AATCC Review

29 June 2024: Received
02 August 2024: Revised
07 September 2024: Accepted
09 October 2024: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Natural Incidence of Entomopathogenic Fungus *Metarhizium rileyi* (Farlow) Kepler S.A. Rehner & Humber (Ascomycetes: Hypocreales) in the Scarce Rainfall Zones of Andhra Pradesh

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ABSTRACT

Metarhizium rileyi (Farlow) Kepler S.A. Rehner & Humber, an entomopathogenic fungus of Lepidoptera, targets many noctuids, which are key pests of agricultural crops. Since indigenous isolates of entomopathogenic fungi are more likely to survive and endure and are better suited to the local climate, employing them to control insect pests is an efficient way to fight pesticide resistance and resurgence. In order to identify and isolate native fungal isolates, a survey was carried out in a number of locations inside Andhra Pradesh's Scarce Rainfall Zone (SRZ). Insect cadavers were collected for this purpose. The surveys were carried out from October to January 2021-2022 and October to December 2022, during which infected larvae samples were collected from various locations including Kurnool, Anantapur, Prakasam, Kadapa, and Chittoor. The crops surveyed for mummified caterpillars included groundnut, greengram, redgram, tomato, castor, blackgram, rice, onion, chili, soybean, cowpea, and maize. The pests observed during the survey were Spodoptera frugiperda, Spodoptera litura, Helicoverpa armigera, and Aproarema modicella. Most M. rileyi infected cadavers were found in pulse crop infested insects, while no mummified larval cadavers were found in other crops such as brinjal, okra, tomato, cotton, rice, cauliflower, cabbage, and chili. Cadavers from various sites were collected separately in sterilized vials or polythene bags and brought to the laboratory. The average maximum and minimum temperatures reported in the Andhra Pradesh SRZ during the survey period were 29-36°C and 14-28°C, respectively. Rainfall varied from 59.40 to 302.00 mm, while the average relative humidity in the morning and evening was 49-77% and 81-100%, respectively.

Keywords: *Metarhizium rileyi; Scarce Rainfall Zone; Survey; Cadaver; Entomopathogenic fungi; Indigenous isolate*

Introduction

Biological control is an environmentally friendly option for managing important pathogens, and *Metarhizium rileyi* (Farlow) Kepler S.A. Rehner & Humber (Ascomycetes: Hypocreales), previously known as *Nomuraea rileyi* Farlow [7], exemplifies this approach. This fungus can regulate caterpillar populations in various crops. *M. rileyi* is a cosmopolitan species that can infect numerous noctuids such as *Spodoptera frugiperda* (J.E. Smith), *Spodoptera litura* (Fabricius), *Helicoverpa armigera* (Hübner), *Trichoplusia ni* (Hübner), *Anticarsia gemmatalis* (Hübner), and *Pseudoplusia* sp. [13]. This microorganism is distributed across wide agroecosystems and frequently induces natural epizootics in many Lepidopteran species [18].

Entomopathogenic fungi (EPF) are important natural regulators of insect populations and have potential as mycoinsecticidal agents against diverse agricultural pests. These fungi are universally distributed across several ecological niches, including air, water, phylloplane, soil, and infected insects. On the other hand, the infections caused by a number of EPF in living hosts are only temporary during their life cycle. For the remainder of the life cycle, these species presumably remain dormant as conidia in the soil near the dead host cadaver.

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DOI: https://doi.org/10.21276/AATCCReview.2024.12.04.11

Limited saprobic growth is sometimes possible using resources contained in the host cadaver. The dead host cadavers typically fall to the ground, creating a reservoir of fungal material in the soil environment. Further dispersal from cadavers likely occurs due to weather (rain and wind), soil manipulation, and insect activity [12]. The conidia that are generated on the surface of deceased host cadavers have a considerable lifespan. It is generally believed that most EPF of the Hypocreales can disperse from sporulating cadavers [9,19], as infections in migrating insect hosts [2], or by infectious conidia in wind currents [5]. However, the passively dispersed conidia must eventually be deposited, and one likely sink for these propagules would be aerial plant surfaces such as phylloplanes. The regenerating capacity of EPF greatly reduces their frequency of application, resulting in lower costs and higher efficiency compared to chemical insecticides [4].

The significance of surveys is that natural enemies identified could become part of a backup plan to be utilized if pest populations assume serious proportions [21]. Epizootics of *M. rileyi* under natural conditions have been reported in the SRZ of Andhra Pradesh on *H. armigera* [11,16,22], *S. frugiperda* [14], and *S. litura* [17] in various crops such as groundnut, castor, pigeonpea, soybean, maize, and cotton. Surveys of naturally occurring fungal biodiversity in a specific region can provide a pool of potential biological control agents for pest control purposes [15]. Additionally, exotic strains of EPF developed for use as pest control agents in different countries could be ineffective due to strain and environmental differences[8]. Previous studies revealed marked variability among isolates of various EPF collected from different geographical locations and

their efficacy against insect pests [23]. Controlling insect pests using indigenous strains of EPF is an effective method to combat insecticide resistance and resurgence, as these local isolates have a higher chance of survival and persistence with better adaptability to local climatic conditions. Consequently, a survey was conducted at a number of areas inside Andhra Pradesh's Scarce Rainfall Zone (SRZ) in order to isolate and identify the native fungal isolates.

Materials and Methods

Survey and Sample Collection

M. rileyi was collected by a roving survey in the SRZ of Andhra Pradesh from lepidopteran caterpillars in the field and horticultural crops. The survey was carried out twice: from October to January 2021-2022 and from October to December 2022. The districts covered included Kurnool, Anantapur, Prakasam, Kadapa, and Chittoor.

In each selected district, villages were chosen for the survey. Cadavers of lepidopteran caterpillars infested with *M. rileyi* were found in each village's main fields and horticultural crops. Among the villages, sampling fields were chosen at random. Dead corpses attached to leaves or any other plant portion exhibiting external signs of mycosis were collected using a fine brush and placed into sterilized plastic vials as suggested by [14]. After collecting the entomopathogenic fungal cadavers, the vials were wrapped with parafilm and labeled with details including the date of collection, village, crop, district, insect cadaver, and zone. Five randomly chosen spots within the field were used to count the number of insect cadavers per square meter. In Redgram, one meter of row length was taken for observations of *M. rileyi* infected larvae [11]. As recommended by, collected samples were individually placed on wet filter paper in Petri dishes to promote fungal growth. The samples were then incubated at 28 ± 2°C with a relative humidity of 45 ± 5% and a photoperiod of 11L:13D. Mummified cadavers with green spores were dried to prevent deterioration and stored in a refrigerator.

Results

During the surveys conducted from October to January 2021-22 and October to December 2022, samples of infected larvae were collected from various locations in the SRZ of Andhra Pradesh, including Kurnool, Anantapur, Prakasam, Kadapa, and Chittoor. The crops surveyed for mummified caterpillars included groundnut, greengram, redgram, tomato, castor, blackgram, rice, onion, chili, soybean, cowpea, and maize. The pests observed during the survey were *S. frugiperda*, *S. litura*, *H. armigera,* and *A. modicella*. No mummified larval cadavers were noticed in other crops like brinjal, okra, tomato, cotton, rice, cauliflower, cabbage, and chili. During the entire survey period, the actual and normal rainfall of SRZ of Andhra Pradesh is mentioned in Tables 6 and 7.

Metarhizium rileyi infected Cadaver

The *M. rileyi* infected larvae were observed to adhere to the husk of cobs, at the tips of cobs, and in the whorls of leaves. The following traits were used to identify the caterpillars infected with *M. rileyi*: the larvae developed into hard, mummified structures with an elevated head and anterior portion of the body that stuck to the leaves and other plant components with their prolegs. With the exception of the head capsule, the entire body of the afflicted caterpillar was coated with white mycelial growth.

The fungus that infected the caterpillars sporulated widely throughout the field, resulting in fine, light green spores covering the whole body of the insects. The dead larval cadavers were hard and brittle (Fig.1).

Scarce rainfall zone of Andhra Pradesh

Kurnool district:

A roving survey was carried out in seven villages of the Kurnool district namely Bilakala Gudur, Gadivemula, Noonepalli, Pirushebpeta, Veldurthi, Ramallakota, and Kapulapalle to investigate the natural occurrence of the EPF, *M. rileyi* on lepidopteran caterpillars (Table 1). The crops surveyed for mummified caterpillars included groundnut, red gram, tomato, castor, greengram, blackgram, cowpea, rice, onion, chili, soybean, and maize. The pests observed during the survey were *S. frugiperda*, *S. litura*, *H. armigera*, and *A. modicella*. The mean number of cadavers per square meter observed during the survey is presented in Table 1. No mummified larval cadavers were noticed in crops like chili, tomato, and onion. During the survey period, the average maximum and minimum temperatures recorded in Kurnool district were 30-33°C and 15.2-24°C, respectively. The average morning and evening relative humidity levels were 56-74% and 82-100%, respectively. The rainfall ranged from 89.25 to 193.41 mm.

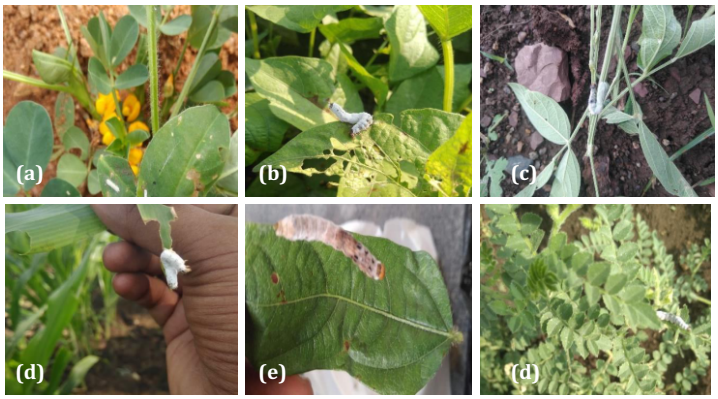

Fig. 1 Metarhizium rileyi infected cadavers on different crops

(a) *Aproaerema modicella* in Groundnut (b) *Helicoverpa armigera* in Greengram (c) *Helicoverpa armigera* in Redgram (d) *Spodoptera frugiperda* in Maize (e) *Spodoptera litura* in Blackgram (f) *Helicoverpa armigera* in Chickpea

Kadapa District

In order to determine the natural occurrence of the entomopathogenic fungus, *M. rileyi* on lepidopteran caterpillars such as *S. litura*, *H. armigera*, *S. frugiperda*, and *A. modicella* in the fields, a roving survey was conducted in seven villages in the Kadapa district: Ramapuram, Peddamuduam, Jangalapalle, Peddapasupula, Akkampeta, Nemmaldinne, and N kottallapalle. The highest mean number of *M. rileyi* infected *H. armigera* (10 cadavers/sq.m) was recorded in the Peddapasupula village in Chickpea crop, while no EPF infected cadavers were found in Chilli, Brinjal, Okra, Cotton and Tomato (Table 2). The average maximum and minimum temperatures recorded in Kadapa district were 29.21-34°C and 17.21-27°C. The average relative humidity in the morning and evening recorded was 49-77% and 81-97%, respectively while the rainfall ranging from 81-250 mm.

Chittoor District

In Chittoor district, a survey for the collection of cadavers was conducted in six villages: Tirupathi, Perumallapalli, Srikalahasti, Ramachandrapuram, Venkatapuram, and Chandragiri.

The *M. rileyi* infected pests recorded during the survey were *S. litura* and *H. armigera* and *A. modicella* in groundnut, *S. frugiperda* in maize, and *S. litura* in greengram and blackgram. No cadavers were found in cabbage and cauliflower cropping ecosystems while maximum occurrence of *M. rileyi* (8.2 cadavers/sq.m) was observed in *S. litura* in Blackgram crop in Tirupathi (Table 3). During the survey period, the average maximum and minimum temperatures recorded in Chittoor district were 29-34°C and 14-24°C, respectively. The average morning and evening relative humidities were 59-71% and 84-100%, respectively. The rainfall received ranged from 56.21 to 302.00 mm.

Anantapur District

The villages surveyed in the Anantapur district included Kapulapalle, Amakathadu, Juturu, Narpala, Bandameeda Palli, and Ravi Venkatam Palli in different crops (Table 4). Field observations focused on the mycosis of *M. rileyi* on larval populations of *A. modicella*, *S. litura*, and *H. armigera* on host plants such as greengram, groundnut, cowpea, and chickpea. The highest mean number of *M. rileyi* infected *A. modicella* (7 cadavers/sq.m) was recorded in Groundnut folded leaves in Amakathadu (Table 4). During the survey period, the average maximum and minimum temperatures recorded in Anantapur district were 31-36°C and 17-28°C, respectively. The average relative humidity during morning and evening was 59-71% and 84-100%, respectively and the rainfall varied from 75 to 220 mm.

Prakasam District

The roving survey was carried out in the Prakasam district of AP in Neredupalli, Kanigiri, Gogala Palli, Agrhaaram, Talluru, and Varimodugu villages (Table 5). to record the natural incidence of *M. rileyi* in different cropping ecosystems. Field observations on mycosis of *M. rileyi* on larval populations of *S. litura* and *H. armigera* on host plants greengram, blackgram, redgram, groundnut, and chickpea were observed. No cadavers were found in Sesame while the maximum occurrence of *M. rileyi* (7 cadavers/sq.m) was observed in *S. litura* in Blackgram crop in Agrhaaram (Table 5). During the survey period, the average maximum and minimum temperatures recorded in Prakasam district were 27.93 -35°C and 14-27°C, respectively. The average morning and evening relative humidities recorded were 55% - 72% and 81-95 %, respectively. Rainfall of 59.40-204 mm was received.

Table 1. Incidence of Metarhizium rileyi on lepidopteran pests of major crops in Kurnool district

Sl. no	Village	Crop	Cadavers of Lepidopteran larvae noticed	Mean no. of cadavers/sq.m
1.	Bilakala gudur	Maize	*Spodoptera frugiperda*	2.2
2.		Greengram	*Spodoptera litura*	5
3.		Blackgram	*Spodoptera litura*	6.4
4.		Soybean	*Helicoverpa armigera*	7
5.		Chilli	*Spodoptera litura*	1
6.		Redgram	*Helicoverpa armigera*	4
7.		Chickpea	*Helicoverpa armigera*	6.8
8.		Rice	Nil	0
9.		Chilli	Nil	0
10.		Cotton	Nil	0
11.	Gadivemula	Greengram	*Helicoverpa armigera*	4.4
12.		Sorghum	*Spodoptera frugiperda*	2
13.		Maize	*Spodoptera frugiperda*	3
14.		Rice	Nil	0
15.		Chilli	Nil	0
16.		Cotton	Nil	0
17.		Pigeonpea	*Helicoverpa armigera*	5.3
18.	Noonepalli	Maize	*Spodoptera frugiperda*	3
19.		Sorghum	*Spodoptera frugiperda*	2
20.		Chickpea	*Helicoverpa armigera*	6.4
21.		Chilli	*Spodoptera litura*	0
22.		Rice	Nil	0
23.		Soybean	*Helicoverpa armigera*	7.2
24.		Tomato	Nil	0
25.	Pirushebpeta	Chickpea	*Helicoverpa armigera*	10
26.		Greengram	*Spodoptera litura*	6.4
27.		Cowpea	*Spodoptera litura*	5.6
28.	Veldurthi	Groundnut	*Aproaerema modicella*	4.2
29.		Castor	*Spodoptera litura*	3
30.		Onion	Nil	
31.	Ramallakota	Groundnut	*Spodoptera litura*	5.2
32.	Kapulapalle	Groundnut	*Spodoptera litura*	4.4
33.		Onion	Nil	0

Table 2. Incidence of Metarhizium rileyi on lepidopteran pests of major crops in Kadapa district

Sl. no	Village	Crop	Cadavers of Lepidopteran larvae noticed	Mean no. of cadavers/sq.m
1.	N kottallapalle	Groundnut	*Spodoptera litura*	5
2.		Chilli	Nill	0
3.		Greengram	*Spodoptera litura*	3
4.		Maize	*Spodoptera frugiperda*	2
5.	Peddamuduam	Chickpea	*Helicoverpa armigera*	4.2
6.		Sorghum	*Spodoptera frugiperda*	3
7.	Akkampeta	Chickpea	*Helicoverpa armigera*	5
8.		Brinjal	Nill	0
9.		Okra	Nill	0
10.	Nemmaldinne	Chickpea	*Helicoverpa armigera*	6.6
11.		Greengram	*Spodoptera litura*	7.2
12.		Cowpea	*Spodoptera litura*	6.8
13.	Peddapasupula	Chickpea	*Helicoverpa armigera*	10
14.		Groundnut	*Helicoverpa armigera*	6
15.		Castor	*Spodoptera litura*	2
16.	Ramapuram	Maize	*Spodoptera frugiperda*	3
17.		Groundnut	*Aproaerema modicella*	7
18.	Jangalapalle	Chickpea	*Helicoverpa armigera*	8
19.		Cotton	Nill	0
20.		Tomato	Nill	0

Table 3. Incidence of Metarhizium rileyi on lepidopteran pests of major crops in Chittoor district

Sl. no	Village	Crop	Cadavers of Lepidopteran larvae noticed	Mean no. of cadavers/sq.m
1.	Tirupathi	Groundnut	*Spodoptera litura*	6.2
2.		Greengram	*Spodoptera litura*	7.5
3.		Blackgram	*Spodoptera litura*	8.2
4.		Maize	*Spodoptera frugiperda*	3.4
5.	*Perumallapalli*	Groundnut	*Aproaerema modicella*	7
6.		Cabbage	Nill	0
7.		Cauliflower	Nill	0
8.		Castor	*Spodoptera litura*	5.4
9.	Srikalahasti	Maize	*Spodoptera frugiperda*	3
10.		Green gram	*Spodoptera litura*	6.6
11.		Groundnut	*Spodoptera litura*	5.2
12.	Ramachandrapuram	Groundnut	*Aproaerema modicella*	5.8
13.	Venkatapuram	Greengram,	*Spodoptera litura*	7
14.		Blackgram	*Spodoptera litura*	7.6
15.		Castor	*Spodoptera litura*	4
16.	Chandragiri	Maize	*Spodoptera frugiperda*	3

Table 4. Incidence of Metarhizium rileyi on lepidopteran pests of major crops in Anantapur district

Sl. no	Village	Crop	Cadavers of Lepidopteran larvae noticed	Mean no. of cadavers/sq.m
1.	Kapulapalle	Greengram	*Spodoptera litura*	4.2
2.		Groundnut	*Aproaerema modicella*	5.6
3.		Cowpea	*Spodoptera litura*	6.3
4.	Amakathadu	Groundnut	*Aproaerema modicella*	7
5.	Juturu	Greengram	*Spodoptera litura*	4.8
6.		Groundnut	*Aproaerema modicella*	6
7.	Narpala	Groundnut	*Spodoptera litura*	4
8.		Greengram	*Spodoptera litura*	6.8
9.	Bandameeda palli	Chickpea	*Helicoverpa armigera*	8
10.	Ravi Venkatam Palli	Green gram	*Spodoptera litura*	5.4
11.		Groundnut	*Spodoptera litura*	4.4
12.		Blackgram	*Spodoptera litura*	6

Table 5. Incidence of Metarhizium rileyi on lepidopteran pests of major crops in Prakasam district

Sl. no	Village	Crop	Cadavers of Lepidopteran larvae noticed	Mean no. of cadavers/ sq.m
1.	Neredupalli	Redgram	*Helicoverpa armigera*	4.8
2.		Blackgram	*Helicoverpa armigera*	6.8
3.		Sesame	Nil	0
4.	Kanigiri	Redgram	*Helicoverpa armigera*	4.4
5.	Gogala palli	Greengram	*Spodoptera litura*	6.2
6.	Agrhaaram	Blackgram	*Spodoptera litura*	7
7.		Sesamum	Nil	0
8.	Talluru	Chickpea	*Helicoverpa armigera*	5.8
9.		Redgram	*Helicoverpa armigera*	3.8
10.	Varimodugu	Redgram	*Helicoverpa armigera*	4.2
11.		Blackgram	*Spodoptera litura*	6
12.		Greengram	*Spodoptera litura*	6.4
13.		Sesame	Nil	0

Table 6. Actual and Normal Rainfall (mm) in Andhra Pradesh (September to December 2021)

Actual and Normal Rainfall (mm)in Andhra Pradesh (September to December 2021)												
Sub-Division	September			October			November			December		
	Actual	Normal	% Depliation	Actual	Normal	% Depliation	Actual	Normal	% Depliation	Actual	Normal	% Depliation
Coastal Andhra Pradesh	236.201	161.701	46.001	98.80	191.30	-48.00	245.30	117.30	109.00	16.50	29.50	-44.00
SRZ	94.80	139.60	-32.00	146.40	129.80	13.00	302.00	70.20	330.00	21.40	23.30	-8.00

Table 7. Actual and Normal Rainfall (mm) in Andhra Pradesh (September to December 2022)

Actual and Normal Rainfall (mm) in Andhra Pradesh (September to December 2022)												
Sub-Division	September			October			November			December		
	Actual	Normal	% Depliation	Actual	Normal	% Depliation	Actual	Normal	% Depliation	Actual	Normal	% Depliation
Coastal Andhra Pradesh	181.30	163.00	11.00	200.60	182.20	10.00	63.00	113.10	-44.00	78.00	27.60	183.00
SRZ	114.60	136.90	-16.00	141.20	132.10	7.00	59.40	78.40	-24.00	87.50	25.90	238.00

Source: Ministry of Earth Sciences, Govt. of India

Discussion

During surveys conducted from October to January 2021-22 and October to December 2022, samples of infected larvae were collected from various locations in the SRZ of Andhra Pradesh. The crops surveyed for mummified caterpillars included groundnut, redgram, tomato, castor, greengram, blackgram, cowpea, rice, onion, chili, soybean, maize, cauliflower, and cabbage. Most of the *M. rileyi* infected cadavers were found in crops with severe infestations of lepidopteran caterpillars such as *S. litura*, *A. modicella*, *H. armigera,* and *S. frugiperda*. No mummified larval cadavers were noticed in crops like brinjal, okra, tomato, cotton, rice, cauliflower, cabbage, and chili. Similar findings were reported by [23], who noted that the EPF *M. rileyi* causes severe natural infections in important lepidopteran pests such as *H. armigera*, *S. litura*, and *Chrysodeixis spp*., which attack several economically important crops. [11] first recorded the infection of *M. rileyi* on *H. armigera* larvae during October in the SRZ of Andhra Pradesh, specifically in Kharif groundnut. [22] reported the incidence of *M. rileyi* infected lepidopteran caterpillars in groundnuts during a survey conducted in January 2010 in the Chittoor district. *M. rileyi* has been shown to cause epizootics in several economically important lepidopterous pests across different crop ecosystems [6]. This EPF infects 60 species of lepidoptera infesting crops such as cotton, sunflower, corn, and soybean [3].

The favorable conditions during the survey period from October to January 2021-22, including good rainfall, resulted in luxuriant crop growth and high humidity in the ecosystem. The average maximum and minimum temperatures reported in the Andhra Pradesh SRZ during this period were 29-36°C and 14-28°C, respectively. Rainfall varied from 59.40 to 302.00 mm, while the average relative humidity in the morning and evening was 49-77% and 81-100%, respectively. These favorable conditions contributed to the infestation of maize by *S. frugiperda* larvae, which were found during this survey. Similar results were reported by [14], who observed EPF cadavers on *S. frugiperda* in maize crops in Noonepalli during the second fortnight of October 2019 in Kurnool, part of the SRZ. The high infestation of fall armyworm (FAW) ranged from 11.02% to 46.88% from the second fortnight of October to the first fortnight of December, with minimum temperatures of 19.63–24.39°C and high relative humidity (90–98%) [25,10]. In Nandyal, similar findings were reported in cotton by [16]. Cotton was heavily infested with *S. litura* during October and November, and *H. armigera* during September and October 2005. *S. litura* infected with *M. rileyi* was first noticed in the second fortnight of October 2005, with the infection gradually increasing to 10% by the end of October. *H. armigera* infested with *M. rileyi* was first observed in September (2%) and the infection gradually increased to 12% in October. During this period, the mean maximum and minimum temperatures and morning and evening relative humidities (RH) recorded ranged between 29.1 to 31.0°C, 22.5 to 22.7°C, 92.1-86.1%, and

75.2-73.7%, respectively. Similar findings were reported by [24] who observed a severe outbreak of *M. rileyi* infection on *S. litura* larvae under favorable weather conditions. High relative humidity (90.8%) and high rainfall (84 mm) with a minimum temperature of 23.67°C were found to be conducive to the natural mycosis of *M. rileyi* on *S. litura*. High humidity and rainfall favor the primary infection of insects by EPF and the subsequent invasion of various tissues, supporting the growth and sporulation of EPF. This leads to the dispersal of propagules onto plant surfaces, which initiates new infections and the progression of mycosis.

In this survey, most *M. rileyi*-infected cadavers were found in pulse crops with infested insects. No mummified larval cadavers were noticed in other crops like brinjal, okra, tomato, cotton, rice, cauliflower, cabbage, and chili. This is likely due to the comparatively lower usage of pesticides in pulse crops compared to crops like cabbage, cauliflower, and chili. Additionally, the prevalence of Bt cotton was attributed to no incidence of *M. rileyi* in cotton. Before the introduction of BT cotton, *M. rileyi* was found to infect cotton pests like *H. armigera* and *S. litura* in non-Bt cotton areas and This was the first report on the natural occurrence of *M. rileyi* on *S. litura* and *H. armigera* in cotton in Nandyal, Kurnool District [17], and Prakasam District [11], which belong to the SRZ of Andhra Pradesh with an average rainfall of less than 750 mm.

Pulse crops may host a significant number of insects susceptible to *M. rileyi*, including larvae of certain moth species. The environment of pulse crops, characterized by humidity and temperature, is conducive to the growth and spread of *M. rileyi*. This fungus thrives in humid conditions, which are common in the microclimate of dense crop foliage. Proper coverage of crops that maintain a favorable microclimate supports the persistence and spread of *M. rileyi*. The fungus can persist in the soil and on plant surfaces, spreading through spores. When susceptible insects come into contact with these spores, they become infected. The lifecycle of the fungus often involves killing the host insect, leading to visible cadavers. Pulse crops naturally attract pests susceptible to *M. rileyi*, increasing the likelihood of infections and subsequent cadaver formation. These crops may also serve as natural reservoirs for *M. rileyi*, leading to repeated infections and visible signs of the fungus's activity, such as infected insect cadavers. In Andhra Pradesh, several reports document the occurrence of *M. rileyi* on various pests. [1,20] observed *M. rileyi* on *S. litura* in groundnut fields. [14] reported *M. rileyi* on blackgram, and [11] recorded *M. rileyi* on *H. armigera* in chickpea and redgram during the rabi season of 2001-02.

The presence of *M. rileyi* and its impact on pest populations can be beneficial for pest control, as it reduces the number of harmful insects in crops. However, it also highlights the complex interactions between crops, pests, and pathogens in agricultural ecosystems.

Conclusion

The survey in the Scarce Rainfall Zone of Andhra Pradesh highlights the effectiveness of the entomopathogenic fungus *M. rileyi* in controlling lepidopteran pests in pulse crops. *M. rileyi* infected cadavers were predominantly found in pulse crops, likely due to lower pesticide use and favorable microclimatic conditions. The fungus's ability to adapt and persist in local agro-climatic conditions makes it a promising biocontrol agent. This study underscores the potential of indigenous fungal isolates in sustainable pest management, reducing reliance on chemical pesticides, and supporting the development of region-specific biopesticides that can effectively control pest populations while minimizing environmental impact.

Conflict of interest

The authors declares no competing interests.

Acknowledgments

The authors are thankful to the Director, ICAR-IARI for providing facilities to carry out the research work. The fellowship received by Rajareddy, G. from ICAR is duly acknowledged.

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