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Integrated Pest and Disease Management in Cumin (*Cuminum cyminum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Cumin is an important cash crop and its management through integrated pest and disease management is best strategy to increase its productivity both quantitatively and qualitatively. Through this approach the income of the farmers can be enhanced effectively. A field trial was carried out using a randomized block design with three replications during the Rabi seasons of 2018-19, 2019-20, and 2020-21 at the Seed Spices Research Station in Jagudan. The application of three sprays of kresoxim-methyl 44.3 SC at 0.044% (10 ml/10 L), with the initial spray applied at

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the onset of blight disease and subsequent sprays at 15-day intervals, along with two sprays of thiamethoxam 25 WG at 0.0084% (3.36 g/10 L), the first at the onset of aphid infestation and the second 10 days later, proved effective in managing both blight and aphid infestation in cumin.

Keywords: Cumin; aphid; blight; integrated pest; disease management.

1. INTRODUCTION

Cumin (*Cuminum cyminum* L.), a valuable seed spice crop, is predominantly cultivated in the arid to semi-arid regions of Gujarat and Rajasthan (Didwania, 2019; Islam et al., 2021). India is a key producer and exporter of cumin, accounting for a significant share of both its value and volume (Bhati & Bhati, 2007; Mishra, 2020). In 2019, India contributed to 85% of the global cumin demand, producing 26% of the world's supply (Abo-Elyousr *et al*., 2022; Akhter *et al*., 2023; Kiran *et al*., 2024). However, cumin is susceptible to various insect pests and diseases under field conditions. Therefore, the present study on integrated pest and disease management in cumin (Gujarat cumin-4) was designed to effectively and economically control these threats while minimizing pesticide residues. The experiment, conducted from the 2018-19 to 2020-21 *Rabi* seasons, involved fourteen different treatments using a combination of fungicides, insecticides, and biocontrol agents (Shekhawat et al., 2016; Bhatnagar et al., 2013).

2. MATERIALS AND METHODS

A field trial was carried out using a randomized block design with three replications during the Rabi seasons of 2018-19, 2019-20, and 2020-21 at the Seed Spices Research Station, S.D. Agricultural University, Jagudan. Cumin variety Gujarat Cumin 4 (GC 4) was planted in November with a row spacing of 30 cm, utilizing a seeding rate of 12 kg per hectare. The experiment involved three fungicide applications (the first applied at the onset of disease, followed by two more sprays at 15-day intervals) and two insecticide/biopesticide treatments, each administered according to the specified concentrations. The first insecticide spray was applied at the start of aphid infestation, with the second spray applied 10 days after the initial treatment.

2.1 Cumin Blight

The severity of blight disease in cumin was assessed by selecting 20 plants randomly from each plot, using a 0-5 scale as outlined below:

0 = No symptoms / Healthy
1 = Only leaf tips exhibiting blight symptoms
2 = Most leaves displaying blight
3 = Blight symptoms observed on both leaves and umbels
4 = Blight affecting leaves, with some lesions on the stem
5 = Blight present on leaves, umbels, stem, and seeds

Based on these observations, percent disease intensity (PDI) of blight was worked out by using following formula.

List 1. Formula of percent disease intensity (PDI)

$$\text{Per cent disease intensity (PDI)} = \frac{\text{Sum of all numerical ratings}}{\text{Total plants examined} \times \text{Maximum rating}} \times 100$$

2.2 Powdery Mildew

The severity of powdery mildew disease was assessed by selecting 20 plants randomly from each plot, and the intensity was recorded using a 0-4 scale as described below. Based on these assessments, the percentage of disease intensity was calculated.

0 = No symptoms / Healthy
1 = Small whitish spots on the leaf
2 = Whitish growth covering the whole leaf
3 = Whitish growth on both leaf and stem
4 = Whitish growth on leaf, stem, and umbel

2.3 Aphid Index

Five plants were randomly chosen from the net plot area of each treatment. These plants were thoroughly examined for cumin aphid infestations. Aphid population counts were recorded prior to and 3 and 7 days after the application of various insecticidal treatments. The average aphid index was calculated using the following formula.

Average aphid index

$$= \frac{0N + 1N + 2N + 3N + 4N + 5N}{\text{Total number of plants observed}}$$

Where, 0, 1, 2, 3, 4, 5 are the aphid index,

N = Number of plants showing respective aphid index

Table 1. Aphid index

Aphid Index	Level of Infestation
0	Plant free from aphids
1	Aphids present, but no established colonies; no visible damage from pest activity
2	Small aphid colonies present on leaves; slight curling of leaves due to aphid feeding
3	Larger aphid colonies on leaves and other plant parts; visible damage from aphid feeding
4	Most leaves covered with aphid colonies; plant shows extensive damage and counting is not feasible
5	Plant completely infested with aphids; growth severely affected due to pest feeding

Table 2. Total fourteen (14) treatments were applied as mentioned below

Sr.No	Treatments
T_1	Three sprays of hexaconazole 5 EC @ 0.005% (10 ml/ 10 L) + two sprays of thiamethoxam 25 WG (0.0084%)
T_2	Three sprays of hexaconazole 5 EC @ 0.005% (10 ml/ 10 L) + two sprays of *Beauveria bassiana* 1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)
T_3	Three sprays of hexaconazole 5 EC @ 0.005% (10 ml/ 10 L) + two sprays of *Lecanicilliumlecanii*1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)
T_4	Three sprays of kresoxim-methyl44.3 SC @ 0.044% (10 ml/ 10 L) + two sprays of thiamethoxam 25 WG (0.0084%)
T_5	Three sprays of kresoxim-methyl44.3 SC @ 0.044% (10 ml/ 10 L) + two sprays of *Beauveriabassiana*1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)
T_6	Three sprays of kresoxim-methyl44.3 SC @ 0.044% (10 ml/ 10 L) + two sprays of *Lecanicilliumlecanii*1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)
T_7	Three sprays of hexaconazole 5 EC @ 0.005% (10 ml/ 10 L) + first spray of thiamethoxam 25 WG (0.0084%) and second spray of *Beauveriabassiana* ($1x10^9$ cfu/g) (40 g/10 L)
T_8	Three sprays of kresoxim-methyl44.3 SC @ 0.044% (10 ml/ 10 L) + first spray of thiamethoxam 25 WG (0.0084%) and second spray of *B. bassiana* ($1x10^9$ cfu/g) (40 g/10 L)
T_9	Three sprays of hexaconazole 5 EC @ 0.005% (10 ml/ 10 L) + first spray of thiamethoxam 25 WG (0.0084%) and second spray of *Lecanicillium lecanii* 1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)
T_{10}	Three sprays of kresoxim-methyl44.3 SC @ 0.044% (10 ml/ 10 L) + first spray of thiamethoxam 25 WG (0.0084%) and second spray of *Lecanicillium lecanii* 1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)
T_{11}	Three sprays of hexaconazole 5 EC @ 0.005% (10 ml/ 10 L) + first spray of *Beauveria bassiana* 1.15 WP ($1x10^9$ cfu/g) (40 g/10 L) and second spray of *Lecanicillium lecanii* 1.15 WP ($1x10^9$ cfu/g) (40 g/10 L)

Sr.No	Treatments
T_{12}	Three sprays of kresoxim-methyl44.3 SC @ 0.044% (10 ml/ 10 L) + first spray of *Beauveria bassiana* 1.15 WP (1x10^9 cfu/g) (40 g/10 L) and second spray of *Lecanicillium lecanii* 1.15 WP (1x10^9 cfu/g) (40 g/10 L)
T_{13}	Four sprays of mancozeb 75 WP 0.25% (33 g/10 L), two sprays of wettable sulphur 80 WP 0.2% (25 g/ 10 L) + first spray of thiamethoxam 25 WG (0.00625%) and second spray of thiacloprid 21.7 SC (0.0062)
T_{14}	Untreated Control

3. RESULTS AND DISCUSSION

A total of fourteen treatments, comprising thirteen pesticide/biopesticide applications and one untreated control, were assessed for their effectiveness in managing pests and diseases in cumin.

3.1 Blight Disease Intensity

The data indicated a significant variation in the percentage of disease intensity due to blight across all the years and in the pooled results. The lowest blight intensity was observed in T4, which consisted of three applications of kresoxim-methyl 44.3 SC (0.044%) (10 ml/10 L) combined with two applications of thiamethoxam 25 WG (0.0084%). This treatment showed comparable results to treatments T10, T6, and T8 across all individual years and the pooled analysis (Table 3).

3.2 Powdery Mildew Disease Intensity

It is revealed from the data that there was significant difference in percent disease intensity of powdery mildew during all the years and pooled results. Powdery mildew intensity was found significantly lower in all the treatments as compared to untreated control. Lowest powdery mildew intensity was observed in T1 *i.e.,* three sprays of hexaconazole 5 EC (0.005%) (10 ml/ 10 L) + two sprays of thiamethoxam 25 WG (0.0084%) and was at par with T2, and T3 during all the years and pooled results too, while it was also at par with T9 except the year 2018-19 (Table 4).

3.3 Aphid Index

The data on aphid index prior to as well as three and seven days after both of the sprays are presented in Table 5.

It is revealed from the data that there was significant difference in aphid index. All the treatments were found significantly superior in controlling aphid infestation as compared to control at 3 and 7 days after both sprays in all the years and pooled results also. Aphid index was found significantly low in the treatment T4 *i.e.,* three sprays of kresoxim-methyl44.3 SC (0.044%) (10 ml/ 10 L) + two sprays of thiamethoxam 25 WG (0.0084%) at 3 and 7 days after both sprays in all the years and pooled results.

The aphid index was found significantly low in the treatment T4 *i.e.,* three sprays of kresoxim-methyl44.3 SC (0.044%) (10 ml/ 10 L) + two sprays of thiamethoxam 25 WG (0.0084%) in pooled over spray as well as pooled over years.

3.4 Seed Yield

Effect of different treatments on cumin seed yield was found significant during 2018-19, 2019-20, 2020-2021 and pooled analysis also (Table 6). Significantly higher yield was recorded with treatment T4 *i.e.,* three sprays of kresoxim-methyl44.3 SC (0.044%) (10 ml/ 10 L) + two sprays of thiamethoxam 25 WG (0.0084%) and was at par with treatment T13 *i.e.,* four sprays of mancozeb 75 WP (0.25%) (33 g/10 L), two spray of wettable sulphur 80 WP (0.2%) (25 g/10 L) + first spray of thiamethoxam 25 WG (0.0084%) and second spray of thiacloprid and T10 *i.e.,* three sprays of kresoxim-methyl44.3 SC (0.044%) (10 ml/ 10 L) + first spray of thiamethoxam 25 WG (0.0084%) and second spray of *Lecanicillium lecanii*1.15 WP (1x10^9 cfu/g) (40 g/10 L) during 2020-21 and pooled result.

The present study demonstrated that thiamethoxam 25 WG (0.0084%), when applied twice in combination with effective fungicides, significantly reduced aphid infestation in cumin across all three years and the pooled data. The treatment involving thiamethoxam not only maintained a consistently lower aphid index at 3 and 7 days after application but also contributed to a notable increase in seed yield compared to the untreated control. This highlights the effectiveness of thiamethoxam in suppressing aphid populations during critical crop stages.

Table 3. Effect of different treatments on blight disease intensity in cumin

Treatments	Blight disease intensity (PDI)			
	2018-19	2019-20	2020-21	Pooled
T_1	34.24* [b] (31.67)	31.74 [b] (28.33)	23.17 [c] (15.50)	29.72 [b] (25.17)
T_2	33.83 [b] (31.00)	37.12 [b] (36.67)	25.59 [b] (18.67)	32.18 [b] (28.78)
T_3	33.78 [b] (30.92)	38.16 [b] (38.33)	25.10 [b] (18.00)	32.35 [b] (29.08)
T_4	22.72 [d](14.92)	15.68 [c] (7.33)	15.75 [e] (7.37)	18.05 [c] (9.87)
T_5	23.97 [cd] (16.52)	19.90 [c] (11.67)	16.84 [e] (8.40)	20.24 [c] (12.19)
T_6	23.70 [cd] (16.17)	18.85 [c] (10.67)	16.49 [e] (8.07)	19.68 [c] (11.63)
T_7	33.52 [b] (30.50)	30.95 [b] (26.67)	21.86 [cd] (13.87)	28.78 [b] (23.68)
T_8	23.45 [d] (15.83)	19.97 [c] (11.67)	16.39 [e] (7.97)	19.94 [c] (11.82)
T_9	33.36 [b] (30.25)	34.02 [b] (31.67)	20.84 [d] (12.67)	29.41 [b] (24.86)
T_{10}	23.51 [cd] (15.92)	18.28 [c] (10.00)	16.14 [e] (7.73)	19.31 [c] (11.22)
T_{11}	33.52 [b] (30.50)	32.55 [b] (29.00)	23.05 [c] (15.33)	29.71 [b] (24.94)
T_{12}	24.73 [c] (17.50)	19.36 [c] (11.00)	16.21 [e] (7.80)	20.10 [c] (12.10)
T_{13}	23.44 [d] (15.83)	15.93 [c] (7.67)	15.78 [e] (7.40)	18.38 [c] (10.30)
T_{14}	38.35 [a] (38.50)	50.94 [a] (60.00)	33.90 [a] (31.13)	41.06 [a] (43.21)
S.Em	0.39	3.02	0.45	1.89
C.D at 5%	1.13	8.78	1.29	5.50
C.V%	2.32	19.1	3.76	12.01
Y X T				S

**Arcsine values, Figures in the parenthesis are retransformed values, Treatments means with the letter (s) in common are not significant by DNMRT at 5% level of significance*

Table 4. Effect of different treatments on powdery mildew disease intensity

Treatments	Powdery mildew intensity (PDI)			
	2018-19	2019-20	2020-21	Pooled
T_1	23.18* [d] (15.50)	17.59 [d](9.13)	16.74 [c] (8.30)	19.17 [f] (10.98)
T_2	23.71 [cd] (15.17)	17.62 [d](9.17)	17.58 [c] (9.13)	19.63 [ef] (11.49)
T_3	24.09 [cd] (16.67)	17.93 [d](9.50)	17.36 [c] (8.93)	19.79[def] (11.70)
T_4	27.68 [b] (21.58)	22.33 [b] (14.43)	20.41 [b] (12.17)	23.47 [b] (16.06)
T_5	27.56 [b] (21.42)	22.35 [b] (14.47	21.65 [b] (13.63)	23.86 [b] (16.51)
T_6	27.33 [b] (21.08)	21.86 [b] (13.87)	21.21 [b] (13.10)	23.47 [b] (16.02)
T_7	24.35 [cd] (17.00)	19.25 [c] (10.87)	18.02 [c] (9.60)	20.54 [cd] (12.49)
T_8	26.57 [b] (20.00)	21.75 [b] (13.73)	21.21 [b] (13.10)	23.17 [b] (15.61)
T_9	24.53 [c] (17.25)	17.72 [d](9.27)	17.19 [c] (8.73)	19.81[def] (11.75)
T_{10}	27.45 [b] (21.25)	22.00 [b] (14.03)	21.52 [b] (13.47)	23.66 [b] (16.25)
T_{11}	24.79 [c] (17.58)	19.46 [c] (11.10)	17.78 [c] (9.33)	20.68 [c] (12.67)
T_{12}	27.21 [b] (20.92)	21.74 [b] (13.73)	20.87 [b] (12.70)	23.28 [b] (15.78)
T_{13}	24.60 [c] (17.33)	18.67 [cd](10.25)	17.42 [c] (8.97)	20.23[cde] (12.19)
T_{14}	34.13 [a] (31.50)	27.05 [a] (20.70)	28.18 [a] (22.33)	29.79 [a] (24.84)
S.Em	0.41	0.40	0.54	0.26
C.D at 5%	1.20	1.16	1.56	0.74
C.V%	2.73	3.37	4.7	3.55
Y X T				NS

**Arcsine values, Figures in the parenthesis are retransformed values, Treatments means with the letter (s) in common are not significant by DNMRT at 5% level of significance*

These findings are well supported by the results of Italiya *et al*. (2018), who reported that a single application of thiamethoxam at 0.0125% led to a marked reduction in aphid population (8.20 aphids/plant) compared to the control (43.99 aphids/plant), and resulted in a 75.20% increase in seed yield over the untreated control. The consistency between the present study and Italiya et al.'s results underscores the efficacy of thiamethoxam as a systemic neonicotinoid insecticide that provides quick knockdown and residual activity against sucking pests like aphids.

Table 5. Effect of different treatments on aphid index in cumin (pooled over year)

Treat. No.	Treatments	Before spray	Aphid index			
			2018-19	2019-20	2020-21	Pooled over year
1.	T_1	2.13 (4.05)	1.86^{bcd} (2.95)	1.78^{bcd} (2.67)	1.71^{cde} (2.46)	1.78^{ef} (2.69)
2.	T_2	2.14 (4.08)	1.92^{bc} (3.20)	1.84^{bc} (2.89)	1.78^{bcd} (2.71)	1.85^{bcd} (2.93)
3.	T_3	2.13 (4.04)	1.93^{bc} (3.22)	1.90^{ab} (3.14)	1.85^{b} (2.94)	1.89^{bc} (3.10)
4.	T_4	2.09 (3.87)	1.59^{g} (2.05)	1.51^{e} (1.83)	1.46^{g} (1.73)	1.52^{i} (2.20)
5.	T_5	2.12 (3.99)	1.95^{b} (3.31)	1.91^{ab} (3.16)	1.85^{b} (2.94)	1.90^{b} (3.14)
6.	T_6	2.09 (3.87)	1.90^{bc} (3.10)	1.86^{bc} (2.97)	1.81^{bc} (2.82)	1.86^{bc} (2.96)
7.	T_7	2.09 (3.87)	1.89^{bc} (3.07)	1.84^{bc} (2.90)	1.80^{bcd} (2.77)	1.84^{cd} (2.91)
8.	T_8	2.10 (3.91)	1.80^{bcdef} (2.73)	1.72^{cd} (2.49)	1.68^{de} (2.37)	1.73^{fg} (2.53)
9.	T_9	2.11 (3.95)	1.86^{bcd} (2.97)	1.79^{bc} (2.72)	1.76^{bcd} (2.61)	1.80^{de} (2.77)
10.	T_{10}	2.12 (3.99)	1.78^{cdef} (2.67)	1.64^{de} (2.23)	1.61^{ef} (2.10)	1.68^{g} (2.33)
11.	T_{11}	2.09 (3.87)	1.89^{bc} (3.08)	1.86^{bc} (2.99)	1.83^{bc} (2.85)	1.86^{bc} (2.97)
12.	T_{12}	2.06 (3.74)	1.90^{bc} (3.11)	1.88^{b} (3.06)	1.82^{bc} (2.85)	1.87^{bc} (3.01)
13.	T_{13}	2.10 (3.91)	1.71^{dfg} (2.44)	1.56^{e} (1.98)	1.51^{fg} (1.83)	1.59^{h} (2.08)
14.	T_{14}	2.11 (3.95)	2.18^{a} (4.21)	2.04^{a} (3.67)	2.08^{a} (3.80)	2.10^{a} (3.89)
S.Em.±	T	0.01	0.047	0.046	0.038	0.018
	P	-	0.044	0.004	0.150	0.053
	S	-	0.004	0.004	0.006	0.174
	Y	-	-	-	-	0.004
	TxP	-	0.017	0.017	0.052	0.024
	TxS	-	0.017	0.017	0.023	0.011
	PxS	-	0.006	0.006	0.009	0.062
	YxT	-	-	-	-	0.014
	YxP	-	-	-	-	0.005
	YxS	-	-	-	-	0.005
	TxPxS	-	0.024	0.023	0.033	0.027
	YxSxT	-	-	-	-	0.019
	YxSxP	-	-	-	-	0.007
	YxPxT	-	-	-	-	0.019
	YxSxPxT	-	-	-	-	0.027
C.D.at 5%	T	NS	0.144	0.140	0.115	0.052
	YxSxPxT	-	-	-	-	-
C.V. (%)		1.92	2.19	2.26	3.41	2.63

Figures in parenthesis are retransformed values, those outside are $\sqrt{X+0.5}$ transformed values, DAS: Days after spray; Treatments means with the letter (s) in common are not significant by DNMRT at 5% level of significance

Table 6. Effect of different treatments on seed yield

Treatments	Seed yield (Kg/ha)			
	2018-19	2019-20	2020-21	Pooled
T_1	572 a	548 bc	477 bcd	532 abcd
T_2	161 d	475 c	338 d	324 fg
T_3	188 d	532 c	398 cd	372 efg
T_4	647 a	705 a	680 a	677 a
T_5	180 d	631 ab	417 abc	410 def
T_6	380 c	640 a	440 abc	487 bcde
T_7	456 bc	537 c	424 cd	472 bcdef
T_8	551 ab	644 a	516 abc	570 abc
T_9	540 ab	537 c	423 cd	500 bcde
T_{10}	591 a	660 a	598 ab	616 ab
T_{11}	221 d	509 c	378 d	370 efg
T_{12}	223 d	638 a	425 abc	429 cdef
T_{13}	628 a	702 a	**644** a	658 a
T_{14}	129 d	364 d	248 e	247 g
S.Em	34	29	37	48
C.D at 5%	99	84	107	140
C.V%	15.07	8.62	13.91	12.14
Y X T				S

Treatments means with the letter (s) in common are not significant by DNMRT at 5% level of significance

The findings of the present study revealed that thiamethoxam 25 WG (0.0084%), when applied twice in combination with fungicides, was highly effective in controlling aphid infestation in cumin. Across all three years and in the pooled analysis, treatments including thiamethoxam consistently recorded a significantly lower aphid index at both 3 and 7 days after application compared to the untreated control. This reduction in aphid population also translated into a substantial increase in seed yield, indicating the insecticide's positive impact on overall crop performance.

These results are in close agreement with the study conducted by Dangi *et al*. (2017), who reported that the application of thiamethoxam 25 WG at 25 g a.i./ha effectively reduced the mean aphid population to 76.27, and significantly increased cumin yield to 399.8 kg/ha, compared to 180.9 kg/ha in the untreated control. This highlights the efficiency of thiamethoxam as a systemic insecticide with strong residual activity, capable of suppressing aphid populations during key crop growth stages.

The study showed that kresoxim-methyl 44.3 SC was highly effective in managing cumin blight, consistently recording the lowest disease intensity and higher seed yield across all seasons. These results align with findings by Verma *et al*. (2020), who reported that captan + hexaconazole significantly reduced blight and powdery mildew intensity while improving yield. This highlights the effectiveness of systemic fungicides in managing cumin diseases and enhancing crop productivity.

The results of the present study clearly indicate that kresoxim-methyl 44.3 SC was the most effective fungicide in managing cumin blight, as evidenced by the significantly lower disease intensity observed across all three years and the pooled data. These findings are in strong agreement with the observations reported by Patel et al. (2017), who found that kresoxim-methyl (44.3 SC), along with difenoconazole (25 EC) and propiconazole (25 EC), effectively reduced disease intensity in cumin. The present study further validates the efficacy of kresoxim-methyl as a potent strobilurin fungicide that inhibits fungal respiration, providing both curative and protective action against blight pathogens. The consistency of its performance over multiple seasons under field conditions reinforces its suitability for inclusion in integrated disease management strategies for cumin (Rana et al., 2018).

4. CONCLUSION

Over three consecutive Rabi seasons, the field trial demonstrated that integrated use of specific fungicides and insecticides significantly improved cumin health and productivity. The combination of three sprays of kresoxim-methyl 44.3 SC (0.044%) and two sprays of

thiamethoxam 25 WG (0.0084%) consistently resulted in the lowest blight intensity, reduced aphid population, and highest seed yield across all years and pooled data. For effective control of powdery mildew, the treatment involving hexaconazole 5 EC with thiamethoxam was most successful. These results highlight that timely, targeted applications of compatible plant protection products can effectively manage major diseases and pests in cumin, while also enhancing yield. This integrated approach is recommended for sustainable cumin cultivation in similar agro-climatic zones.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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