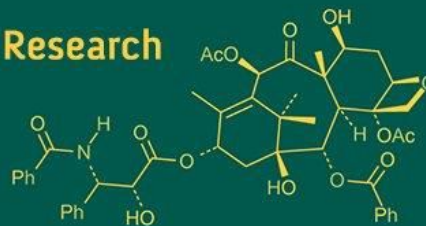


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Studies on the efficacy of some entomopathogenic fungi against sucking pest of rice

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Abstract

A field experiment was carried out during the kharif seasons of 2023 to evaluate the effectiveness of various entomopathogenic fungi, including *Beauveria bassiana*, *Metarhizium anisopliae*, and *Lecanicillium saksnae*, applied at a rate of 5 g/l with a concentration of 1x10⁸ CFU. This was compared with a standard treatment using Thiamethoxam 25WG at 0.2 g/l against the brown plant hopper and its natural predators (lady beetles, rove beetles, and spiders). The results clearly indicated that Thiamethoxam 25WG at 0.2 g/l was highly effective against BPH and earhead bug but highly toxic to natural enemies, with a higher grain yield and higher benefit-cost ratio. However, *B. bassiana* and *M. anisopliae* at 5 g/l, though found to be ineffective at 5 and after the first spray, had their efficacy against BPH increase with an increase in days after the spray and were found to be at par with Thiamethoxam 25WG 0.2 g/l at 10 days after the second and third sprays. Among the entomopathogens, *M. anisopliae* and *B. bassiana* were found to be relatively more effective against BPH relatively less toxic to natural, followed by *Lecanicillium saksnae*.

Keywords: Rice, brown plant hopper, Entomogenous fungi - *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium saksnae*, efficacy, CFU (colony form unit) natural enemies

1. Introduction

Rice (*Oryza sativa* L) is one of the most important cereal crop and staple food for about half of the world's population. Rice belongs to the family Poaceae. Rice dominates Indian agriculture and accounts for 40 per cent production under food grains.

From transplanting to maturity, the rice crop also needs warm, humid weather, which is ideal for the growth of insect pests. Only 23 of the over 300 insect pest species that have been identified in rice crops are known to inflict financial harm. In India cultivation of rice is mainly practiced in Uttar Pradesh, West Bengal, Andhra Pradesh, Chhattisgarh and Bihar. Bihar ranks fifth in the cultivation of rice (3268 tone ha). A number of insect pests that attack rice plants account for yield losses of 24% worldwide. Insect pest causes at least 20% field losses in rice in India. At least 20 of the more than 70 insect pest species that are known to feed on rice have the potential to significantly reduce rice output. Pest outbreaks can be caused by a number of factors, including climatic conditions, inadequate irrigation, high nitrogen fertilizer application rates, and excessive pesticide usage. Insect pests attack all parts of the rice plant at all growth stages and some serve as vectors of viruses that adversely affect the plant. (Pathak *et al.*, 1982) [8].

Over 100 species of insect's attack and damage rice. Many of them often appear sporadically but do not cause economic loss. The main pests of economic significance in India are the stem borers (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*), brown planthopper (*Nilaparvata lugens* Stal), leaf folder (*Cnaphalocrocis medinalis*), and green leafhopper (*Nephotettix virescens*). These pests frequently cause production constraints in a variety of rice-growing environments. *Leptocorisa oratorius* (Fabricius), *L. acuta* (Thunberg), and *L. chinensis* (Dallas) are the three most prevalent seed-feeding bugs of rice (*Oryza sativa* Linnaeus) in Asia. The rice earhead bugs, both nymphs and adults, cause damage by feeding on the sap of milky grain and turning them chaffy. The management of earhead bugs (*Leptocorisa spp.*) as rice pests primarily involves the use of chemical insecticides. With public concern over the use of chemicals in agriculture and their impact on the environment

continuing to mount, safer approaches like biological control are gaining greater significance. A number of natural enemies have been evaluated against rice bugs. Among these, the entomopathogenic fungi, particularly *Beauveria bassiana*, *Metarhizium anisopliae*, and *Lecanicillium saksnae*, are the most important.

Entomopathogenic fungi (EPF) are fungal species that are pathogenic to insects. These fungal pathogens play a vital role in insect population dynamics, making them the earliest insect pest control agents. Earliest farmers relied on the actions of predators, pathogens, and host plant resistance for the control of insect pests until the discovery of insecticides. The brown planthopper (BPH), *Nilaparvata lugens* Stål, is a major sap-sucking pest of rice, *Oryza sativa* L., inducing symptoms commonly referred to as hopper burn and causing substantial yield loss in most rice-producing countries. Heretofore, neither was the biology or ecology clearly understood, nor was there an effective method of controlling this sucking pest other than using chemicals.

2. Materials and Methods

2.1 Methodology

The field trial was taking place at IGKV Raipur's research farm during the Kharif 2023 season. It was used a random block design with five treatments: three entomopathogenic fungi *Lecanicillium saksnae* (1×10^8 spores/gm), *Beauveria bassiana* (1×10^8 spores/gm), *Metarhizium anisopliae* (1×10^8 spores/gm), one standard check insecticide (thiomethoxan 0.2 g/l), and an untreated control. The treatments were applied thrice at 10 days interval with knapsack sprayer using 500 Lt/ha spray fluid at panicle initiation stage that coincided with the initiation of pest infestation. The pre and post treatment count for BPH was recorded one day before and 5 and 10 days after each spray for 10 randomly selected hills in each treatment and replication. The count data obtained from this experimentation for plant feeder BPH was analysed after appropriate transformation for analysis of variance to draw the concrete conclusion.

S. No.	Treatments	Dose/liter of water
1	<i>Lecanicillium saksnae</i> (1×10^8 spores/gm.)	5 gm.
2	<i>Beauveria bassiana</i> (1×10^8 spores/gm.)	5 gm.
3	<i>Metarhizium anisopliae</i> (1×10^8 spores/gm.)	5 gm.
4	Thiamethoxam 25WG	0.2 gm.
5	Untreated	-

3. Results and Discussion

3.1 At first spray

The observations were recorded 5 DAS and revealed that all the treatments were significantly superior to untreated control. The treatment (T₄) Thiamethoxam 25 WG was found to be most effective over the rest of the treatments, which recorded the lowest hopper count of 9.99 per hills, which was at par with treatment (T₃) *Metarhizium anisopliae* (1×10^8 spores/gm) 13.60 with (T₂) *Beauveria bassiana* (1×10^8 spores/gm) 14.50 and treatment (1) *Lecanicillium saksnae* (1×10^8 spores/gm) 16.00 hoppers per hills, respectively. The observation recorded at 10 DAS revealed that all the treatments were significantly superior to untreated control. The treatment (T₄) Thiamethoxam 25 WG was found to be most effective over the rest of the treatments, which recorded the lowest hopper count of 6.12 per hill, which was followed by treatment (T₃) *Metarhizium anisopliae* (1×10^8 spores/gm) 9.12, with (T₂) *Beauveria*

bassiana (1×10^8 spores/gm) 10.02 and treatment (T₁) *Lecanicillium saksnae* (1×10^8 spores/gm) 10.01 hoppers per hill, respectively.

3.2 At second spray

The observations were recorded 5 DAS and revealed that all the treatments were significantly superior to untreated control. The treatment (T₄) Thiamethoxam 25 WG was found to be most effective over the rest of the treatments, which recorded the lowest hopper count of 5.89 ± 2.62 per hill, which was followed by treatment (T₃) *Metarhizium anisopliae* (1×10^8 spores/gm) 8.11 ± 3.01 with (T₂) *Beauveria bassiana* (1×10^8 spores/gm) 12.99 ± 3.74 and treatment (1) *Lecanicillium saksnae* (1×10^8 spores/gm) 11.09 ± 3.47 hoppers per hill, respectively. The observations were recorded 5 DAS and revealed that all the treatments were significantly superior to untreated control. The treatment (T₄) Thiamethoxam 25 WG was found to be most effective over the rest of the treatments, which recorded the lowest hopper count of 3.21 ± 2.05 per hill, which was followed by treatment (T₃) *Metarhizium anisopliae* (1×10^8 spores/gm) 5.21 ± 2.49 with (T₂) *Beauveria bassiana* (1×10^8 spores/gm) 8.01 ± 3.00 and treatment (T₁) *Lecanicillium saksnae* (1×10^8 spores/gm) 9.01 ± 3.16 hoppers per hill, respectively.

3.3 At third spray

The observations were recorded 5 DAS and revealed that all the treatments were significantly superior to untreated control. The treatment (T₄) Thiamethoxam 25 WG was found to be most effective over the rest of the treatments, which recorded the lowest hopper count of 2.89 ± 1.97 per 10 hills, which was at par with treatment (T₃) *Metarhizium anisopliae* (1×10^8 spores/gm) 3.12 ± 2.03 with (T₂) *Beauveria bassiana* (1×10^8 spores/gm) 4.23 ± 2.28 and treatment (T₁) *Lecanicillium saksnae* (1×10^8 spores/gm) 7.01 ± 2.83 hoppers per 10 hills, respectively. The observations were recorded 10 DAS and revealed that all the treatments were significantly superior to the untreated control. The treatment (T₄) Thiamethoxam 25 WG was found to be most effective over the rest of the treatments, which recorded the lowest hopper count of 1.81 ± 1.66 per 10 hills, which was followed by treatment (T₃) *Metarhizium anisopliae* (1×10^8 spores/gm) 2.89 ± 2.97 , and treatment (T₂) *Beauveria bassiana* (1×10^8 spores/gm) 3.42 ± 2.10 , and treatment (1) *Lecanicillium saksnae* (1×10^8 spores/gm) 5.12 ± 2.47 hoppers per 10 hills, respectively.

3.4 Overall mean population of brown plant hopper

The overall mean population across all post-treatment observations highlighted the superior efficacy of Thiamethoxam (4.99 ± 2.44 individuals/10 hills), followed by *Metarhizium anisopliae* (6.92 ± 2.81), *Beauveria bassiana* (8.86 ± 3.14), and *Lecanicillium saksnae* (9.72 ± 3.27). The control averaged 18.27 ± 4.40 individuals/10 hills. Relative to the control, Thiamethoxam achieved the highest population reduction (72.68%), followed by *Metarhizium anisopliae* (62.12%), *Beauveria bassiana* (51.50%), and *Lecanicillium saksnae* (49.26%).

3.5 Effect on natural enemies

The combined analysis of data obtained after three sprayings, indicated that thiamethoxam 25WG was found most effective against coccinellids, as it was recorded

lowest overall population (1.94 coccinellids/hill), followed by *Lecanicillium saksenae* (1×10^8 spores/gm) (2.26 coccinellids/hill). The next effective treatment was *Beauveria bassiana* (1×10^8 spores/gm) (2.27/hill) and *metarhizium anisoplaea* (1×10^8 spores/gm) (2.30 coccinellids/hill). *Lecanicillium saksenae* (1×10^8 spores/gm) *Beauveria bassiana* (1×10^8 spores/gm) and *metarhizium anisoplaea* (1×10^8 spores/gm) was declared as the least effective treatment. The highest coccinellid population (2.39 coccinellids/ hill) was recorded in an untreated control. Overall mean population of spider after first, second spray and third spray: The combined analysis of data obtained after three sprayings, indicated that thiamethoxam was found most effective against spiders, as it was recorded lowest overall population (2.08 spiders/hill) and *Lecanicillium saksnae* (1×10^8 spore/gm) (2.23 spiders/hills), followed by *metarhizium anisoplaea* (2.26 spiders/hill) and *beauveria abssiana* (2.24 spiders/hill). The highest spider population (2.32 spiders/ hill) was recorded in an untreated control. Overall mean population of spider after first, second spray and third spray: The combined analysis of data obtained after three sprayings, indicated that thiamethoxam was found most effective against rove beetle, as it was recorded lowest overall population (1.91 rove beetle/hill) and *Lecanicillium saksnae* (1×10^8 spore/gm) (2.27 rove beetle/hill), followed by *metarhizium anisoplaea* (2.30 rove beetle/hill) and *beauveria bassiana* (2.27 rove beetle/

hill). The highest spider population (2.39 rovebeetle/hill) was recorded in an untreated control.

4. Yield analysis: The data on the yield of rice that was influenced by various entomopathogen treatments are presented in Table 4.2.13. It could be seen from the data that all the entomopathogen treatments recorded higher yields than the untreated control. All the treatments gave significantly higher yields than the untreated control. The highest grain yield of rice (51.57 q/ha) was obtained in a treatment (T₄) Thiamethoxam with 25 WG 0.2 g/l found on par with treatment (T₃) *Metarhizium anisoplaea* 1×10^8 spores/gm, and (T₂) *Beauveria bassiana* 1×10^8 spores/gm. The next best treatment was (T₃) *Metarhizium anisoplaea* 1×10^8 spores/gm which was 49.00 q/ha grain yield of rice which is on par with treatment (T₂) *Beauveria bassiana* 1×10^8 (46.76 q/hac) spores/gm and (T₁) *Leacnicillium saksnae* 1×10^8 (38.50 q/ha). This result is in consonance with Kiran and Veerana (2012) reported that Spraying of *Metarhizium anisoplaea* @ 2.5 kg/ha produced significantly higher grain yield of paddy (8060 kg/ha) over *Metarhizium anisoplaea* @ 2 kg/ha (7643 kg/ha) *Metarhizium anisoplaea* at 2 kg/ha (7643 kg/ha), Clothiandidin (6701 kg/ha), and control (5922 kg/ha). This was at par with Thiomethoxam (8313 kg/ha) and Imidachloraprid (7843 kg/ha). The *Metarhizium anisoplaea* 2.5 kg/ha was not found to be phytotoxic, and it was safer for natural enemies.

Table 1: Relative efficacy entomopathogens application on population intensity of Brown planthopper after all over of spraying

S. No.	Treatment	Dosage g/l	Pre-treatment BPH/ hill	Post treatment BPH/ hill						Overall mean	Population reduction over control (%)
				First spray		second spray		Third spray			
				5 DAS	10 DAS	5 DAS	10 DAS	5 DAS	10 DAS		
1	<i>Lecanillium saksenae</i> (1x10 ⁸ spores/gm)	5	19.75 (4.44)	16 (4.10)	10.01 (3.31)	11.09 (3.47)	9.01 (3.16)	7.01 (2.83)	5.12 (2.47)	9.72 (3.27)	49.26
2	<i>Beauveria bassiana</i> (1x10 ⁸ spores/gm)	5	20.5 (4.63)	14.5 (3.93)	10.02 (3.32)	12.99 (3.74)	8.01 (3.00)	4.23 (2.28)	3.42 (2.10)	8.86 (3.14)	51.50
3	<i>Metarhizium anisopliae</i> (1x10 ⁸ spores/gm)	5	18.75 (4.44)	13.6 (3.72)	9.12 (3.17)	8.11 (3.01)	5.21 (2.49)	3.12 (2.03)	2.89 (2.97)	6.92 (2.81)	62.12
4	Thiamethoxam 25 WG	0.2	20.11 (4.26)	9.99 (3.31)	6.12 (2.66)	5.89 (2.62)	3.21 (2.05)	2.89 (1.97)	1.81 (1.66)	4.99 (2.44)	72.68
5	Control		16.75 (4.20)	17.25 (4.27)	17.75 (4.32)	18.25 (4.41)	18.27 (4.44)	19.00 (4.41)	19.25 (4.47)	18.27 (4.40)	-
CD at 5%			NS	0.44	0.23	0.44	0.23	0.17	0.10	0.12	

Figure in parentheses are square root transformed values, NS = Non significant, DAS = Days after spray, CD-critical difference

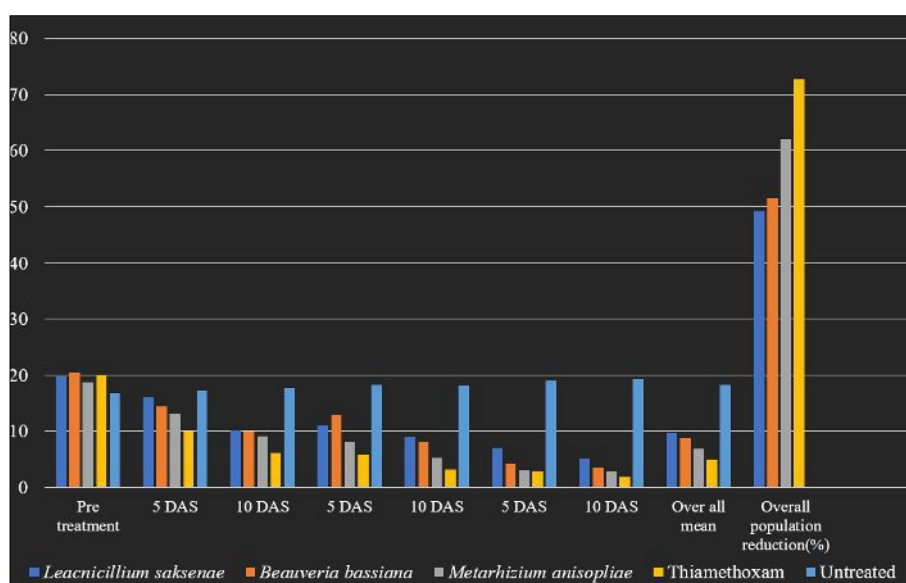
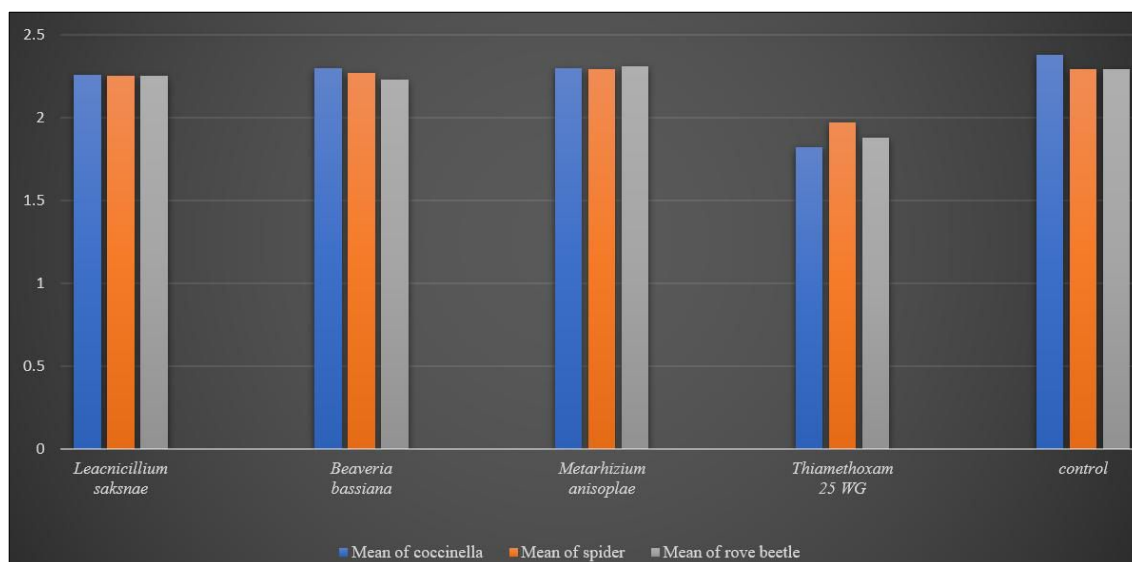


Fig 1: Relative entomopathogens application on population intensity of Brown Planthopper after over all spraying

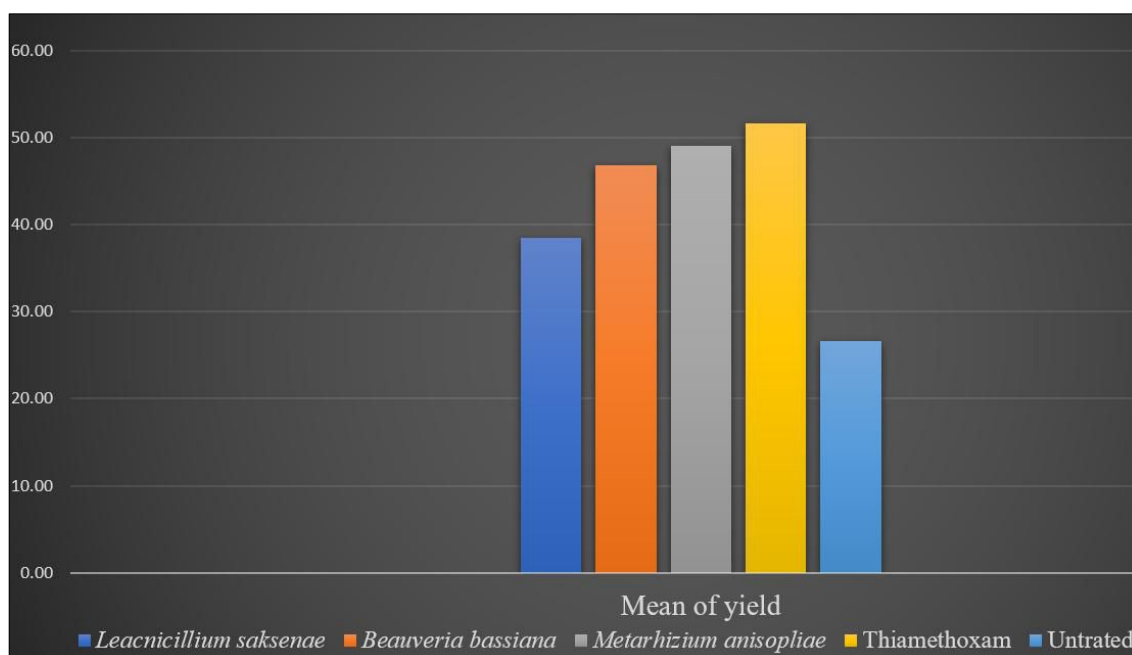
Table 2: The effect of entomopathogens apply on non-target organisms in rice

Treatment	Dosage g/l	Mean of coccinella	Mean of spider	Mean of rove beetle
<i>Lecanillium saksenae</i> (1x10 ⁸ spores/gm)	5	2.26 (1.85)	2.25 (1.80)	2.25 (1.78)
<i>Beauveria bassiana</i> (1x10 ⁸ spores/gm)	5	2.30 (1.87)	2.27 (1.80)	2.23 (1.87)
<i>Metarhizium anisopliae</i> (1x10 ⁸ spores/gm)	5	2.30 (1.88)	2.29 (1.81)	2.31 (1.83)
Thiamethoxam 25 WG	0.2	1.82 (1.69)	1.97 (1.72)	1.88 (1.82)
Control	-	2.38 (1.90)	2.29 (1.82)	2.39 (1.84)
CD at 5%		NS	NS	NS

**Fig 2:** Mean of natural enemies**Table 3:** Grain yield of Swarna paddy as influence by different treatment during kharif 2023

S. No.	Treatments	Dosage g/l	Grain yield kg/ha	Grain yield of paddy (q/ha)	Grain yield kg/plot	Increase in yield over control (%)
1	<i>Lecanillium saksenae</i> (1x10 ⁸ spores/gm)	5	3850	38.50 (6.10)	7.70	45.08
2	<i>Beauveria bassiana</i> (1x10 ⁸ spores/gm)	5	4676	46.76 (6.21)	9.35	76.54
3	<i>Metarhizium anisopliae</i> (1x10 ⁸ spores/gm)	5	4900	49.00 (6.32)	9.80	86.59
4	Thiamethoxam 25 WG	0.2	5157	51.57 (6.38)	10.31	94.93
5	Control	-	2666	26.66 (5.49)	5.33	-
6	CD at 5%			0.20		

Figure in parentheses are square root transformed values, G=gram, L=litre CD-critical differences

**Fig 3:** Effect of entomopathogens on grain yield of rice

5. Conclusion

Overall performance of various microbial treatments based on mean hopper population data revealed that, the treatment with thiamethoxam 25 WG, *Metarhizium anisopliae* with 1×10^8 spore/gm was the most consistently effective and significantly superior over all other fungal treatments throughout the trial followed by *B. bassiana* 1×10^8 spore/gm and *Lecanicillium saksnae* 1×10^8 spore/gm reducing the hoppers population. *Metarhizium anisopliae* is superior to *Beauveria bassiana* and *Lecanicillium saksnae* on 5 DAS and 10 DAS, whereas *Metarhizium anisopliae* recorded a 60-65 percent reduction in the survival population. The results obtained from the study clearly revealed that the efficacy of *Metarhizium anisopliae*, *Beauveria bassiana*, and *Lecanicillium saksnae* increased with an increase in the number of days after spray and reached the highest efficacy on 10 DAS in each spray.

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