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IN-VITRO ANTIFUNGAL ACTIVITY OF VOLATILE PLANTS OF EASTERN UTTAR PRADESH AGAINST *FUSARIUM OXYSPORUM* F. SP. *LYCOPERSICI* (SACC.) SYNDER & HANSEN

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ABSTRACT Tomato (*Solanum lycopersicum L.*) is an economically important vegetable crop severely affected by Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lycopersici*. The present investigation aimed to evaluate in vitro antifungal potential of volatile compounds released from selected aromatic and medicinal plants of Eastern Uttar Pradesh against this pathogen under controlled conditions. A total of 16 aqueous extracts obtained from different plant parts of 14 species belonging to 10 families were screened using the inverted petri plate technique to assess vapor- phase inhibition of fungal growth. The highest inhibition was recorded in *Anethum graveolens* (leaf) (92.26%), followed by *Spilanthes acmella* (flower) (78.26%) and *Callistemon citrinus* (leaf) (77.42%). Variations in antifungal efficacy between different plant parts of the same species suggested organ-specific differences in volatile secondary metabolites. Members of the Apiaceae family demonstrated comparatively strong antifungal potential, indicating their richness in bioactive volatile constituents.

KEYWORDS : Tomato (*Solanum lycopersicum L.*), *Fusarium oxysporum* f. sp. *lycopersici*, Fusarium wilt, Volatile plant compounds, Antifungal activity, Aromatic medicinal plants, In vitro screening.

INTRODUCTION

Tomato (*Solanum lycopersicum L.*) is a vegetable crop with a significant economic value and is considered a nutritional commodity due to its wide range of applications in the fresh and processed food industries that are found globally (Maurya et al. 2025). However, the yield of tomatoes is severely limited by a variety of biotic stresses, one of which is Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* being one of the most devastating soil-borne pathogens (Bihon et al. 2022). Traditional management approaches like resistant cultivars, crop rotation and fungicides provide limited and often unsustainable control as the pathogens are varied, environmental issues and there is a threat of developing resistance.

Pesticides such as fungicides used in large scale are man-made chemicals that possess non target action also besides some of them having resistance in the environment to address these issues over the last twenty years, the agricultural scientists have done heavy work to find chemical of plant's origin that have antibacterial or antifungal effects (Ahmad et al. 2024; Islam et al. 2024). The vast majority of the commercialized pesticides are halogenated hydrocarbons whose half-lives in the environment are relatively long and which have more possible toxicology than most natural substances. The diseases and harmful organism has been controlled using synthetic pesticides as well as the fungicides, but most of the synthetic compounds have been discovered to have teratogenecity, mutagenecity, carcinogenecity, phytotoxicity and residual effect (Pathak et al. 2022). Majority of the fungicides are toxic and have direct effects on the Central Nervous System (CNS) of mammals such as human being. The effect of consumptions by grains treated with organomercurials has led to numerous deaths and permanent neurological disability of human beings in Pakistan, Iraq and other countries (Lini et al. 2024).

Over the past few years, plant-based volatile organic compounds have become a topic of interest as the more eco-friendly alternative to fungicides of synthetic nature. These bioactive secondary metabolites, terpenoids, phenolics and essential oils have potent antifungal effects in that they cause by disrupting fungal cell membrane, inhibit spore germination and interposes with the metabolic pathways (Deresa & Diriba, 2023). Various aromatic and medicinal plants have been shown to have an inhibitory effect on phytopathogenic fungi and it is important to evaluate it specifically by region due to the variability of volatile composition by geography and climate (Rivas et al. 2025).

The Eastern Uttar Pradesh, the province of the Indo-Gangetic plains, is a home to the various aromatic and medicinal plant varieties that have been used since the era of the pest and disease controls. However, there are limited systematic researches on the antifungal uses of volatile compounds. Thus, the main goals of the current research are to assess antifungal potential of the selected plant volatiles of Eastern Uttar Pradesh against the *Fusarium oxysporum* f. sp. *lycopersici* under controlled conditions as well as to determine potential candidates to the sustainable management of the Fusarium wilt in tomatoes (Yadav, 2014).

MATERIAL AND METHOD

A total of 16 plants part from 14 species of 10 different families were collected from different localities across the Azamgarh district in Eastern Uttar Pradesh. The collected plant were taxonomically identified in the department of botany S.N.C. Azamgarh using Duthies flora (1903- 1924) (Duthie et al. 1903). For each sample 5 gram fresh plant material was surface sterilized using 0.1% mercuric chloride solution for 1–2 minutes and rinsed three times with sterile distilled water. The material was then crushed in10 ml. of distilled water using a sterile mortar and pestle. The crushed material was filtered through muslin cloth followed by Whatman No.1 filter paper to obtain a clear fresh extract (Xi et al. 2022). The extract was used immediately for antifungal screening through the inverted Petri plate method. The antifungal activity of volatile compounds released from plant extracts without direct contact between the extract and fungal culture was observed. The method allows assessment of vapor-phase inhibition. Czapek Dox Agar medium was poured into Petri plates and allowed to solidify. A 5 mm diameter fungal disc from a 5–7 days old culture was placed at the center of each plate. After 7 days incubation, radial growth of the fungal colony was measured in centimeters. Each treatment including the control was maintained in triplicates Percentage inhibition was calculated using the formula (Beg et al. 2025):

$$\text{Mycelial inhibition} = \frac{C-T}{C} \times 100$$

Where: C = Radial growth in control
T = Radial growth in treatment

RESULT AND DISCUSSION

Table 1: Screening of different parts of volatile plant extracts on mycelial inhibition (%) of *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Synder & Hansen

Plants	Family	Used part	Mycelial Inhibition (%)
Ageratum conozoides L.	Asteraceae	Leaf	57.14
Ageratum conozoides L.	Asteraceae	Flower	12.15
Allium sativum L.	Liliaceae	Leaf	16.13
Anethum graveolens L.	Apiaceae	Leaf	92.26
Callistemon citrinus Dum. Courus	Myrtaceae	Leaf	77.42
Cestrum nocturnum L.	Solanaceae	Leaf	3.23
Cinnamomum verum Blume	Lauraceae	Leaf	54.17
Citrus lemon L.	Rutaceae	Leaf	14.28
Coriandrum sativum L.	Apiaceae	Leaf	66.77
Curcuma longa L.	Zingiberaceae	Leaf	51.42
Cymbopogon citratus (DC.) Stapf	Poaceae	Leaf	59.35
Foeniculum vulgare Mill.	Apiaceae	Leaf	44.00
Mentha piperata L.	Lamiaceae	Leaf	39.35
Sonchus oleraceus L.	Asteraceae	Leaf	62.50
Spilanthes acmella (L.) Murray	Asteraceae	Leaf	66.89
Spilanthes acmella (L.) Murray	Asteraceae	Flower	78.26

The present study tested antifungal activities of volatile compounds emitted by aqueous extracts of 14 plant species (16 plant parts) of 10 different families against *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Synder & Hansen through inverted Petri plate technique (Beg et al., 2025). There was also a significant difference in the mycelial inhibition of the tested plants, which suggested the varying antifungal activity of plant-derived volatiles. Of all treatments, *Anethum graveolens* L. (leaf) showed the highest mycelial inhibition (92.26%), and therefore the antifungal properties in the vapor phase were excellent. This was preceded by *Spilanthes acmela* (flower) (78.26%) and *Callistemon citrinus* (leaf) (77.42%). On the contrary, low levels of inhibition were noted in *Cestrum nocturnum* (leaf) (3.23%), *Ageratum conyzoides* (flower) (12.15%), and *Allium sativum* (leaf) (16.13%).

Figure 1: Showing mycelial inhibition of *Fusarium oxysporum* f. sp . *lycopersici* (Sacc.) Synder & Hansen by leaf of *Anethum graveolens* L.

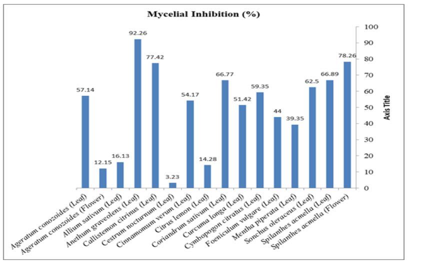

Figure 2: Samples of sixteen plants showing antifungal activity against *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Synder & Hansen

The antifungal action was more variable in the various parts of the same plant was also observed. The leaf extract of *Ageratum conyzoides* (57.14%) had a significantly better inhibition than its flower extract (12.15%). However, on the other hand, *Spilanthes acmella* flower extract (78.26%) proved better than the leaf extract (66.89%). These discrepancies could be as a result of qualitative and quantitative changes in volatile secondary metabolites across organs in plants. The Apiaceae family, which consisted of *Anethum graveolens, Coriandrum sativum* and *Foeniculum vulgare,* has moderate to high antifungal activity, which implied that the family is a good source of bioactive volatile compounds.It is apparent that Eastern Uttar Pradesh is home to several plant species that have potential antifungal uses against *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Synder & Hansen Specifically, *Anethum graveolens*, *Spilanthes acmella* and *Callistemon citrinus* were identified as the potential subjects of the further research. The results underscore the opportunities of aromatic and medicinal plants that are locally available to be used as green substitutes of synthetic fungicides into sustainable and eco-safe methods of managing plant diseases.

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