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Evaluation of Phytoextracts and Cow-based Products Against *A. alternata* under *In vitro* and *In vivo* Condition

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ABSTRACT: Coriander (*Coriandrum sativum* L., 2n=22) is a vital herb extensively used for culinary and medicinal purposes. However, its cultivation is significantly impacted by leaf blight caused by *Alternaria alternata* (Fr.) Keissler. This study aims to investigate the effectiveness of various management strategies to control coriander leaf blight. Specifically, it investigates the efficacy of different phytoextracts and cow-based products were evaluated against *A. alternata* under *in vitro* and *in vivo* conditions. Among phytoextracts tested under *in vitro* condition, *Allium sativum* at 10 per cent concentration showed the maximum mycelial growth inhibition (65.23%). In the case of cow-based products, the maximum mycelial growth inhibition (88.56%) was observed in *Panchagavya* at 60 per cent concentration. To validate the efficacy of phytoextracts and cow-based products, a trial was also conducted under field conditions. The results showed that foliar application of *Panchagavya* was significantly superior over the rest of the treatments and showed minimum disease intensity (10.55%) at 60 per cent concentration with 84.16 per cent disease control. Looking to the yield, the treatment *Panchagavya* at 60 per cent gave maximum seed yield (1406 kg/ha) with 86.21 per cent yield increased over control. The effective phytoextracts and cow-based products discovered in this study can be incorporated into an integrated disease management approach for *A. alternata* in coriander.

Keywords: Coriander, *A. alternata*, phytoextracts, cow-based products, management.

INTRODUCTION

In India, spices are regarded as the highest quality in the world, earning the country the title "Home of Spices" Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant, which belongs to the family *Umbelliferae* or *Apiaceae*. The genus *Coriandrum* to which coriander belongs contains only two species. One is the cultivated plant *C. sativum* and the other is a wild species *C. tordylium* (Hedge and Lamond 1972). The closest genus to *Coriandrum* is *Bifora* (Rickett, 1969). Coriander leaves are small herbs having numerous branches and sub branches (Khan *et al*., 2014). The new leaves are oval, while the aerial leaves are elongated. Flowers are white with slightly brinjal like shades and the fruit are round in shape (Kassahun, 2018). The coriander plant is susceptible to several diseases caused by fungi and other microorganisms. Notable fungal diseases include stem galls or tumours (*Protomyces macrosporus*), stem rot (*Sclerotinia sclerotiorum*), wilt (*Fusarium oxysporum* f. sp. *coriandri* and *F. solani*), powdery mildew (*Erysiphe polygoni*), root and stem rot (*Rhizoctonia solani* and *Macrophomina phaseolina*) and alternaria blight caused by *Alternaria alternata* (Fr.) Keissler (Khan *et al*., 1984). Out of these, alternaria blight of coriander is emerging as a major and wide spread disease in India as well as in Gujarat. A significant disease caused by the *Alternaria* genus is the blight, which can result in yield losses averaging between 32-57 per cent (Conn and Tiwari 1990). A characteristic of this disease is brown or dark brown spots on leaves, often outlined by concentric lines within the spots. Leaf blight occurs when circular spots coalesce to form large patches. Occasionally, dark spots may also appear on tender stems and pods (Valkonen and Koponen 1990). *A. alternata* is characterized by uniform conidia that are longitudinal and transverse septa. These multicellular pigmented conidia are produced in chains, broader at the base and tapered into elongate beaks. Recent trends involve the use of phytoextracts and cow-based products are used for control of the disease. Phytoextracts and cow-based products are eco-friendly, leave no residual effect and are more economical than chemical control methods. Therefore, this study is proposed to generate new

scientific insights into managing alternaria blight of coriander, aiming to reduce crop losses effectively.

MATERIALS AND METHODS

Evaluation of phytoextracts against *A. alternata* under *in vitro* condition. The efficacy of ten different phytoextracts *viz*., Ardusi, Garlic, Neem, Aakdo, Tulsi, Datura, Onion, Ginger and Indradhanu was tested at 5, 7.5 and 10 percent concentration. The experiments were conducted in the Laboratory of the Department of Plant Pathology, College of Agriculture, JAU, Junagadh using a Completely Randomized Design (Factorial concept) with three repetitions. To prepare the samples, Fresh leaves, rhizomes, cloves or bulbs of respective plant parts were thoroughly washed with running tap water and then with sterilized distilled water. Each sample was homogenized in sterilized distilled water at the rate of 1 ml/gm of tissues (1:1 V/W) with a pestle and mortar and filtered through fine muslin cloth. The filtrate thus obtained was centrifuged at 5000 rpm for 20 minutes and the supernatant was filtered with sterilized funnel having the pore size of 1-2 micron, which was consider as a standard phytoextracts solution (100%). Required concentrations of respective phytoextracts were prepared accordingly (Ansari, 1995). The measured quantity of extracts were individually incorporated into PDA medium without change in the composition at 5, 7.5 and 10 per cent concentration in 250 ml conical flasks and sterilized at 15 psi (1.038 kg/cm^2) at 121.6°C for 15 minutes in autoclave. After that, this molten poisoned medium was poured at the rate of 20 ml per 90 mm sterilized Petri plates for each extract at each concentration. All the Petri plates were inoculated with 4 mm diameter mycelial bit of fresh growing pathogen in the centre of Petri plate and incubated at 28 ± 1 °C. Control plate was also maintained without phytoextracts for each concentration till attains full growth and observations were recorded on linear mycelial growth in treated and control plates. The per cent growth inhibition of the fungus in each treatment was calculated by using the following formula (Vincent, 1947).

$$I = \frac{C - T}{C} \times 100$$

Where,
I = Per cent inhibition of mycelial growth
T = Radial growth of fungus in treated plate (mm)
C = Radial growth of fungus in control plate (mm)

Evaluation of cow-based products against *A. alternata* under *in vitro* condition. The efficacy of four different cow-based products *viz*., cow urine (at 5% and 7.5% concentrations), Fermented butter milk (at 15% and 20% concentrations), Jeevamrut type 1 and type 2 (both at 50% concentrations) and *Panchagavya* (at 40% and 60% concentrations) under *in vitro* condition. The experiments were conducted in the Laboratory of the Department of Plant Pathology, College of Agriculture, JAU, Junagadh using a Completely Randomized Design with three repetitions.

— Cow urine was prepared by the following method suggested by Jandaik *et al.* (2015)

Preparation of cow urine. Fresh cow urine was collected in a sterile container from a Gir cow. The urine was filtered through Whatman No. 1 filter paper to remove debris and precipitated material. The filtered urine was stored in airtight container at 4°C until use.

— Butter milk was prepared by the following method suggested by Anon. (2019)

Preparation of fermented butter milk. In a copper vessel, combine 100 g of black mustard seed powder with 1000 ml of cow buttermilk. After thoroughly mixing, cover the vessel with a cotton cloth and place it in a shady area for 7 to 10 days. During this period, the upper layer will develop a light blue or green color, indicating that the cow-based product is ready for use.

— Jeevamrut was prepared by the following method suggested by Pandia *et al.* (2019)

Preparation of Jeevamrut

Jeevamrut - type 1	Combine 2.5 g cow dung, 7.5 ml cow urine, 1 g jaggery, 1 g pulse flour and 0.05 g soil was added into 100 ml water.
Jeevamrut - type 2	Combine 5 g cow dung, 5 ml cow urine, 1 g jaggery, 1 g pulse flour and 0.05 g soil was added into 100 ml water.

— *Panchagavya* was prepared by the following method developed by the National Centre of Organic Farming (NCOF), Ghaziabad (Anon., 2017)

Preparation of *panchagavya.* Mix 500 g of fresh cow dung with 50 g cow ghee and place the mixture in a pot. This mixture was stored for three days and stirred two times a day during these three days, once in the morning and the other time in the evening. After three days, add 500 ml cow urine and 500 ml water was mixed into this mixture. Store for another three days, stirring twice daily. Then, add 100 ml cow milk, 100 g curd, 150 g jaggery and 1 ripened banana fruit by making a paste was added in the mixture. The mixture was stirred daily for 15 days and closed tightly. After this period, the *panchagavya* was ready and used for the experiment.

After that, this molten composition was poured at the rate of 20 ml per 90 mm (diam.) sterilized Petri plates for each treatment. After solidification, all the Petri plates were inoculated with 4 mm diameter mycelial bit of actively growing pathogen in the center of Petri plate in inverted position to make direct contact with solidified PDA medium and incubated at 28 ± 1 °C. Control plate was also maintained without cow-based products for each treatments till attain full growth and observations were recorded on linear mycelial growth in treated and control plates. Per cent mycelial growth inhibition was calculated as described earlier in phytoextracts.

Management of Alternaria blight through phytoextracts and cow-based products under field condition. A field trial was conducted at Research Farm of Department of Plant Pathology, Junagadh Agricultural University, Junagadh to study the efficacy of different nine phytoextracts and cow-based products for the management of leaf blight disease of coriander during *Rabi* season. The trial was arranged in Randomized Block Design with three replications.

Coriander variety GC-3 was sown at a spacing of 30 cm × 15 cm spacing in each of the gross plot size of 3.75 m × 2.40 m and net plot size of 3.15 m × 1.80 m in manually fertilized soil (40-30-20 NPK kg/ha). All agronomic practices were followed as and when required except phytoextracts and cow-based products treatments.

In present study, the nine phytoextracts and cow-based products found effective under *in vitro* condition against the test pathogen were evaluated for their efficacy under field condition. Spraying of phytoextracts and cow-based products were carried out on initiation of disease and subsequent spray was carried out at 15 days interval. Observation on per cent disease intensity (PDI) was recorded at 7 days after last spray.

Preparation of phytoextracts and cow-based products solutions for spraying. Required quantity of respective phytoextracts and cow-based products were added to measured quantity of water so as to get desired concentration. The spraying of phytoextracts and cow-based products was carried out at initial appearance of disease and thereafter sprayed at 15 days interval. Control was also maintained simultaneously without spraying of any cow-based products and phytoextracts. The details of phytoextracts and cow-based products are given in Table 1.

Table 1: List of treatments for the management of leaf blight disease of coriander through phytoextracts and cow-based products under *in vivo* condition.

Tr. No.	Phytoextracts and cow-based products	Conc. (%)	Quantity of phytoextracts and cow-based products/10 liters of water
T_1	Garlic	10	1.11 L
T_2	Aakdo	10	1.11 L
T_3	Ardusi	10	1.11 L
T_4	Indradhanu	10	1.11 L
T_5	Fermented butter milk - 20%	20	2.5 L
T_6	Jeevamrut type 1 - 50%	50	10 L
T_7	Jeevamrut type 2 - 50%	50	10 L
T_8	*Panchagavya* - 40%	40	6.66 L
T_9	*Panchagavya* - 60%	60	15 L
T_{10}	Control	-	-

Observations recorded. Observations on disease intensity was recorded from ten tagged plants randomly selected from each treatment after 15 days of inoculation using 0-5 scale (Table 2) as given by Jaiman *et al.* (2013). The tagged plant was evaluated for its disease reaction by scoring the disease intensity on top, middle and lower five leaves from main branch on each plant and then these grades was converted into per cent disease intensity (PDI) by using the formula given below

$$\text{PDI} = \frac{\text{Sum of individual ratings}}{\text{Number of plant observed} \times \text{Maximum disease rating}} \times 100$$

Table 2: Details of the disease rating scale (Jaiman *et al.*, 2013).

Score	Description
0	No symptoms
1	Symptoms on leaf tip and leaves only (up to 10%)
2	Symptoms on leaves and petiole (11-25%)
3	Symptoms on leaves, petiole and stem (26-50%)
4	Symptoms on leaves, stem and inflorescence (51-75%)
5	Symptoms on leaves, stem and inflorescence including seeds (>75%)

The per cent disease control was calculated with the help of following formula (Mathur *et al.*, 1971).

$$\text{Disease control (\%)} = \frac{\text{P.D.I. in control plot} - \text{P.D.I. in treated plot}}{\text{P.D.I. in control plot}} \times 100$$

Yield. The yield was recorded in kg/ha at time of harvest. The per cent increase in yield in each treatment over control was worked out by using the following formula.

$$\text{Yield increase (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

RESULTS AND DISCUSSION

Evaluation of phytoextracts against *A. alternata* under *in vitro* condition. The efficacy of naturally available ten phytoextracts were tested against *A. alternata* at 5, 7.5 and 10 per cent concentrations along with control by using poisoned food technique with three replications. Per cent mycelial growth inhibition in each of the treatment was calculated after fourteen days of inoculation. The results obtained are communicated here under (Table 3 and Plate 1).

All the three concentrations of phytoextracts tested against *A. alternata* were found moderately effective in inhibiting the mycelial growth of *A. alternata* over control. As the concentration of phytoextracts increased, the inhibition of mycelial growth also increased.

Allium sativum at 10 per cent concentration showed the maximum mycelial growth inhibition (65.23%) and remained statistically at par with *Lantana camara*, *Calotropis gigantea* and *Adhatoda vasica* at same concentration with 63.75, 64.86 and 64.49 per cent mycelial growth inhibition, respectively. The next effective treatment was *Allium cepa* at 10 per cent

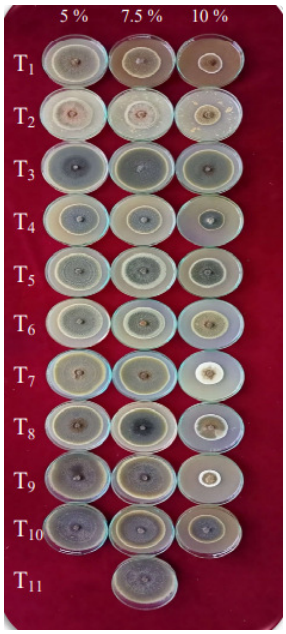
concentration gave 56.71 per cent mycelial growth inhibition followed by *Allium sativum* at 7.5 per cent concentration with 50.04 per cent mycelial growth inhibition. However, *Tagetes erecta* was found to be less effective treatment as compared to other phytoextracts, exhibiting a minimum mycelial growth inhibition of 1.72, 19.65 and 45.96 per cent at 5, 7.5 and 10 per cent concentration, respectively.

More or less similar kind of trend was also observed by Khursheed *et al*. (2021) tested different phytoextracts against *A. alternata* of brinjal under *in vitro* condition and recorded that clove extract of garlic at 10 per cent found to be the most effective with 80.22 per cent mycelial growth inhibition of *A. alternata* followed by leaf extract of *Datura stramonium* at 10 per cent (63.11%). Mayweed leaf extract at 10 per cent remain least effective in inhibiting growth (23.89%) of *A. alternata*.

Table 3: Evaluation of phytoextracts against *A. alternata* under *in vitro* condition.

Tr. No.	Phytoextracts	Mycelial growth inhibition (%)			Mean mycelia growth inhibition (%)
		5%	7.5%	10%	
T_1	*Adhatoda vasica* Ness. (Ardusi)	34.14 (31.50)	41.83 (44.48)	53.42 (64.49)	43.13 (46.82)
T_2	*Allium sativum* L. (Garlic)	39.25 (40.03)	45.02 (50.04)	53.87 (65.23)	46.05 (51.77)
T_3	*Azadirachta indica* L. (Neem)	15.32 (6.98)	22.93 (15.19)	29.40 (24.09)	22.55 (15.42)
T_4	*Calotropis gigantea* L. (Aakdo)	38.60 (38.92)	40.54 (42.25)	53.65 (64.86)	44.26 (48.68)
T_5	*Ocimum sanctum* L. (Tulsi)	31.82 (27.80)	36.40 (35.22)	41.40 (43.74)	36.54 (35.58)
T_6	*Datura stramonium* L. (Datura)	31.35 (27.06)	37.50 (37.06)	41.62 (44.11)	36.82 (36.08)
T_7	*Allium sepa* L. (Onion)	22.93 (15.17)	29.14 (23.71)	48.86 (56.71)	33.64 (31.87)
T_8	*Zingiber officinale* Rosc. (Ginger)	27.87 (21.86)	30.38 (25.57)	44.60 (49.30)	34.28 (32.24)
T_9	*Lantana camara* L. (Indradhanu)	9.03 (2.47)	29.64 (24.46)	52.98 (63.75)	30.55 (30.29)
T_{10}	*Tagetes erecta* L.(Marigold)	7.54 (1.72)	26.31 (19.65)	42.68 (45.96)	25.51 (22.44)
Mean		23.44 (19.41)	30.88 (28.88)	42.04 (47.48)	
		Phytoextracts (P)	**Concentration (C)**		**F × C**
S. Em. ±		0.36	0.20		0.62
C. D. at 5 %		1.01	0.55		1.75
C. V. %		3.03			

Note: Data outside the parentheses are arcsine transformed, whereas inside are re-transformed values.



T_1 : *Adhatoda vasica* Ness, **T_2 :** *Allium sativum* L., **T_3 :** *Azadirachta indica* L., **T_4 :** *Calotropis gigantea* L., **T_5 :** *Ocimum sanctum* L., **T_6 :** *Datura stramonium* L., **T_7 :** *Allium sepa* L., **T_8 :** *Zingiber officinale* Rosc., **T_9 :** *Lantana camara* L., **T_{10}:** *Tagetes erecta* L., **T_{11}:** Control

Plate 1. Evaluation of phytoextracts against *A. alternata* under *in vitro* condition.

Evaluation of cow-based products against *A. alternata* under *in vitro* condition. The efficacy of cow-based products were tested against *A. alternata* at different concentration along with control by using poisoned food technique and replicated thrice. Per cent mycelial growth inhibition in each of the treatment was calculated after fourteen days of inoculation. The results obtained are communicated here under.

The data presented in Table 4 and Plate 2 indicated that all the cow-based products were capable in reducing the mycelial growth as compared to control. Among different cow-based products, the maximum mycelial growth inhibition (88.56%) was observed in *Panchagavya* at 60 per cent concentration and remains significantly superior over rest of the treatments and remained statistically at par with Jeevamrut type - 2 at 50 per cent and *Panchagavya* at 40 per cent concentration found 88.19 per cent and 87.45 per cent mycelial growth inhibition, respectively. Fermented butter milk at 20 per cent concentration was found moderately effective treatment with 83.00 per cent mean mycelial growth inhibition. While, minimum mycelial growth inhibition was found in cow urine at 5 per cent concentration (15.57%).

All the cow-based products tested against *A. alternata* were found effective in inhibiting the mycelial growth of *A. alternata* over control.

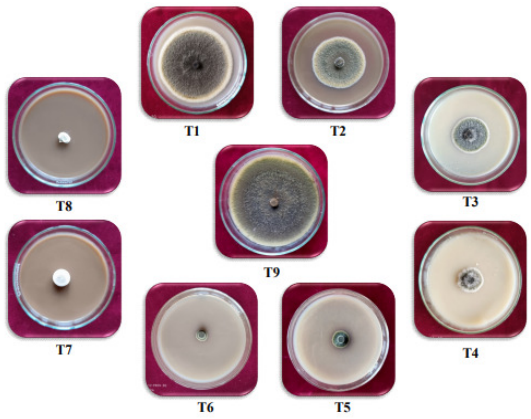
The present findings are in close conformity with the results of Pandia *et al.* (2019). They evaluated different components and the final product of Jeevamrut. Among them, Jeevamrut type - 2 found most effective in inhibiting *A. alternata* of mungbean under *in vitro* condition with 93.34 per cent mycelial growth inhibition. Tested four cow by-products at 5, 10 and 15

per cent concentration against *A. brassicae* of mustard and found that at 5 per cent concentration, the maximum inhibition of the growth of fungus was observed in *Panchgavaya* (60.16%) followed by cow urine (47.53%).

Table 4: Evaluation of cow-based products against *A. alternata* under *in vitro* condition.

Tr. No.	Treatments	Per cent growth inhibition (%)
T_1	Cow urine - 5%	23.24 (15.57)
T_2	Cow urine - 7.5%	38.16 (38.18)
T_3	Fermented butter milk - 15%	56.36 (69.31)
T_4	Fermented butter milk - 20%	65.66 (83.00)
T_5	Jeevamrut type 1 - 50%	68.93 (87.08)
T_6	Jeevamrut type 2 - 50%	69.89 (88.19)
T_7	*Panchagavya* - 40%	69.25 (87.45)
T_8	*Panchagavya* - 60%	70.22 (88.56)
S. Em. ±		0.38
C. D. at 5 %		1.15
C. V. %		3.27

Note: Data outside the parentheses are arcsine transformed, whereas id re-transformed values.



T_1 : Cow urine - 5%, **T_2 :** Cow urine - 7.5%, **T_3 :** Fermented butter milk - 15%, **T_4 :** Fermented butter milk - 20%, **T_5 :** Jeevamrut type 1 - 50%, **T_6 :** Jeevamrut type 2 - 50%, **T_7 :** *Panchagavya* - 40%, **T_8 :** *Panchagavya* - 60%, **T_9 :** Control

Plate 2. Evaluation of cow-based products against *A. alternata* under *in vitro* condition.

Management of Alternaria blight through phytoextracts and cow-based products under field condition

The treatments demonstrating higher efficacy under *in vitro* condition were selected for managing of alternaria leaf blight of coriander under field condition. Coriander sowing commenced on 21st November, 2023 and total nine phytoextracts and cow-based products were evaluated for their efficacy under field condition. Each of these treatments was compared with a control to assess their effectiveness.

The observations on per cent disease intensity (PDI) and seed yield (kg/ha) were recorded and results obtained are communicated here under. According to the data presented in Table 5 revealed that all the treatments were effective in reducing the disease intensity with corresponding increase in seed yield as compared to control under field condition.

Among different treatments, *Panchagavya* was significantly superior over the rest of the treatments and showed minimum disease intensity (10.55%) at 60 per cent concentration with 84.16 per cent disease control, but it was statistically at par with Jeevamrut type - 2 at 50 per cent (17.79%) concentration with 73.27 per cent disease control. The next effective treatment was *Panchagavya* at 40 per cent concentration with 23.17 per cent disease intensity and 65.35 per cent disease control followed by Jeevamrut type - 1 at 50 per cent (23.88%) concentration with 64.36 per cent disease control. While, maximum disease intensity was found in the control (67.59%).

Looking to the yield, the treatment *Panchagavya* at 60 per cent gave maximum seed yield (1406 kg/ha) with 86.21 per cent yield increased over control, But, it was remained statistically at par with Jeevamrut type - 2 at 50 per cent (1322 kg/ha) with 75.12 per cent yield increase over control. The next effective treatment was *Panchagavya* at 40 per cent concentration with 1226 kg/ha seed yield and 62.44 per cent yield increased over control followed by Jeevamrut type - 1 at 50 per cent concentration with 1095 kg/ha seed yield and 45.01 per cent yield increased over control. While, minimum seed yield was found in the control (755 kg/ha).

The results obtained here were in accordance with the study of Pandia *et al.* (2019), they tested different components and final product of Jeevamrut against alternaria leaf spot of mung bean under cage house and found that foliar spray of Jeevamrut type - 2 gave maximum 75.2 per cent disease control followed by Jeevamrut type - 1 with 68.6 per cent disease control. Meena *et al.* (2022) tested phytoextracts against alternaria blight of fennel under field conditions. Among them, garlic clove extract was found to be the most effective in reducing disease intensity (38.62%) and increasing seed yield (49.54%). It was significantly superior over neem (58.36%) and tulsi (62.44%).

Table 5: Per cent disease intensity and seed yield of coriander leaf blight as influenced by different phytoextracts and cow-based products.

Tr. No.	Treatments	Concen-tration (%)	Per cent disease intensity	Per cent disease control	Seed yield (kg/ha)	Seed yield increase over control
T_1	Garlic	10	36.49 (35.36)	47.52	1005	33.12
T_2	Aakdo	10	37.23 (36.61)	45.54	981	29.95
T_3	Ardusi	10	40.78 (42.67)	36.63	975	29.16
T_4	Indradhanu	10	41.94 (44.67)	33.66	915	21.24
T_5	Fermented butter milk - 20%	20	30.98 (26.49)	60.40	1017	34.71
T_6	Jeevamrut type 1 - 50%	50	29.25 (23.88)	64.36	1095	45.01
T_7	Jeevamrut type 2 - 50%	50	24.95 (17.79)	73.27	1322	75.12
T_8	*Panchagavya* - 40%	40	28.78 (23.17)	65.35	1226	62.44
T_9	*Panchagavya* - 60%	60	18.96 (10.55)	84.16	1406	86.21
T_{10}	Control	-	55.30 (67.59)	0	755	0
S. Em. ±			2.28		55.03	
C. D. at 5 %			6.78		163.49	
C. V. %			11.47		8.91	

CONCLUSIONS

Leaf blight caused by *Alternaria alternata* (Fr.) Keissler poses a significant threat to coriander crops. From our investigations, it is evident that among the tested phytoextracts, *Allium sativum* at 10 per cent concentration showed the maximum 65.23 per cent mycelial growth inhibition. Similarly, among different cow-based products evaluated, *Panchagavya* at 60 per cent concentration showed the maximum 88.56 per cent mycelial growth inhibition. In field conditions, *Panchagavya* at 60 per cent concentration was significantly superior over the rest of the treatments and showed minimum disease intensity (10.55%) with 84.16 per cent disease control.

FUTURE SCOPE

For future research papers focusing on the evaluation of phytoextracts and cow-based products against *Alternaria alternata* (Fr.) Keissler, consider the following potential areas of exploration:

Biochemical mechanisms: Investigate the biochemical pathways involved in the inhibition of *A. alternata* by phytoextracts and cow-based products. This could include studying enzyme activities, secondary metabolite production and their effects on fungal cell structures.

Resistance development: Study the potential for *A. alternata* to develop resistance to phytoextracts and cow-based products. Explore strategies to mitigate resistance development through rotation, combination treatments or dosage adjustments.

Formulation development: Develop improved formulations of phytoextracts and cow-based products to enhance stability, efficacy and ease of application in agricultural settings.

Economic analysis: Conduct economic analyses to evaluate the cost-effectiveness of integrating these products into existing disease management practices for coriander and other crops affected by *A. alternata*.

Comparative studies: Compare the efficacy of phytoextracts and cow-based products with conventional chemical fungicides in terms of disease control, environmental impact and sustainability.

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