

**Assessment of Insecticide Compatibility with *Metarhizium anisopliae* for Fall Armyworm
(*Spodoptera frugiperda* J.E. Smith) Management in Maize**

Abstract

The fall armyworm (*Spodoptera frugiperda*) is ~~a major maize pest~~ an invasive pest of maize, ~~and while which are kept under control by mostly~~ chemical insecticides ~~are commonly used for control~~. ~~The~~ environmental impact and potential for resistance ~~development due to continuous use of~~ insecticides ~~have has resulted in the driven the~~ search for alternatives ~~for the management of~~ FAW. *Metarhizium anisopliae*, an entomopathogenic fungus (EPF), is a promising biological control agent ~~that has been recorded effective against several lepidopteram pests including *S. frugiperda*.~~ ~~An array of insecticides have been recommended for the management of FAW, while simultaneous studies pertaining to evaluation of EPF are made to target the pest through non chemical approaches. However, The the~~ compatibility between insecticides and the entomopathogenic fungus ~~*Metarhizium M. anisopliae* has not been studied at large. The present study focuses on the compatibility of insecticides with EPF in the management of FAW. was evaluated to determine their impact on fungal growth.~~ Six insecticides, representing different chemical classes, were tested ~~at their field recommended doses~~ for their inhibitory effects on *M. anisopliae* fungal colony growth, at various concentrations (50%, 75%, and recommended concentrations). Mycelial growth inhibition was measured at 7, 14, and 21 days after inoculation (DAI). Results showed that most insecticides exhibited varying degrees of compatibility with *M. anisopliae*, with growth inhibition ranging from 6.25% to 51.88% at 7 DAI. The lowest growth inhibition occurred with ~~Emamectin benzoate 5 SG and Novaluron 5.25 + Emamectin benzoate 0.9 SC, showing minimal suppression of fungal growth. In contrast, Spinetoram 11.7 SC and Thiodicarb 75 WP caused significant inhibition at higher concentrations, with the latter showing up to 51.88% inhibition at 7 DAI. At 14 and 21 DAI, the growth inhibition generally decreased across treatments, with Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC and Emamectin benzoate 5 SG demonstrating the best compatibility. Overall, the results suggest that most insecticides tested were compatible with *M. anisopliae*, with Spinetoram and Thiodicarb being exceptions, particularly at higher concentrations. This study provides valuable insights into selecting insecticide-fungus combinations for integrated pest management.~~

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Keywords: Compatibility, fall armyworm, inhibition, *Metarhizium anisopliae*

Introduction

The battle against agricultural pests in maize crop production is a perpetual struggle for farmers worldwide. Among these pests, the fall armyworm (*Spodoptera frugiperda*) stands out as a formidable adversary, notorious for its rapid spread and devastating impact on maize crop production. In recent years, the fall armyworm has emerged as a significant threat to global food security, causing substantial yield losses and economic hardship for farmers, particularly in regions where maize is a staple crop. Traditional methods of pest control, such as chemical insecticides, have been widely employed to mitigate the damage caused by the fall armyworm. However, the indiscriminate use of chemical pesticides poses environmental risks, disrupts ecological balances, and may lead to the development of resistance in pest populations (Sparks & Nauen, 2015). In this context, the integration of biological control agents, such as entomopathogenic fungi, has garnered increasing attention as a sustainable and environmentally friendly alternative for pest management. Entomopathogenic fungi are capable of infecting and killing a wide range of insect species, including the fall armyworm. Unlike chemical pesticides, which often target specific biochemical pathways in insects, entomopathogenic fungi utilize multiple modes of action, making them less susceptible to resistance development. Moreover, these fungi are biodegradable and pose minimal risk to non-target organisms and the environment. Despite the potential of entomopathogenic fungi in controlling the fall armyworm, their effectiveness can be influenced by various factors, including environmental conditions and interactions with other pest management strategies, such as chemical insecticides. Understanding the compatibility between insecticides and entomopathogenic fungi is crucial for optimizing integrated pest management (IPM) programs and maximizing their efficacy in controlling fall armyworm infestations. Therefore, this study aims to investigate the compatibility of different insecticides commonly used against fall armyworm with entomopathogenic fungi strains. By assessing the impact of insecticide-fungus interactions on the viability and effectiveness of entomopathogenic fungi, this research seeks to provide valuable insights into the development of more sustainable and integrated approaches for fall armyworm management in maize crops.

Materials and Methods

~~It was reported that FAW is gaining resistance to certain insecticides as well as biopesticides. It is essential to enhance the efficacy and effectiveness of biopesticides.~~

In this regard, compatibility studies between entomopathogenic fungi and *Ad-hoc* recommended insecticides were undertaken (Table 1). Compatibility of *Metarhizium anisopliae* with *Ad-hoc* recommended insecticides for fall armyworm management was studied in the under laboratory condition by employing poisoned food technique (Moorhouse *et al.*, 1992). The effect of insecticides on the radial growth and germination of entomopathogenic fungi was evaluated (Table 2). The insecticide concentrations were calculated based on active ingredient (ai) recommended per hectare. The different concentration of insecticides *viz.*, recommended, 75 percent of the recommended concentration (3/4th) and 50 percent of the recommended concentration (1/2) was tested for compatibility with the entomopathogenic fungi.

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Table 1. *Ad-hoc* recommended insecticides for fall armyworm management

Sl. No.	Name of insecticides	Dosage/ ha (ml or gm a.i.)
1)	Chlorantraniliprole 9.3+Lambda-cyhalothrin 4.6ZC	35
2)	Spinetoram 11.7SC	30
3)	Chlorantraniliprole 18.5SC	40
4)	Thiodicarb 75WP	750
5)	Emamectin benzoate 5SG	20
6)	Novaluron 5.25 + Emamectin benzoate 0.9SC	92.25

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Inoculum and Maintenance of Pure Culture of Entomopathogenic Fungi

Inoculum for pure culture of *Metarhizium anisopliae* was obtained by spraying commercial fungal spore products on different larval instars of fall armyworm, which were then incubated for one week. After incubation, the infected larvae, which exhibited mycelial growth, were used to maintain the pure culture. To maintain the culture, PDA medium was sterilized at 15 psi and 121°C for 30 minutes in an autoclave, then poured into sterilized petri-Petri plates and cooled. A loopful of inoculum from the infected larvae was transferred under aseptic conditions to the petri-Petri plates. The plates were incubated at room temperature (26 ± 2°C) for 10 days. The pure culture was sub-cultured for use in subsequent experiments.

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Preparation of test chemical insecticide concentrations

Six insecticides were evaluated by poisoned food technique (Moorhouse *et al.*,1992) in Potato Dextrose Agar (PDA) medium mentioned in Table 2. Five hundred ml of PDA medium was sterilized in individual boiling tubes and the insecticide emulsions of required concentration were incorporated into the melted sterile PDA aseptically, thoroughly mixed, poured into sterile petriplates Petri plates and allowed to solidify under laminar air flow cabinet.

Inoculation of the entomopathogenic fungi to the poisoned PDA media

An agar disc along with mycelium mat of fungi will cored from the periphery of 10 days old colony of fungi by needle and transferred into the centre of the PDA plates which are poisoned by test insecticides. The growth medium (PDA) without insecticide but inoculated with mycelialmycelia disc served as untreated check. The plates were incubated at room temperature for 14 days to allow maximum growth. Each treatment was replicated three times.

Calculation of growth diameter and growth inhibition by the test chemicals

The diameter of growing culture in excess of the plugs in each Petri petri-dish was measured on at 7 days after inoculation (DAI) (when radial growth in the control plate fully covered the medium) and also on 14 and 21 days after inoculation. The data was expressed as diameter of colony growth and percentage growth inhibition of entomopathogenic fungi (Hokkanen and Kotiluoto, 1992). The percent growth inhibition is calculated by using the formula,

$$X = \frac{Y - Z}{Z} \times 100$$

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Where, X, Y, Z stand for percentage of growth inhibition, radial growth of fungus in untreated check and radial growth of fungus in poisoned medium, respectively. The insecticides were classified into evaluation categories of 1- 4 scoring index in *in vitro* toxicity tests (Table 3) according to Hassan's classification scheme (Hassan, 1989). Also test insecticides were classified into evaluation categories of 1 - 4 scoring index of Compatibility (Table 4) according to Jayasing's classification (Jayasing, 2011).

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Table 2. Treatment details of compatibility studies between test insecticides and entomopathogenic fungi

Sl. No.	Treatment details.	Concentration (%)
1	Chlorantraniliprole9.3+Lambda-cyhalothrin4.6ZC(RC)	0.050
2	Chlorantraniliprole9.3+Lambda-cyhalothrin4.6ZC(75%RC)	0.037
3	Chlorantraniliprole9.3+Lambda-cyhalothrin4.6ZC(50%RC)	0.025
4	Spinetoram11.7SC(RC)	0.050
5	Spinetoram11.7SC(75%RC)	0.037
6	Spinetoram11.7SC(50%RC)	0.025
7	Chlorantraniliprole18.5SC(RC)	0.043
8	Chlorantraniliprole18.5SC(75%RC)	0.032
9	Chlorantraniliprole18.5SC(50%RC)	0.021
10	Thiodicarb 75WP(RC)	0.200
11	Thiodicarb 75WP(75%RC)	0.150
12	Thiodicarb 75WP(50%RC)	0.100

13	Emamectinbenzoate5SG(RC)	0.080
14	Emamectinbenzoate 5SG(75%RC)	0.060
15	Emamectinbenzoate 5SG(50%RC)	0.040
16	Novaluron5.25+Emamectinbenzoate 0.9SC(RC)	0.300
17	Novaluron5.25+Emamectin benzoate 0.9SC(75%RC)	0.224
18	Novaluron5.25+Emamectin benzoate 0.9SC(50%RC)	0.150

Table 3. Categories of 1-4 scoring index in invitro toxicity tests according to Hassan's classification scheme (Hassan, 1989)

Score	Definition	Reduction in beneficial capacity
1	Harmless	<50%
2	Slightly harmful	50-79%
3	Moderately harmful	80-90%
4	Harmful	>90%

Table

4. Compatibility ratings for test insecticides were reclassified in evaluation categories of 1-4 scoring index

Sl.No.	Compatibility status	Average reduction in growth
1	Highly compatible	< 20 %
2	Compatible	20-50%
3	Partially compatible	50-80%

4	Incompatible	> 80 %
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Results and Discussion

To understand the extent of compatibility between the insecticides and entomopathogenic fungi, the beneficial fungal growth inhibition was calculated by measuring the diameter of the fungal colony growth. Six insecticides belonging to different groups or classes of insecticides were tested for the compatibility with the common entomopathogenic fungi that affects fall armyworm.

Mycelial growth of *Metarhizium anisopliae* on insecticide treated media and inhibitory growth effect of various insecticides observations at 7 days after inoculation

The compatibility between *Metarhizium anisopliae* and insecticides were showed significant reduction in mycelial growth when compared with the control. The mycelial growth inhibition by the tested insecticides varied from 6.25 to 51.88 per cent and were significant with one another. All the insecticides combined with *Metarhizium anisopliae* were highly compatible and harmless except Chlorantraniliprole 18.5 SC, Thiodicarb 75 WP and Spinetoram 11.7 SC (Table 5).

The lowest colony growth inhibition (6.25 %) and highest colony growth (75 mm) were recorded in case of half the RC of Emamectin benzoate 5 SG, followed by 15.38 percent reduction in growth capacity and 67.5 mm colony growth in case of 3/4th of RC. At RC the insecticides suppressed the fungal colony by 18.75 per cent. The Emamectin benzoate 5% SG showed high compatibility and harmless effect to the *Metarhizium anisopliae*.

Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC showed high compatibility and harmless effect to *Metarhizium anisopliae*. The colony growth of fungus was 73.2, 72.2 and 67.5 mm of mean mycelial growth with 8.5, 9.75 and 15.63 percentage of reduction in growth capacity of fungal colony at different concentrations *i.e.*, 1/2 of RC, 3/4th of RC and RC respectively. Novaluron 5.25 + Emamectin benzoate 0.9 SC showed high compatibility and harmless effect to *Metarhizium anisopliae* irrespective of their concentrations. The better colony growth was observed (70, 72.5 and 67.5 mm) with lesser growth inhibition (12.5, 9.38 and 15.63%) at the various concentrations *i.e.*, 1/2 of RC, 3/4th of RC and full RC respectively. At low concentrations (1/2 of RC and 3/4th of RC) of Chlorantraniliprole 18.5 SC high compatibility and harmless effect were observed, with the 9.38 and 16.75 per

cent suppression of fungal colony over control with the colony growth of 72.5 mm and 66.6 mm respectively. Whereas the same molecule at the RC showed compatibility and harmless effect with 32.5 percent of growth inhibition.

In case of Thiodicarb 75 WP at the low concentrations (1/2 of RC and 3/4th of RC) the fungus was able to grow to a mean growth of 68.8 and 70 mm and showed highly compatible and harmless effect towards the fungus, with a growth inhibitory effect of 14 and 12.5 percent respectively. At RC of insecticide suppresses more *i.e.*, 41.75 percent with lesser mycelial colony growth of 46.6 mm. At full RC the insecticide showed compatible and harmless effect towards the fungus (Table 5).

The highest inhibition of Spinetoram 11.7 SC was observed in case of RC and the mean fungal diameter was 38.5 mm. The insecticide had an inhibitory effect on growth about 51.88 percent, which found to be partially compatible and slightly harmful to the fungus. In case of 3/4th of RC of same molecule the fungal growth was inhibited up to 40.63 percent with a colony growth of 47.5 mm was found to be compatible and harmless (Table 5). At the half of RC, the insecticide was found to be highly compatible and harmless to the fungus *Metarhizium anisopliae* with a mycelial growth of 71 mm and with lesser growth suppression (11.25 %).

Table 5. Effect of insecticides on the growth of entomopathogenic fungus, *Metarhizium anisopliae* at 7 days after inoculation

Sl. No.	Treatments	Growth inhibition (%)			Colony growth (mm)		
		RC	75% of RC	50% of RC	RC	75% of RC	50% of RC
1	Chlorantraniliprole 9.3+ Lambda-cyhalothrin 4.6 ZC	15.63 (23.29)*	9.75 (18.20)	8.50 (16.95)	67.50	72.20	73.20
2	Spinetoram 11.7 SC	51.88 (46.08)	40.63 (39.60)	11.25 (19.60)	38.50	47.50	71.00

3	Chlorantraniliprole 18.5SC	32.50 (34.76)	16.75 (24.16)	9.38 (17.83)	54.00	66.60	72.50
4	Thiodicarb75 WP	41.75 (40.26)	12.50 (20.71)	14.00 (21.98)	46.60	70.00	68.80
5	Emamectinbenzoate5SG	18.75 (25.66)	15.38 (23.09)	6.25 (14.48)	65.00	67.70	75.00
6	Novaluron 5.25 +Emamectinbenzoate0.9SC	16.00 (23.58)	9.75 (18.20)	12.50 (20.71)	67.20	72.20	70.00
7	Control	0.00			80.00		
	Particulars	S.E m ±			CD@1%		
	Insecticides(I)	0.69			2.67		
	Concentration I	0.49			1.89		
	I*C	1.20			4.63		

RC:RecommendedConcentration,*Figuresinparenthesisarearcsintransformedvalues.

Observations at 14 days after inoculation

All the insecticides combined with the entomopathogenic fungus *Metarhiziumanisopliae* showed significant difference with respect to control. Among the tested insecticides at various concentrations showed significant difference with one another. The fungal mycelial growth inhibition ranged from 2.94 to 32.12 per cent. The lowest growth inhibition (2.94 %) was recorded in case of half the RC of Novaluron 5.25 + Emamectin benzoate 0.9 SC, with a mean mycelial colony diameter of 82.5 mm. The molecule showed 5.88 and 11.76 per cent growth inhibition with 80- and 75-mm colony growth at respective concentrations of 3/4th of RC and full RC of Novaluron 5.25 + Emamectin benzoate 0.9 SC (Table 6).

The lowest growth inhibition of 3.53 percent, with 82 mm colony growth were recorded at the half of RC of Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC, whereas in other two concentrations, (3/4th of RC and full RC) the mean mycelial colony growth recorded were 80 and 77.7 mm respectively, with 5.88 and 8.59 per cent of growth inhibition towards the fungus. The insecticide at all concentrations showed high compatibility and harmless effect towards the *Metarhiziumanisopliae*.

Emamectin benzoate 5% SG at two lower concentrations *i.e.*, at 1/2 of RC and 3/4th of RC inhibited the *Metarhiziumanisopliae* fungal colony growth with only 4.71 and 5.88 percentage, followed by 11.76 per cent inhibition in growth at full RC. The mean fungal colony diameter recorded at 1/2 and 3/4th of RC was 81 and 80 mm respectively and in case of RC the mean colony diameter was 75 mm. Emamectin benzoate 5 SG was found to be highly compatible and harmless towards *M. anisopliae*.

Chlorantraniliprole 18.5 SC showed high compatibility and harmless effect at two concentrations *i.e.*, at 1/2 of RC and 3/4th of RC. The insecticide concentration inhibited the beneficial capacity of fungus in a negligible percentage *i.e.*, 7.29 and 17.65% respectively. The insecticide was found to be compatible at the RC by inhibiting the fungal colony growth up to 20.35 per cent. The mean colony growth was 78.8, 70 and 67.7 at the 1/2 of RC, 3/4th of RC and RC respectively (Table 6).

Thiodicarb 75 WP showed 9.65, 14.71 and 23.53 per cent of growth inhibitory effect towards the *M. anisopliae* at the concentrations 1/2 of RC, 3/4th of RC and RC respectively. The colony growth recorded were 76.8, 72.5 and 65 mm respectively. The insecticide concentration showed high compatibility and harmless effect at 1/2 of RC and 3/4th of

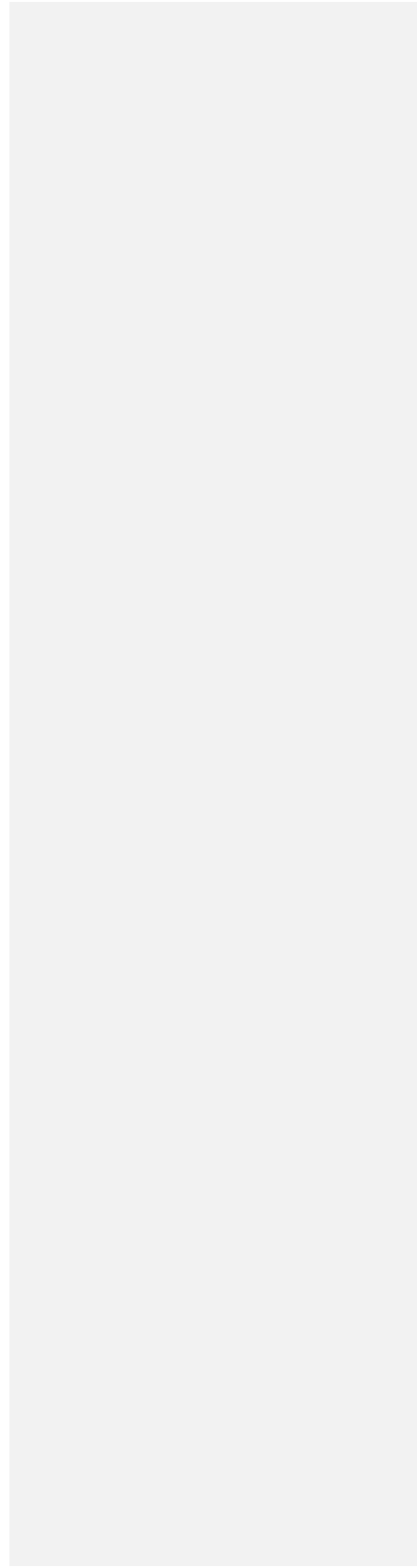
RC, at the RC the insecticide was found to be compatible and harmless.

Table 6. Effect of insecticides on the growth of entomopathogenic fungus, *Metarhizium anisopliae* at 14 days after inoculation

Sl. No.	Treatments	Growth inhibition (%)			Colony growth (mm)		
		RC	75% of RC	50% of RC	RC	75% of RC	50% of RC
1	Chlorantraniliprole 9.3+ Lambda-cyhalothrin 4.6ZC	8.59 (17.04)*	5.88 (14.04)	3.53 (10.83)	77.70	80.00	82.00
2	Spinetoram 11.7SC	32.12 (34.53)	20.59 (26.99)	8.82 (17.28)	57.70	67.50	77.50
3	Chlorantraniliprole 18.5SC	20.35 (26.82)	17.65 (24.84)	7.29 (15.67)	67.70	70.00	78.80
4	Thiodicarb 75 WP	23.53 (29.02)	14.71 (22.55)	9.65 (18.1)	65.00	72.50	76.80
5	Emamectin benzoate 5SG	11.76 (20.06)	5.88 (14.04)	4.71 (12.53)	75.00	80.00	81.00
6	Novaluron 5.25 +Emamectin benzoate 0.9SC	11.76 (20.06)	5.88 (14.04)	2.94 (9.88)	75.00	80.00	82.50
7	Control	0.00			85.00		
	Particulars	S.E m ±			CD@1%		
	Insecticides (I)	0.55			2.13		
	Concentration I	0.39			1.50		
	I*C	0.96			3.68		

RC: Recommended Concentration, * Figures in parenthesis are arcsin transformed values.

UNDER PEER REVIEW



At 14 days after inoculation the highest growth inhibition was recorded in case of Spinetoram 11.7 SC. At RC of insecticide, there was 32.12 percent reduction in growth capacity of *M. anisopliae* and contributed the growth of 57.7mm. At 3/4th of RC the growth inhibition was reduced to 20.59 percentage. Spinetoram 11.7 SC showed compatible and harmless effect against *M. anisopliae* while 1/2 of RC showed high compatibility and harmless effect with only 8.82 percent reduction in growth capacity of fungus. The colony growth record were 77.5, 67.5 and 57.7 mm at the concentrations 1/2 of RC, 3/4th of RC and full RC respectively (Table 6).

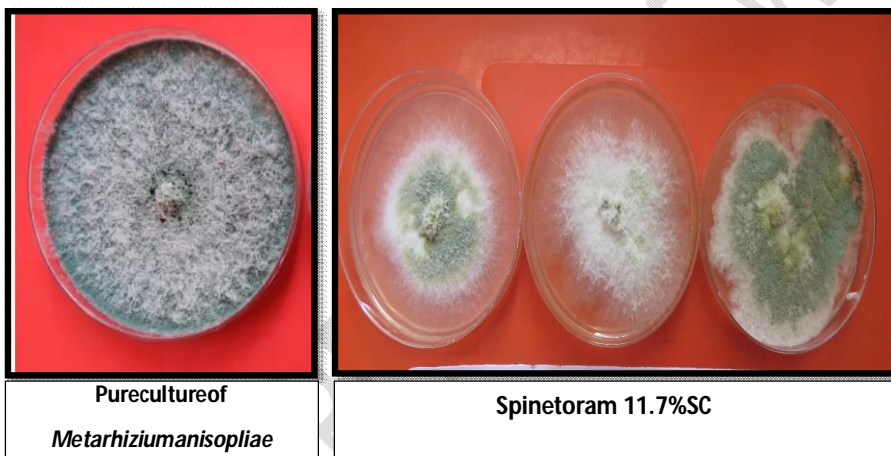
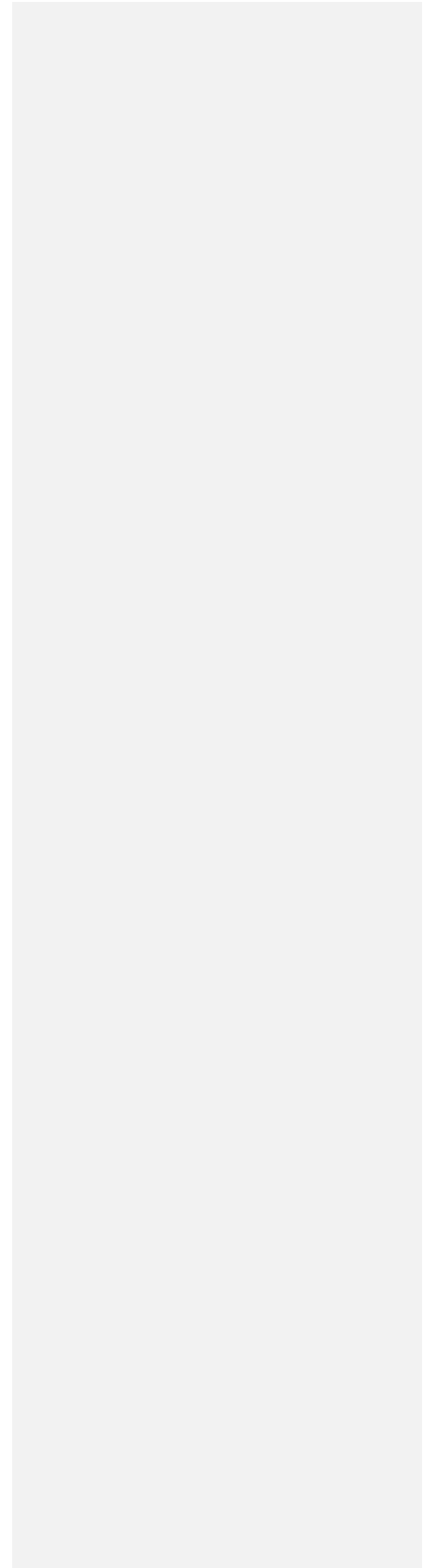


Plate1. Compatibility of *Metarhiziumanisopliae* with different test insecticides at various concentrations

UNDER PEER REVIEW



Observations at 21 days after inoculation

All the insecticide concentrations when combined with *M. anisopliae* were found to be significant in relation to the control. The growth inhibition by the insecticides varied from 0.71 to 20 percent and all the treatments were significant among one another. The lowest growth inhibition (0.71%) with highest colony growth found to be 84.4 mm was observed at 1/2 of RC of Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC. Whereas maximum growth inhibition (20%) with smallest colony growth (68 mm) was observed in RC of Thiodicarb 75 WP (Table 7). At the 21 days after inoculation all the test insecticides show highly compatible and harmless effect towards the fungus *M. anisopliae*.

The insecticide Chlorantraniliprole 9.3 + Lambda-cyhalothrin 4.6 ZC recorded least growth inhibition of 0.71 per cent and promoted the colony growth of 84.4 mm at 1/2 of RC. There was a 3.29 percent growth inhibition with a mean colony growth of 82.2 mm at 3/4th of RC, but at RC of insecticide the fungal colony grew up to 80 mm with 5.88 percent inhibitory effect on the growth capacity was recorded.

The fungal colony grew to a mean diameter of 83.8 mm, with negligible growth inhibition of 1.41 percent was recorded in case of 1/2 of RC of Novaluron 5.25 + Emamectin benzoate 0.9 SC. At high concentrations *i.e.*, 3/4th of RC and RC, 3.29 and 8.24 percent inhibition in growth capacity of *M. anisopliae* respectively, was recorded with the mean colony growth of 82.2 and 78 mm.

Emamectin benzoate 5 SG recorded 4.71 per cent growth inhibition and promoted growth of about 81 mm in diameter at 1/2 of RC. At 3/4th of RC, the fungal colony was able to grow to a mean size of 82 mm, with the 3.53 per cent inhibitory effect. At RC, the insecticide suppressed the growth up to 8.82 per cent, and promoted colony growth to a mean diameter of 77.5 mm.

Chlorantraniliprole 18.5 SC recorded an inhibition of 5.88, 11.76 and 17.65 percent of growth capacity of entomopathogenic fungus, *M. anisopliae* respectively with a colony growth of 80, 75 and 70 mm at the respective concentrations of insecticides *i.e.*, 1/2 of RC, 3/4th of RC and full of the RC (Table 7).

There was 7.29, 11.06 and 17.65 percent of fungal growth inhibition were recorded with a colony growth of 78.8, 75.6 and 70 mm at the respective concentrations *i.e.*, 1/2 of RC, 3/4th of RC and full of the insecticide Spinetoram 11.7 SC.

At 21 days after inoculation the high percentage of fungal growth inhibition (20%) with a colony growth

of (68 mm) were recorded in case of Thiodicarb 75 WP, at the RC. At the other respective concentration of 1/2 of RC and 3/4th of RC the growth inhibition recorded were 11.18 and 16.47 per cent with the colony growth of 75.5 and 70 mm respectively (Table 7).

All the insecticides showed best results with the *Metarhizium anisopliae* except full recommended concentration of Spinetoram 11.7 SC and Thiodicarb 75 WP, all the other chemicals showed compatible relationship with the *Metarhizium anisopliae* (Table 8). This may be due to the inherent variability in the chemical insecticides on the suppression of entomopathogenic fungal growth capacity (Rajeshwari *et al.*, 2020). In the present study, the highest growth inhibition towards the *Metarhizium anisopliae* was observed in case of Spinetoram 11.7 SC and Thiodicarb 75 WP. The results obtained are in agreement with the earlier reports by Rachappa *et al.* (2007). They reported that collectively carbamate group of insecticides inhibits the *Metarhizium anisopliae* by 45.45%, wherein the Thiodicarb showed comparatively detrimental effect towards the mycopathogen by inhibiting 53.5 percent. Similar results were recorded by Ali *et al.*, (2007) who reported that Lorsban was the most toxic insecticide to mycelial growth and conidial germination followed by Lannate, Larvin and Pirate. At the same time, Cascade, Match, Steward and Proclaim were comparatively less toxic to mycelial growth (36.78-48.67% inhibition) and conidial germination (40.32-49.97% inhibition) of the fungal pathogen.

Table 7. Effect of insecticides on the growth of entomopathogenic fungus, *Metarhizium anisopliae* at 21 days after inoculation

Sl. No.	Treatments	Growth inhibition (%)			Colony growth (mm)		
		RC	75% of RC	50% of RC	RC	75% of RC	50% of RC
1	Chlorantraniliprole 9.3+ Lambda-cyhalothrin 4.6 ZC	5.88 (14.04)*	3.29 (10.46)	0.71 (4.82)	80.00	82.20	84.40
2	Spinetoram 11.7 SC	17.65 (24.84)	11.06 (19.43)	7.29 (15.67)	70.00	75.60	78.80
3	Chlorantraniliprole 18.5 SC	17.65 (24.84)	11.76 (20.06)	5.88 (14.04)	70.00	75.00	80.00
4	Thiodicarb 75 WP	20.00 (26.57)	16.47 (23.95)	11.18 (19.53)	68.00	71.00	75.50
5	Emamectin benzoate 5 SG	8.82 (17.28)	3.53 (10.83)	4.71 (12.53)	77.50	82.00	81.00
6	Novaluron 5.25 + Emamectin benzoate 0.9 SC	8.24 (16.68)	3.29 (10.46)	1.41 (6.82)	78.00	82.20	83.80
7	Control	0.00			85.00		
	Particulars	S.E m ±			CD@1%		
	Insecticides (I)	0.49			1.88		
	Concentration I	0.34			1.33		
	I*C	0.84			3.25		

RC: Recommended Concentration, * Figures in parenthesis are arcsin transformed values.

Table 8. Mean effect of insecticides on growth inhibition of *Metarhiziumanisopliae* at weekly intervals

Sl. No.	Insecticides	Mean growth inhibition(%)		
		7DAI	14DAI	21DAI
1	Chlorantraniliprole9.3+Lambda-cyhalothrin 4.6 ZC	11.29	6.00	3.29
2	Spinetoram1 1.7SC	34.58	20.51	12.00
3	Chlorantraniliprole18.5SC	19.54	15.10	11.76
4	Thiodicarb75 WP	22.75	15.96	15.88
5	Emamectinbenzoate5SG	13.46	7.45	5.69
6	Novaluron5.25+Emamectinbenzoate 0.9SC	12.75	6.86	4.31

DAI:Daysafterincubation.

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