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MANAGEMENT OF EARLY BLIGHT OF TOMATO (*SOLANUM LYCOPERSICUM* L.) INCITED BY *ALTERNARIA SOLANI* (ELL. & MART.)

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ABSTRACT

Tomato (*Solanum lycopersicum* L.) is a vital vegetable crop globally, but its production faces substantial challenges, with diseases like early blight caused by *Alternaria solani* posing significant threats. This research investigates diverse management strategies against early blight, including cultural, biological, and chemical controls. Experimental work was done at Rama University, Uttar Pradesh, during 2021-22 examined different culture media's suitability, botanical extracts, essential oils, and fungicides against *Alternaria solani*. Results highlighted Potato Dextrose Agar (PDA) as optimal for pathogen growth. Botanicals like *Eucalyptus globulus* and essential oils such as lemon grass showed notable inhibition. Thifluzamide and Hexaconazole were effective fungicides, reducing disease intensity and enhancing yield under field conditions. Hexaconazole emerged as a promising control option. This study provides valuable insights for managing early blight, enhancing tomato production sustainability, and informing agricultural practices.

Key words : *Alternaria solani*, Botanicals, Early blight and Tomato.

Introduction

Tomato (*Solanum lycopersicum* L.) is a globally important vegetable crop, valued for its nutritional content, culinary versatility and economic significance. Its cultivation spans diverse agro ecological regions, contributing significantly to food security and livelihoods. However, tomato production faces numerous challenges, with biotic stresses such as diseases posing significant threats to yield and quality. Among these diseases, early blight caused by the fungal pathogen *Alternaria solani* (Ell. & Mart.), stands out as a particularly detrimental menace to tomato growers worldwide. Early blight is a foliar disease characterized by the formation of dark, necrotic lesions on the lower leaves of tomato plants (Meitei *et al.*, 2014). These lesions typically begin as small spots, gradually enlarging and coalescing as the infection progresses. The disease can spread rapidly under favorable environmental conditions, affecting not only foliage, but also stems and fruits. Premature defoliation caused by early blight weakens the plant's vigor, impeding photosynthesis and nutrient uptake, ultimately leading to reduced yield and quality. Additionally, infected fruits may develop rot, rendering them unmarketable and further exacerbating economic losses. The causal agent of early blight, *Alternaria solani*, is a ubiquitous fungal pathogen with a wide host range beyond tomato, including other solanaceous crops and weeds (Amsaraj *et al.*, 2020). This necrotrophic fungus overwinters in infected crop debris and soil, surviving adverse conditions to initiate infections in subsequent growing seasons. *Alternaria solani* produces abundant conidia (asexual spores) that are disseminated by wind,

rain, and human activities, facilitating the spread of the disease within and between fields. Under conducive environmental conditions, such as warm temperatures and high humidity, spore germination occurs, and the fungus penetrates plant tissues through natural openings or wounds, initiating infection. The economic impact of early blight on tomato production is multifaceted, encompassing direct yield losses, increased production costs, and marketability issues. Studies have documented yield reductions ranging from 20% to nearly 80% in severely affected fields, with losses attributed to reduced fruit set, smaller fruit size and premature senescence of plants. Beyond yield reduction, early blight necessitates costly disease management interventions, including fungicide applications, cultural practices, and crop rotation strategies (Naik *et al*., 2010). Moreover, the presence of early blight can compromise post-harvest storage and shelf life, diminishing the market value of affected produce. Given the significance of early blight as a constraint to tomato production, research efforts have been directed towards developing effective management strategies to mitigate its impact. This research paper aims to comprehensively investigate various aspects of early blight management, including cultural, biological, and chemical control methods. By evaluating the efficacy of different control measures under diverse environmental and agronomic conditions, this study seeks to provide evidence-based recommendations for integrated disease management programs tailored to specific production contexts. Additionally, the research aims to advance our understanding of the epidemiology, genetic diversity, and virulence mechanisms of *Alternaria solani*, informing future strategies for sustainable disease control. Understanding the complex interactions between tomato plants and *Alternaria solani* and identifying effective strategies for disease management are critical for ensuring the sustainability and profitability of tomato production systems. By elucidating the underlying mechanisms of early blight pathogenesis and evaluating control measures, this research contributes to the development of science-based recommendations that empower growers to mitigate disease risks effectively. Ultimately, the findings of this study are expected to inform policy decisions, enhance grower resilience, and safeguard tomato yields against the threat of early blight in a changing agricultural landscape.

Materials and Methods

The experimental work on the "Management of Early blight of Tomato (*Solanum lycopersicum* L.) incited by *Alternaria solani* (Ell. & Mart.)" was conducted at Rama University, Mandhana, Kanpur, Uttar Pradesh, during the period of 2021-22. The procedures followed for the collection of diseased plant samples, isolation and identification of the pathogen, as well as the evaluation of various management strategies are outlined below.

Collection of Diseased Plant sample

Leaf samples exhibiting typical symptoms of early blight were collected from the field, and transported to the laboratory in sealed polythene bags for further analysis

Preparation of Different culture media

Potato Dextrose Agar Medium : Initially, potatoes were weighed of required quantity and washed thoroughly under running tap water, outer peel was removed and sliced into small pieces. Boil thesliced potato pieces in 500 ml of distilled water for 30 minutes until they become soft.Filter the content using clean muslin cloth. Mix 20 g dextrose and molten agar to this supernatant make up the final volume to 1 liter. Allow them to boil for further 5 moreminutes until agar get properly mixed. Pour the prepared media in to flasks and close them tightly with non-absorbent cotton. Place them in an autoclave for proper sterilizationat 121.6^{0}C temperature and at a pressure of 15l b pound/ square inch (1.05kg/cm^2) for 20 minutes.

Tomato Leaf Extract Agar Medium : Green tomato leaves (200 g) were collected from the field and thoroughly washed under running water and boiled in 500 ml of water for 30 minutes. Extracts was collected by filtering through muslin cloth. The agar was added in the collected filtrate. Finally, volume was made to 1000 ml, collected in the flasks and sterilized in autoclave at 15l bpsi for 20minutes.

Malt Extract Agar Medium (Blakeslee's formula) : Suspended 20 g malt extract, 5g glucose, 1 g peptone and 20 g agar in one litre of distilled water. Mixed well and heated with frequent agitation up to boiling point for melting of agar. Further sterilized in an autoclave at 121^{0}C (15l bpsi) for 20minutes.

Glucose Peptone Yeast Agar Medium : Suspended 40 g glucose, 5 g peptone, 5 g yeast extract and 15 g agar in1000 ml distilled water. Melt the agar by heating the suspension. Then media was sterilized at 121°C in autoclave for 20 minutes.

Oat Meal Agar Medium : Rolled oat was boiled in 500 ml distilled water for 30 minutes, filtered through muslin cloth and agar was melted in 500 ml distilled water. Two solutions were mixed and the volume was made to 1000 ml by adding distilled water and then sterilized at 121^{0}C temperature and pressure15l bpsi for 20 min in autoclave.

Czapek's Dox Agar Medium : Agar was melted in 500 ml distilled water and rest of the ingredients was thoroughly dissolved in 500 ml distilled water. Both the preparations were mixed and the final volume was made up to 1000 ml and then autoclaved.

In vitro evaluation of botanical extracts against *Alternaria solani*

Antifungal activity of various medicinal plant extracts which were collected from Rama campus and investigated under laboratory conditions against *Alternaria solani*. Extracts from locally available six different plants were selected *viz.*, (*Datura stramonium*) Datura green leaf extract (*Polyalthia longifolia*) Ashoka kernel extract, (*Clerodendron viscosum*) wild jasmine leaf extract, (*Eucalyptus globulus*) Eucalyptus dry leaf extract, (*Chromolaena odorata*) Siam weed Leaf extract, (*Lantana camera*) wild sage whole plant extract was tested against the pathogen. Two concentrations *viz.*, 5% and10% was prepared for each plant extract. Efficacy of plant extracts were tested against *Alternaria solani* using poisoned food technique under *in vitro* conditions (Nene and Thapliyal, 1993).

In vitro evaluation of Essential Oils against *Alternaria solani*

Antifungal activity of various essential oils was investigated under laboratory conditions against *Alternaria solani*. Oils were collected from locally available market in the Kanpur *viz.*, Lemon grass Oil (*Andropogon citratus*), Citronella Oil (*Cymbopogon nardus*), Clove Oil (*Syzygium aromaticum*), Peppermint Oil (*Mentha piperita*), Patchouli Oil (*Pogostemon cablin*). The poisoned food technique was followed to evaluate the efficacy of five essential oils against *A. solani* at three concentrations 0.02%, 0.06%, 0.1%.

In vitro evaluation of fungicides against *Alternaria solani*

Two concentrations of newly marketed fungicides were used for *in vitro* and *in vivo* testing, which are found to be effective against *Alternaria solani*. Five fungicides were selected to test against *Alternaria solani* under *in vitro* conditions. Selected fungicides were Azoxystrobin, Thifluzamide, Probineb, Difenconazole and Pyraclostrobin. All the mentioned fungicides were evaluated under two different concentrations of 100 and 300 ppm by poison food technique.

Observations recorded

The radial growth of the fungus on the poisoned medium was recorded at time of mycelium growth reached 90mm in control. Percent inhibition of mycelium growth of the fungus in case of Botanical extracts, Essential oils, Fungicides under *in vitro* conditions was calculated by using the formula described by Vincent (1927).

$I = C\text{-}T/C \times 100$, where, I = Percent inhibition of mycelia growth, C = Colony diameter in control (mm), T = Colony diameter in treatment (mm)

In vivo evaluation of fungicides against *Alternaria solani*

Randomized block design was followed to evaluate the fungicidal efficiency under field conditions of tomato.

Isolation and Identification of pathogen

The isolation and identification of *Alternaria solani* were carried out following a standard tissue isolation technique. Infected leaves were sterilized with ethyl alcohol and then cut into small pieces. The surface of the samples was sterilized with 0.1% mercuric chloride solution and washed with sterile distilled water. After air drying, the samples were transferred onto Potato Dextrose Agar (PDA) medium in Petri dishes and incubated at 25±2°C. Pure cultures of *A. solani* were obtained by hyphal tip culture and morphological and cultural characteristics were compared to standard descriptions.

Identification of *Alternaria solani*

Spores of *Alternaria solani* were mounted on glass slides, mixed with lactophenol, and observed under a compound microscope. The morphological characteristics of the spores and hyphae were compared to standard criteria for identification.

Pathogenicity test of Early Blight Pathogen (Koch's Postulates)

To confirm the pathogenicity of *A. solani*, a pathogenicity test was conducted under open conditions in pots. Tomato seedlings were transplanted into pots, and a conidial suspension of *A. solani* was sprayed onto the plants. Symptoms were observed and compared with those of naturally infected plants. The pathogen was re-isolated from artificially inoculated tomato leaves and its morphological and cultural characteristics were compared with the original pathogen.

Effect of Culture media on *A. solani*

The effect of different culture media on the growth characteristics of *A. solani* was evaluated. Various solid media, including Potato Dextrose Agar (PDA), Tomato Leaf Extract Agar (TLEA), Malt Extract Agar (MEA), Glucose Peptone Yeast Agar (GPYA), Oat Meal Agar (OMA) and Czapek's Dox Agar (CDA) were prepared

according to specified compositions. The growth rate of mycelia was recorded after incubation and observations were made to assess the suitability of each culture medium for *A. solani* growth. The subsequent sections detail the in vitro evaluation of botanical extracts, essential oils, and fungicides against *A. solani*, including the preparation of test solutions, methods of application, and observations recorded for efficacy assessment.

***In vivo* evaluation of Fungicides :** Under field conditions, fungicidal efficacy was evaluated through spraying of selected fungicides on tomato plants, followed by observations on disease intensity, number of fruits per plant, and fruit yield.

Statistical analysis : The data obtained from the experiments were subjected to appropriate statistical analyses, including CRD, factorial CRD, and RBD, as applicable, to determine the significance of the observed results.

Results and Discussion

Suitability of different culture media

The study evaluated six different culture media for the growth of *Alternaria solani*. Result of the study revealed that potato dextrose Agar Medium being the most supportive. Whereas least growth was observed in Glucose Peptone Yeast Agar Medium. These are accordance with Chohan *et al.* (2015) (Table 1).

Effect of Botanicals against *Alternaria solani*

Six botanical extracts were tested for their inhibitory effect on *Alternaria solani* with control. Among these *Eucalyptus globulus* showing the highest effectiveness at both 5% and 10% concentrations. Ashoka kernel extract (*Polyalthia longifolia)* also exhibited significant inhibition. Similar results were reported by Koley *et al.* (2015), Bhanage *et al*. (2019) (Table 2).

In vitro evaluation of Essential oils against *Alternaria solani*

Five essential oils were tested for their inhibitory effect on *Alternaria solani*. Lemongrass oil showed the highest effectiveness at concentrations of 0.02%, 0.06%, and 0.1%. Citronella oil also exhibited significant inhibition. These findings are closely related with Ashour *et al*. (2016) and Tomazoni *et al*. (2017) (Table 3).

In vitro evaluation of chemical fungicides against *Alternaria solani*

Various fungicides were evaluated, with Hexaconazole and Thifluzamide being the most effective

Table 1 : Suitability of different culture media.

S. no.	Culture Media	Radial growth(cm) at different interval				
		2DAI	4DAI	6DAI	8 DAI	10DAI
1	Potato Dextrose Agar Medium	3.3	5.93	7.7	9	10
2	Tomato Leaf Extract Agar Medium	3	5.7	7.33	8.5	9.5
3	Malt Extract Agar Medium	2.63	4	5.6	6.63	7.3
4	Glucose Peptone Yeast Agar Medium	2.3	3.53	3.9	4.53	5
5	Oat Meal Agar Medium	3.1	5.7	7.41	8.7	9
6	Czapek's Dox Agar Medium	2.7	4.23	5.63	7.27	8
SEm±		0.099	0.085	0.163	0.119	0.121
CD at 5%		0.307	0.264	0.507	0.369	0.377

Table 2 : *In vitro* evaluation of different Botanicals on mycelia growth of *Alternaria solani.*

S. no.	Botanicals	Radial growth(cm)		Percent Inhibition(%)	
		5 %	10 %	5 %	10 %
1	Datura (*Datura stramonium*)	6.75	5.82	24.83	35.18
2	Ashoka (*Polyalthia longifolia*)	6.33	5.76	29.51	35.85
3	Wild Jasmine (*Clerodendron viscosum*)	8.03	7.85	10.57	12.69
4	Eucalyptus (*Eucalyptus globulus*)	4.20	3.10	53.11	67.68
5	Siam weed (*Chromolaena odorata*)	7.93	7.56	11.69	15.81
6	Wild Sage (*Lantana camera*)	6.13	5.65	31.73	36.72
7	Control	9.00	9.00	0.00	0.00
		Botanicals	**Concentration**	**Botanicals X Concentration**	
SEm±		0.078	0.045	0.11	
CDat5%		0.228	0.132	0.323	

Table 3 : *In vitro* evaluation of different Essential oils on mycelia growth of *Alternaria solani*.

S. no.	Essential Oils	Radial growth (cm)			Percent inhibition (%)		
		0.02%	0.06%	0.1%	0.02%	0.06%	0.1%
1	Lemon Grass Oil	4.25	3.15	2.27	60.37	74.12	85.32
2	Patchouli Oil	7.2	6.03	5.12	23.5	38.12	49.5
3	Peppermint Oil	6.31	4.58	3.56	34.62	56.25	69
4	Clove Oil	5.91	5.05	4.92	39.62	50.37	52
5	Citronella Oil	5.73	5	3.23	41.87	51	73.12
	Control	9.00	9.00	9.00	0.00	0.00	0.00
		Essential Oils		Concentration		Essentialoils× Concentration	
SEm±		0.109		0.085		0.19	
CDat5%		0.318		0.246		0.55	

Table 4 : *In vitro* evaluation of different fungicides on mycelia growth of *Alternaria solani*.

S. no.	Fungicides	Radial growth (cm)		Percent Inhibition (%)	
		100ppm	300ppm	100ppm	300ppm
1	Thifluzamide	3.42	2.18	74.11	87.8
2	Azoxystrobin	7.18	6.94	32.35	35.22
3	Probineb	7.37	7	30.21	34.33
4	Hexaconazole	2.23	1.51	87.33	95.33
5	Pyraclostrobin	5.56	4.87	50.33	58.83
6.	Control	10.00	10.00	0.00	0.00
		Fungicides	Concent-ration	Fungicides × Concentration	
SEm±		0.146	0.092	0.207	
CD at 5%		0.434	0.124	0.614	

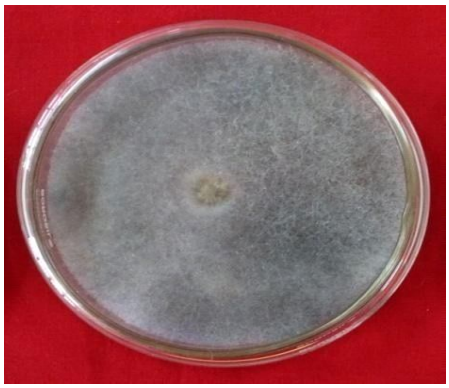

Fig. 1 : Potato Dextrose Agar.

Evaluation of fungicides on Disease intensity of *Alternaria solani* under field condition

The evaluation of fungicides against *Alternaria solani* showed that Thifluzamide and Hexaconazole were the most effective treatments, consistently reducing disease intensity compared to other fungicides and the control. Thifluzamide exhibited the lowest disease intensity percentages across all evaluation periods, followed closely by Hexaconazole. These findings suggest Thifluzamide and Hexaconazole as promising options for managing in controlling *Alternaria solani*. Pyraclostrobin also showed significant control at higher concentrations. These results were supported by Patel *et al.* (2010) and Ghazanfar *et al.* (2016) (Table 4).

Table 5 : Evaluation of fungicides on Disease intensity of *Alternaria solani* under field condition

S. no.	Treatments at 300ppm concentration	Disease Intensity (%)					
		15DAS	30DAS	45DAS	60DAS	75DAS	90DAS
1	Thifluzamide	3.43	6.77	10.87	19.53	43.53	50.87
2	Azoxystrobin	6.10	10.77	19.43	34.67	58.10	68.87
3	Probineb	7.43	12.10	22.10	38.20	62.7	72.10
4	Hexaconazole	2.10	4.10	8.20	14.10	33.43	43.43
5	Pyraclostrobin	4.40	7.43	13.43	24.57	46.50	55.63
6	Control	10.77	16.77	38.57	52.10	73.53	83.43
SEm ±		0.260	0.514	0.837	1.074	2.558	2.451
CD at 5%		0.831	1.639	2.672	3.429	8.163	7.824

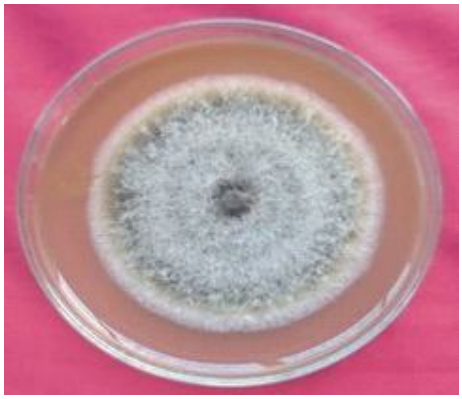

Fig. 2 : Tomato leaf Extract Agar medium.

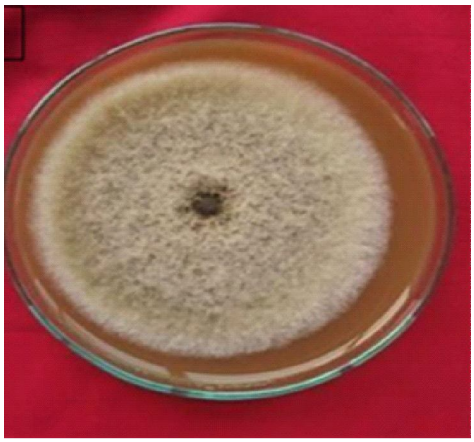

Fig. 3 : Malt Extact Agar Medium.

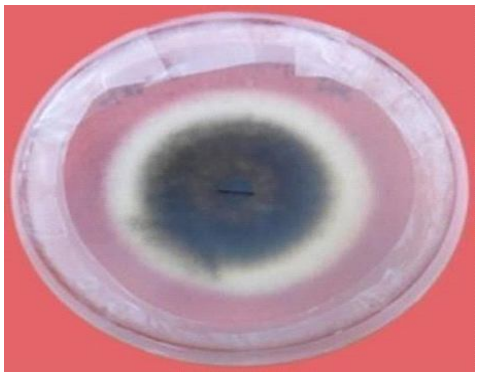

Fig. 4 : Glucose Peptone Yeast Agar Medium.

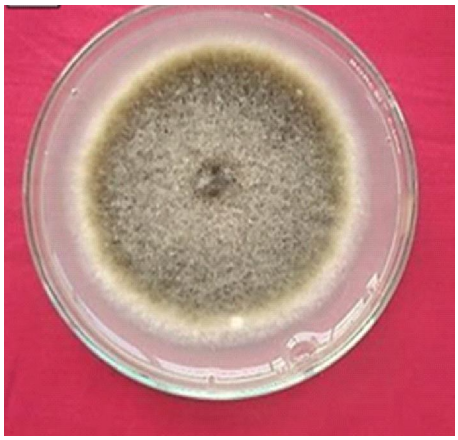

Fig. 5 : Oat Meal Agar Medium.

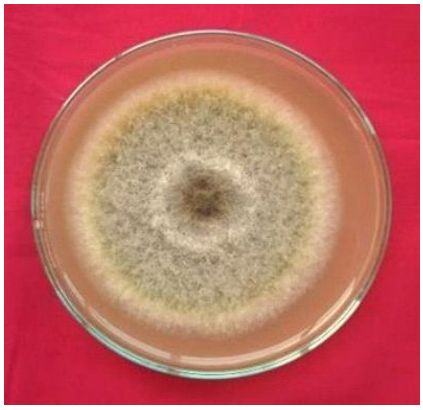

Fig. 6 : Czapek's Dox Agar Medium.

Alternaria solani in field conditions. Similar findings were reported by Sreenivasulu *et al.* (2019) (Table 5).

In vivo Evaluation of different fungicides against *Alternaria solani* and its impact on yield

In field conditions, fungicides like Hexaconazole, Thifluzamide and Pyraclostrobin demonstrated significant control of early blight disease. Hexaconazole was particularly effective even at lower concentrations. Application of Hexaconazole produce maximum number of fruits/ plant (33.33 and 36.00), yield 2.129 and 2.224 (kg/plant), yield 16.05, 16.45 (kg/plot), and 251.75 and

Table 6 : Evaluation of different fungicides against *Alternaria solani* under field conditions and their impact on yield.

S. no.	Fungicides	No. of fruits/ plant		Yield (Kg/plant)		Yield (Kg/plot) 2 × 2 m²		Calculated yield (q/ha) on plot basis		% Increase in yield	
		100ppm	300ppm	100ppm	300ppm	100ppm	300ppm	100ppm	300ppm	100ppm	300ppm
1	Thifluzamide	31.45	33.81	2.052	2.124	15.41	15.61	241.25	244.5	28.41	28.40
2	Azoxystrobin	26.85	28.32	1.901	1.956	14	14.18	217.75	220.75	20.53	20.63
3	Probineb	21.47	25.02	1.714	1.838	13.3	13.53	206.1	208.25	15.95	16.25
4	Hexaconazole	33.33	36.00	2.129	2.224	16.05	16.45	251.75	253.5	41.49	42.29
5	Pyraclostrobin	29.72	31.54	1.991	2.066	15	15.22	234.5	236	26.28	26.44
6	Control	21.27	21.27	1.708	1.708	11.46	11.46	197.5	197.5		
SEm±	0.446	1.608	0.763	2.340	1.670	1.340	2.350	1.450	3.098	2.250	
CDat5%		1.423	5.132	1.943	3.210	2.340	2.350	5.430	2.230	6.340	5.123

253.5 yield (q/ha) 100 and 300 ppm and increase 41.49 and 42.29%. These results are accordance with Nikam *et al*. (2014) and Sadana *et al.* (2015) (Table 6).

Conclusion

The study aimed to evaluate various control measures against early blight disease caused by *Alternaria solani* on tomato plants. The findings provide valuable insights into effective strategies for managing this devastating disease in India. Firstly, the study assessed different culture media for the growth of *Alternaria solani*, with Potato Dextrose Agar (PDA) and Tomato Leaf Extract Agar Medium identified as the most supportive. This knowledge is crucial for laboratory studies aiming to culture and study the pathogen. Furthermore, the study investigated the inhibitory effects of botanical extracts, essential oils, and chemical fungicides against *Alternaria solani*. *Eucalyptus globulus* extract showed the highest effectiveness among botanicals, while Lemongrass oil exhibited significant inhibition among essential oils. Chemical fungicides such as Hexaconazole and Thifluzamide demonstrated remarkable control over the pathogen, even at lower concentrations. These findings offer promising options for disease management in both laboratory and field conditions. In field trials, fungicides like Hexaconazole, Thifluzamide and Pyraclostrobin showed significant control of early blight disease, underscoring their potential for practical application in agricultural settings. Notably, Hexaconazole emerged as particularly effective, highlighting its importance as a viable option for disease management in tomato cultivation. Overall, the comprehensive investigation provides valuable insights into the management of early blight disease in tomato plants. By highlighting the efficacy of different control measures, including botanical extracts, essential oils, and chemical fungicides, the study contributes to the development of effective strategies to mitigate the impact of *Alternaria solani* on tomato productivity in India. These findings can inform agricultural practices and help safeguard tomato crops against this damaging disease, ultimately enhancing agricultural productivity and food security.

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