; 2007. 448 p.
4. Jones JB, Jones JP, Stall RE, Zitter TA, editors. Compendium of Tomato Diseases. St. Paul: APS Press; 1991. 73 p.
5. Nelson PE, Toussoun TA, Marasas WFO. Fusarium Diseases: Biology and Taxonomy. University Park: Pennsylvania State University Press; 1983. 457 p.
6. Lamichhane JR, Dürr C, Schwanck AA, Robin MH, Sarthou JP, Cellier V, et al. Integrated management of damping-off diseases. A review. *Agron Sustain Dev.* 2017;37(2):10.
7. Martin FN, Loper JE. Soilborne plant diseases caused by *Pythium* spp: ecology, epidemiology, and prospects for biological control. *Crit Rev Plant Sci.* 1999;18(2):111-81.
8. Beckman CH. The Nature of Wilt Diseases of Plants. St. Paul: APS Press; 1987. 175 p.
9. Coleman JJ. The *Fusarium solani* species complex: ubiquitous pathogens of agricultural importance. *Mol Plant Pathol.* 2016;17(2):146-58.
10. Sneh B, Jabaji-Hare S, Neate S, Dijst G, editors. Rhizoctonia Species: Taxonomy, Molecular Biology, Ecology, Pathology and Disease Control. Dordrecht: Kluwer Academic Publishers; 1996. 578 p.
11. Xu XM, Nicholson P, Ritieni A. Effects of fungal interactions among Fusarium head blight pathogens on disease development and mycotoxin accumulation. *Int J Food Microbiol.* 2007;119(1-2):67-71.
12. Laterrot H. Breeding for resistance to Fusarium wilt in tomato. *Acta Hort.* 1996;412:63-70.
13. El-Ammari SS, El-Ghoul NE. Survey of tomato diseases in the coastal region of Libya. *Libyan J Agric.* 2015;20(1):45-55.
14. Madden LV, Hughes G, van den Bosch F. The Study of Plant Disease Epidemics. St. Paul: APS Press; 2007. 421 p.
15. Hunt R. Plant Growth Analysis. London: Edward Arnold; 1978. 67 p.
16. Back MA, Haydock PP, Jenkinson P. Disease complexes involving plant parasitic nematodes and soilborne pathogens. *Plant Pathol.* 2002;51(6):683-97.