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Efficacy of natural inputs against *Fusarium oxysporum* f. sp. *cumini* causing wilt in cumin (*Cuminum cyminum* L.)

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Abstract

Wilt caused by *Fusarium oxysporum* f. sp. *cumini* is a major constraint in cumin production. A field experiment was conducted during Rabi 2022-23 and 2023-24 to evaluate natural inputs for sustainable wilt management under open field conditions. Six treatments comprising Beejamrutha seed soaking, soil drenching with cow urine, Panchgavya, Neemastra, Jeevamrutha and an untreated control were tested in a randomized block design. Neemastra significantly reduced pooled wilt incidence (24.79%) compared to control (44.27%) and recorded the lowest AUDPC values, followed by Jeevamrutha. Neemastra also produced the highest seed yield (4.71 and 4.53 q ha⁻¹), followed by Jeevamrutha, whereas volatile oil content and 1000-seed weight remained unaffected. The findings suggest that neem-based and fermented organic formulations, particularly Neemastra, offer an effective and sustainable approach for managing cumin wilt while improving seed yield.

Keywords: Neemastra, Brahmastra, *Fusarium* wilt, cumin, natural farming

Introduction

Cumin (*Cuminum cyminum* L.) is one of the most important seed spices cultivated in India, valued for its characteristic aroma, flavour and medicinal properties. It occupies a prominent position in domestic consumption and export trade, contributing significantly to the spice economy of arid and semi-arid regions. The crop is predominantly grown during the Rabi season under cool and dry climatic conditions, with Gujarat and Rajasthan being the major producing states (Didwania 2019; Anonymous 2024). Despite its economic importance, cumin productivity remains relatively low and unstable due to several biotic constraints.

Among the diseases affecting cumin, wilt caused by *Fusarium oxysporum* f. sp. *cumini* is the most destructive soil-borne disease, capable of causing yield losses up to 70-80 per cent under favourable conditions (Dar *et al.* 2019). The pathogen persists in soil for extended

periods through chlamydospores and is influenced by soil temperature, moisture and cropping practices. Although resistant cultivars and chemical fungicides are commonly used for management, the durability of host resistance has been challenged by the emergence of pathogenic variability, while excessive dependence on fungicides has led to environmental concerns, residue issues and increased production costs (Islam *et al.*, 2024).

In recent years, there has been growing emphasis on sustainable and low-input agriculture. Natural farming formulations such as Beejamrutha, Panchgavya, Jeevamrutha and neem-based preparations are gaining attention due to their potential role in enhancing soil microbial activity, improving plant health and suppressing soil-borne pathogens. However, systematic field-level evaluation of these formulations against cumin wilt under semi-arid conditions remains limited (Ravisankar *et al.* 2025).

Therefore, the present investigation was undertaken to assess the efficacy of selected natural inputs in reducing wilt incidence and improving yield of cumin under field conditions, with the objective of identifying eco-friendly and sustainable alternatives for wilt management.

Materials and Methods

A two-year field study was undertaken during the *Rabi* seasons of 2022-23 and 2023-24 to evaluate the impact of various natural inputs on the incidence of cumin wilt, caused by *Fusarium oxysporum* f. sp. *cumini*. The experiment was conducted using the cultivar Gujarat Cumin 4 (GC 4), which was selected because of its wide cultivation and popularity among the farming community of Gujarat. The experiment was carried out in a field artificially inoculated with *Fusarium oxysporum* f. sp. *cumini* to ensure uniform and adequate disease pressure for evaluating the efficacy of the treatments. The experiment comprised six treatments: The treatments evaluated in the study were as follows: T₁-seed soaking with Beejamrutha @ 300 ml per kg of seeds; T₂-drenching with 10 per cent cow urine at a volume of 1000 L/ha; T₃-drenching with 10 per cent Panchgavya at 1000 L/ha; T₄-drenching with 10 per cent Neemastra at 1000 L/ha; T₅-drenching with 10 per cent Jeevamrutha at 1000 L/ha; and T₆-untreated control.

The trial was arranged in a Randomized Block Design (RBD) with six treatments and four replications. Each gross plot measured 3.0 m × 4.0 m, with a net plot size of 2.4 m × 3.0 m, and an inter-row spacing of 30 cm was maintained throughout. This experimental layout enabled uniform application of treatments and effective assessment of disease incidence under field conditions. The study aimed to assess the efficacy of these organic inputs in reducing wilt incidence while promoting sustainable disease management in cumin cultivation.

Preparation of natural inputs

Beejamrutha (for seed treatment): Took 20 L water, 5 kg local cow dung, 5 L local cow urine, 50 g lime, and a handful of soil from the bund of the farm. Took 5 kg local cow dung in a cloth and bound it with tape. Hung this in the 20 L water for up to 12 hours. Took one liter of water and added 50 g lime to it. Let it settle overnight. The next morning, squeezed the bundle of cow dung in that water three times continuously so that all the essence of the cow dung accumulated in the water. Then added a handful of soil to that water solution and stirred it well. After that, added 5 L desi cow urine to the solution, followed by the lime water, and stirred it thoroughly. Beejamrutha was then ready to treat the seeds (for 100 kg seeds) (Patel *et al.* 2019).

Panchgavya: Cow dung 5 kg and cow ghee 500 g were mixed and kept for 3 days, with regular mixing twice a day. On the 4th day, cow urine 5 L, cow curd 1 L, and tender coconut water 1.5 L were all mixed properly in a plastic container and kept for incubation for 18 days. The mixture was stirred properly twice a day, in the morning and evening. After the incubation, it was used for soil drenching (Patel *et al.* 2019).

Neemastra: Took desi cow dung 5 kg, cow urine 5 L, and neem leaves 5 kg, and added them into 100 L water in a barrel. Covered it and kept it in the shade for 48 hours. Stirred it twice a day, in the morning and evening. Strained it, and it was ready to use (Patel *et al.* 2019).

Jeevamrutha: Took 200 L water in a barrel. Took 10 kg local cow dung and 5 to 10 L cow urine and added them to the water. Then added 2 kg jaggery, 2 kg pulse flour, and a handful of soil from the bund of the farm. Stirred the solution well and kept it to ferment for 48 hours in the shade. It was then ready for use (Patel *et al.* 2019).

The following observations were recorded during the study: per cent wilt incidence at 35, 50 and 60 days after sowing (DAS) from three randomly selected spots (1 m row length each) in each plot, Area Under Disease Progress Curve (AUDPC), seed yield (q ha⁻¹), volatile oil content (%) and 1000-seed weight (g). Volatile oil content of cumin seeds was determined by the steam distillation method as described by Guenther (1972) and followed by Singh *et al.* (2006). The AUDPC was calculated to assess disease progression and the efficacy of treatments against cumin wilt according to the method described by Shaner and Finney (1977).

$$\text{AUDPC} = \sum_{i=1}^{n-1} [2(Y_i + Y_{i+1}) \times (T_{i+1} - T_i)]$$

Where:

- Y_i = Disease incidence (%) at the *i*th observation
- Y_{i+1} = Disease incidence (%) at the (*i*+1)th observation
- T_i = Time (days after sowing) at the *i*th observation
- T_{i+1} = Time at the (*i*+1)th observation
- n = Number of observations

Results and Discussion

Year 2022-23

The effects of natural inputs on cumin wilt disease incidence was evaluated under field conditions during the 2022-23 growing season. The treatments included seed soaking with *Beejamrutha* as well as drenching of cow urine, *Panchgavya*, *Neemastra*, *Jeevamrutha* and a control. The disease incidence was assessed at 35, 50 and 60 days after sowing (DAS) for each treatment.

At 35 DAS

Lowest percent disease incidence (PDI) was observed in T₄ (*Neemastra* drenching), with a PDI of 15.48, which was at par with T₅ (*Jeevamrutha* drenching) at 18.71. Both these treatments significantly outperformed the control (30.15), showing the potential of these natural inputs in managing cumin wilt disease.

At 50 DAS

Treatment 4 (*Neemastra*) continued to show the lowest PDI of 23.48, which was at par with T₅ (24.63). In comparison, the control treatment had a significantly higher PDI of 44.76, indicating the effective role of *Neemastra* and *Jeevamrutha* in reducing disease incidence.

At 60 DAS

Treatment 4 (*Neemastra*) remained the most effective treatment, with the lowest PDI of 29.12. This was at par with T₅ (*Jeevamrutha*), which showed a PDI of 32.15. The control treatment still exhibited the highest PDI at 52.09

Reduction over control

The highest reduction over control in per cent disease incidence was observed in T₄ (44.10%) followed by T₅ (38.28%).

Year 2023-24

In the second year (2023-24), the trend observed for disease incidence was consistent with the previous year. At 35 DAS, the minimum per cent disease incidence (PDI) was recorded in T₄ (17.68%), which was at par with T₅ (20.75%), and significantly lower than the Control (34.33%). At 50 DAS, the lowest PDI was again observed in T₄ (27.99%), followed by T₅ (30.12%) and Control (48.93%). At 60 DAS, T₄ continued to show the best performance (34.33%), followed by T₅ (39.49%), and the highest disease incidence was recorded in the Control (55.22%).

Reduction over control

The highest reduction over control in per cent disease incidence was observed in T₄ (37.83%) followed by T₅ (28.49%).

Pooled over year data

The pooled data over both years (2022-23 and 2023-24) showed a consistent trend in the effectiveness of the treatments. T₄ (*Neemastra*) recorded the lowest PDI of 24.79 per cent, which was at par with T₅ (*Jeevamrutha*), showing a PDI of 27.78 per cent, and significantly lower than the control at 44.27 per cent (Table 4.12).

The effectiveness of *Jeevamrutha* and *Neemastra* in reducing cumin wilt disease can be attributed to their active ingredients, which have well-known antifungal and disease-suppressive properties, particularly against *Fusarium* species (Dhakad *et al.*, 2025).

Cow urine contains antimicrobial compounds such as phenols and ammonia, directly inhibiting the pathogen while also stimulating plant defence mechanisms. Jaggery serves as an energy source for beneficial microbes, allowing them to multiply rapidly and produce organic acids that create unfavourable conditions for the pathogen. Pulse flour supplies essential nitrogen

and amino acids, promoting microbial diversity and fostering the growth of chitinase-producing bacteria that degrade fungal cell walls. Water acts as a carrier, ensuring proper fermentation and microbial activation. Together, these components improve soil fertility, enhance plant vigour, and create an environment that naturally suppresses cumin wilt, making *Jeevamrutha* an effective and sustainable disease management strategy (Prabakaran *et al.* 2022).

Neemastra, on the other hand, is prepared from neem leaves and other organic materials like cow dung and cow urine. Neem is well-documented for its antifungal properties, primarily due to the presence of compounds like azadirachtin, which act as natural inhibitors of fungal growth. The use of *Neemastra* can disrupt the development of *Fusarium oxysporum* by inhibiting its growth and conidia formation, while also enhancing the plant's systemic resistance to infections (Dhakad *et al.*, 2025).

Thus, both *Jeevamrutha* and *Neemastra* show a strong ability to manage *Fusarium* wilt through their microbial communities and antifungal compounds, which directly contribute to reduced disease incidence and improved plant health. This explains why these treatments were highly effective in managing cumin wilt disease in the present study.

AUDPC study of natural inputs against cumin wilt disease (2022-23)

The Area Under Disease Progress Curve (AUDPC) analysis for the effect of natural inputs against cumin wilt disease incidence during the first year (2022-23) revealed significant differences among treatments. The lowest average AUDPC value of 692.19 was recorded with the treatment of drenching with *Neemastra*, followed by drenching with *Jeevamrutha* (757.82). These treatments effectively reduced disease progression compared to the control, which exhibited the highest AUDPC value of 1289.08.

AUDPC study of natural inputs against cumin wilt disease (2023-24)

The analysis of the Area Under Disease Progress Curve (AUDPC) for the effect of natural inputs on cumin wilt disease incidence during the second year (2023-24) revealed significant variations among treatments. The lowest average AUDPC value of 812.51 was recorded

in the treatment involving drenching with *Neemastra*, indicating its superior efficacy in reducing disease progression. This was followed by drenching with *Jeevamrutha*, which resulted in an AUDPC value of 906.26. In contrast, the highest AUDPC value of 1406.23 was observed in the control treatment, highlighting the effectiveness of natural inputs in mitigating cumin wilt incidence.

Effect of different treatments on volatile oil of cumin seeds

Among the different natural input treatments tested under field conditions for both years (2022-23 and 2023-24), there was no significant difference observed in the volatile oil percentage. The volatile oil content ranged from 4.44 to 4.56 per cent across all treatments.

Effect of different treatments on 1000 seed weight of cumin seeds

Among the different natural input treatments tested under field conditions in both years (2022-23 and 2023-24), there was no significant difference observed in the 1000 seed weight. The 1000 seed weight ranged from 4.21 g to 4.35 g across all treatments.

Effect of different treatments on cumin yield

Among the different natural input treatments tested under field conditions, the results from both years (2022-23 and 2023-24) showed that T₄ (*Neemastra* drenching) provided the highest seed yield. In 2022-23, T₄ recorded a seed yield of 4.71 q/ha, which was at par with T₅ (*Jeevamrutha* drenching) at 4.33 q/ha, compared to the control, which yielded 2.38 q/ha. In the second year (2023-24), T₄ again showed the highest yield of 4.53 q/ha, which was at par with T₅ at 4.25 q/ha, while the control produced 2.27 q/ha.

These results indicate that both T₄ and T₅ treatments were significantly more effective in enhancing seed yield compared to the control, with T₄ showing the best results in both years. The improved seed yield in T₄ and T₅ can be attributed to the beneficial effects of these organic inputs in reducing disease incidence, as seen in the PDI observations and promoting better plant growth.

The microorganisms in *Jeevamrutha* not only improve soil fertility but also suppress plant pathogens through competitive exclusion and antagonistic interactions. These effects are reflected in the results, where

Table 1. Effect of the different natural inputs on cumin wilt disease incidence and yield

Treat. No.	Per cent disease incidence (2022-23)						Per cent disease incidence (2023-24)						Pooled over year
	ROC (%)			ROC (%)			ROC (%)			Pooled over year			
	35 DAS	50 DAS	60 DAS	Or Per cent Efficacy over disease control (%)	35 DAS	50 DAS	60 DAS	Or Per cent Efficacy over disease control (%)	2022-23		2023-24		
T1	29.24 ^{ab} (23.88)	35.23 ^{bc} (33.30)	37.73 ^{bcd} (37.48)	28.05	30.55 ^b (25.86)	37.11 ^{bc} (36.42)	41.34 ^{bc} (43.65)	20.95	35.20 ^b (33.51)	2.99 ^b	2.88 ^{bc}	2.93 ^b	
T2	28.47 ^{abc} (22.75)	35.85 ^b (34.33)	40.18 ^b (41.65)	20.04	29.95 ^b (24.94)	38.94 ^{ab} (39.53)	43.78 ^{ab} (47.91)	13.24	36.20 ^b (35.24)	3.08 ^b	3.00 ^b	3.04 ^b	
T3	27.64 ^{bc} (21.54)	33.91 ^{bc} (31.15)	38.94 ^{bc} (39.53)	24.11	30.50 ^b (25.78)	38.94 ^{ab} (39.53)	44.86 ^{ab} (49.79)	09.83	35.80 ^b (34.68)	3.31 ^b	3.15 ^b	3.23 ^b	
T4	23.16 ^c (15.48)	28.97 ^c (23.48)	32.65 ^d (29.12)	44.10	24.85 ^c (17.68)	31.93 ^c (27.99)	35.85 ^d (34.33)	37.83	29.57 ^c (24.79)	4.71 ^a	4.53 ^a	4.62 ^a	
T5	25.62 ^{bc} (18.71)	29.74 ^{bc} (24.63)	34.52 ^{cd} (32.15)	38.28	27.09 ^{bc} (20.75)	33.27 ^{bc} (30.12)	38.92 ^{cd} (39.49)	28.49	31.53 ^c (27.78)	4.33 ^a	4.25 ^a	4.29 ^a	
T6	33.29 ^a (30.15)	41.98 ^a (44.76)	46.18 ^a (52.09)	-	35.85 ^a (34.33)	44.37 ^a (48.93)	47.98 ^a (55.22)	-	41.61 ^a (44.27)	2.38 ^c	2.27 ^c	2.33 ^c	
SEm.	T 1.70	1.98	1.66	-	1.46	1.84	1.51	-	0.71	0.20	0.20	0.14	
P	-	-	-	-	-	-	-	-	0.50	-	-	-	
Y	-	-	-	-	-	-	-	-	0.41	-	-	0.08	
T x P	-	-	-	-	-	-	-	-	1.23	-	-	-	
T X Y	-	-	-	-	-	-	-	-	1.00	-	-	0.20	
P X Y	-	-	-	-	-	-	-	-	0.71	-	-	-	
T X P X Y	-	-	-	-	-	-	-	-	1.74	-	-	-	
CD at 5% T	5.14	5.96	5.02	-	4.40	5.55	4.54	-	1.98	0.60	0.58	0.38	
T X Y	-	-	-	-	-	-	-	-	NS	-	-	-	
C.V. (%)	12.22	11.53	8.68	-	9.79	9.84	7.15	-	9.92	11.91	11.59	11.76	

Note:

1. Figures outside the parentheses are arc sine transformed values and those inside the parentheses are retransformed values
2. Treatment means followed by the same letter(s) are not significantly different by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance (T₁-seed soaking with Beejamrutha @ 300 ml per kg of seeds; T₂-drenching with 10 per cent cow urine at a volume of 1000 L/ha; T₃-drenching with 10 per cent Panchagavya at 1000 L/ha; T₄-drenching with 10 per cent Neemastra at 1000 L/ha; T₅-drenching with 10 per cent Jeevamrutha at 1000 L/ha; and T₆-untreated control.)

Table 2. Effect of the different natural inputs on 1000 seed weight (g) and volatile oil (%) in relation to wilt disease

Treat. No.		1000 seed weight (g)		Volatile oil (%)	
		2022-23	2023-24	2022-23	2023-24
1		4.33	4.31	4.53	4.56
2		4.35	4.34	4.48	4.52
3		4.24	4.34	4.44	4.52
4		4.31	4.27	4.46	4.49
5		4.33	4.33	4.51	4.47
6		4.25	4.21	4.52	4.48
SEm.	T	0.07	0.07	0.08	0.07
	Y	-	-	-	-
	Y x T	-	-	-	-
CD at 5%		NS	NS	NS	NS
C.V. (%)		3.08	3.15	3.54	3.22

Note: Treatment means followed by the same letter(s) are not significantly different by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

(T₁-seed soaking with Beejamrutha @ 300 ml per kg of seeds; T₂-drenching with 10 per cent cow urine at a volume of 1000 L/ha; T₃-drenching with 10 per cent Panchgavya at 1000 L/ha; T₄-drenching with 10 per cent Neemastra at 1000 L/ha; T₅-drenching with 10 per cent Jeevamrutha at 1000 L/ha; and T₆-untreated control.)

(T₁-seed soaking with Beejamrutha @ 300 ml per kg of seeds; T₂-drenching with 10 per cent cow urine at a volume of 1000 L/ha; T₃-drenching with 10 per cent Panchgavya at 1000 L/ha; T₄-drenching with 10 per cent Neemastra at 1000 L/ha; T₅-drenching with 10 per cent Jeevamrutha at 1000 L/ha; and T₆-untreated control.)

Jeevamrutha treatment (T_s) showed a consistent reduction in PDI across both years, demonstrating its potential in controlling *Fusarium* wilt, which directly contributed to the observed increase in seed yield. The findings corroborate earlier studies by Glick and Bashan (1997), who highlighted the role of beneficial microbes in promoting plant health and suppressing pathogens, contributing to enhanced growth and productivity.

Similarly, *Neemastra* (T₄), which contains natural ingredients like neem, is known for its antifungal properties. Neem-based formulations have been reported to inhibit the growth of several soil-borne pathogens, including *Fusarium oxysporum*, due to the presence of active compounds like azadirachtin. In this experiment, *Neemastra* demonstrated the lowest PDI in both years, indicating its strong antifungal activity, which was in agreement with the findings of Patil *et al.* (2007), who reported that natural organic inputs like cow urine and neem extracts effectively suppressed *Fusarium* growth in field conditions. The reduction in PDI in *Neemastra*-treated plots could have resulted in healthier plants that were better able to allocate resources towards seed production, contributing to the higher seed yield observed.

In the second year (2023-24), both *Jeevamrutha* and *Neemastra* continued to perform well, with seed yield values being significantly higher than the control. This consistent performance supports the idea that these treatments are not only effective in disease management but also in promoting plant growth under field conditions. The cumulative beneficial effects of these treatments, including pathogen suppression, nutrient mobilization, and overall plant health, were reflected in the significant increase in seed yield, corroborating the findings of Rakesh *et al.* (2013) and Kumar *et al.* (2020), who demonstrated the antifungal and plant growth-promoting effects of organic inputs like cow urine and *Panchgavya*.

In conclusion, the treatments of *Jeevamrutha* and *Neemastra* exhibited significant potential in reducing *Fusarium* wilt incidence and increasing seed yield. The results suggest that these natural organic inputs are effective biocontrol agents and growth promoters, with *Neemastra* showing superior disease control and

Jeevamrutha contributing to improved overall plant health and yield.

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Conflict of Interest

The authors declare that there is no conflict of interest associated with this publication.

Author Contributions

B. K. Prajapati: Conceptualization, methodology, investigation, data curation, formal analysis, writing an original draft.

N. R. Patel: Conceptualization, methodology, supervision, data curation, writing-review and editing.

Both authors have read and approved the final version of the manuscript.

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