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COMPATIBILITY OF *BEAUVERIA BASSIANA* (BALSAMO) VUILLEMIN WITH DIFFERENT INSECTICIDES

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ABSTRACT

The present investigation entitled "Compatibility of *Beauveria bassiana* (Balsamo) Vuillemin with different insecticide" was carried out at Department of Entomology, C. P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar during 2023-24. The compatibility between entomopathogenic fungus and chemical insecticides were tested individually in laboratory. Nine insecticides were evaluated to check the effect on the growth inhibition of *B. bassiana* at three different doses 25 per cent lower than recommended (0.75 × RD), recommended (1 × RD) and 25 per cent higher than recommended (1.25 × RD) by poison food technique. The results showed that the insecticide emamectin benzoate 5 SG 0.0007 % and chlorantraniliprole 18.5 SC 0.006 % with 16.74 and 17.55 per cent growth inhibition (74.93 and 74.32 mm radial growth) were found to be the most compatible with *B. bassiana*, as it was categorized as harmless (Grade 1) to *B. bassiana*. However, chlorantraniliprole 18.5 SC and chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC were relatively harmless (Grade 1) at all the three doses. Highest per cent growth inhibition of fungus was recorded in profenofos 50 EC at all doses.

***Ke ywords*: Biopesticide, insecticide, compatibility, Entomopathogenic fungi, *Beauveria bassiana* (Balsamo) Vuillemin, chlorantraniliprole, *H. armigera*.

Introduction

Insect pest has loud detrimental effect on agriculture. Agriculture production become scanty from last many years due to insect pest attack. Every year 30 to 35 per cent agriculture yield gets wasted because of insect pests (Anon., 2017). According to states/Union territories zonal conferences on inputs (Plant protection) for *Rabi* and *Kharif* seasons, consumption of chemical pesticides and bio-pesticides in India are 58720 MT and 8898.92 MT, respectively in 2021-22 (Anon., 2022).

Biopesticides currently account for 5 per cent of the pesticide industry in India, with at least fifteen microbial species and 970 microbial formulations registered with the Central Insecticides Board and Registration Committee (CIBRC) (Rana and Tyagi, 2022). As many as 52 species of insect pests are recorded infesting different crop in India. (Singh *et al.*, 1990). Among them *H. armigera* and *S. litura* are important pest infesting the cotton and groundnut. Preference of insecticides depends on their easy availability and applicability, but their excessive and indiscriminate use has resulted in the development of insecticidal resistance in the pests and environmental pollution (Phokela *et al.*, 1990). There is a need to explore alternatives, encompassing available pest control methods and techniques to reduce the sole dependence on insecticides. Among such eco- friendly approaches, entomopathogenic fungi form one of the most important components which are being employed to control noxious insect pest of groundnut ecosystem *viz.*, *H. armigera* and *S. litura*. Among several entomopathogenic fungi, *B. bassiana* is the most important entomopathogenic fungus for its control as well as reducing the chances of development of resistance against *H. armigera* and *S. litura*.

In vitro studies indicated that inhibition of *B. bassiana* by many pesticides (Olmert and Kenneth, 1974). Todorova *et al.*, (1998) reinforced the importance of pesticides influence on conidial germination, vegetative growth and sporulation of fungus and some are compatible with fungus. It has been reported that applications of insecticides have enhanced or decreased the efficiency of the entomopathogenic fungi against insect pests (Dayakar *et al*., 2000; Serebrov *et al*., 2005; Purwar and Sachan, 2006). Therefore, in pest management programme selection of microbial biocontrol agent should be compatible to insecticides (Amjad *et al*., 2012). Thus, the knowledge of the compatibility between fungi and pesticides is important (Neves *et al*., 2001). Combined utilization of selective insecticides with fungal pathogens can be employed in integrated pest management programme which will reduce the amount of applied insecticides, minimize environmental hazards and pest resistance (Moino and Alves, 1998; Quintela and McCoy, 1998). For some products, the combination treatments showed higher dose mortality response than the sole treatments of fungal conidia (Purwar and Sachan, 2006).

Materials and Methods

The laboratory experiment was conducted at bio-control laboratory, Department of Entomology, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during 2023-24. The insecticides selected for compatibility study were commonly used for pest management. The effect of these insecticides on the growth inhibition of *B. bassiana* was evaluated. The insecticides dose was calculated on the basis of 25 per cent lower (0.75 × RD), recommended (1 × RD) and 25 per cent higher (1.25 × RD) for field application rate. Nine insecticides belonging to different chemical groups were tested for their efficacy *in vitro* against *B. bassiana* using poisoned food technique described by Dhingra and Sinclair (1985).

The required quantity of each test insecticide was incorporated in a conical flask containing 100 ml molten PDA. The flask containing insecticidal poisoned material was well shaken to facilitate uniform mixture of insecticides and 20 ml was poured in each sterilized Petri plates. On solidification of the media, the plates were inoculated in the centre by placing 5 mm diameter mycelial culture block cut aseptically with the help of cork borer from 10 days old actively growing pure culture of *B. bassiana* grown on potato dextrose agar media. Growth media (PDA) without insecticide but inoculated with circular disc of *B. bassiana* served as untreated check. The inoculated plates were incubated at 27 ± 2°C temperature. Each plate was examined for radial growth.

Radial growth (colony diameter) of the entomogenous fungus was recorded when full growth obtained with control (15^{th} day of inoculation). The per cent inhibition in radial growth over control was calculated as per the following equation given by Bliss (1934), and statistical analysis was done by angular transformation.

$$I = \frac{C - T}{C} \times 100$$

Where,

I = Per cent inhibition

C = Colony diameter of control plate

T = Colony diameter of treated plate

The growth inhibition percentage of the fungus obtained from each treatment further classified into different categories based on Hassan's classification scheme (Hassan, 1989).

Results and Discussion

Compatibility of *B. bassiana* with different insecticides

The compatibility between entomopathogenic fungus and chemical insecticides were tested individually in laboratory. Nine insecticides were evaluated to check the effect on the growth inhibition of *B. bassiana* at three different doses 25 per cent lower than recommended (0.75 × RD), recommended (1 × RD) and 25 per cent higher than recommended (1.25 × RD). The optimum combined use of fungi and chemicals may be required for long term pest management. Thus, compatibility of *B. bassiana* with commonly used insecticides against *H. armigera* tested under laboratory condition and the results are described in Table 1 to 3.

Compatibility at lower dose (0.75 × RD)

The data on influence of selected chemical insecticides at lower dose (0.75 × RD) on radial growth of the *B. bassiana* are presented in Table 1. The results showed that increase in the concentration of the chemical insecticides decreased the radial growth of the *B. bassiana*. Highest radial growth was recorded in emamectin benzoate 5 SG and chlorantraniliprole 18.5 SC with average 74.93 and 74.19 mm, as compared to rest of treatments. The radial growth of chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC was 70.82 mm and it was at par with thiomethoxam 12.6 + lambda cyhalothrin 9.5 ZC which recorded 68.60 mm and it was followed by flubendiamide 20 WG, *azadirachtin* 1500 ppm, lambda cyhalothrin 5 EC, profenofos 50 EC which recorded 62.54, 59.13, 58.51 and 13.02 mm average radial growth, respectively. The untreated check recorded 89.55 mm radial growth.

The results on the effect of different insecticides tested

Table 1: Effect of different insecticides on the growth of *B. bassiana* at 25 per cent lower than recommended dose (0.75 × RD).

Sr. No.	Treatments	Conc. (%)	Dose (g or ml /litre)	Colony diameter (mm)	Growth inhibition (%)	Grade *
1.	Profenofos 50 EC	0.075	1.50 ml	21.15^{f}(13.02)	67.64^{a}(85.53)	2
2.	Lambda cyhalothrin 5 EC	0.0037	0.75 ml	49.90^{e}(58.51)	36.26^{b}(34.99)	1
3.	Azadirachtin 1500 ppm	0.0005	3.75 ml	50.26^{e}(59.13)	35.85^{bc}(34.30)	1
4.	Emamectin benzoate 5 SG	0.0007	0.225 g	59.95^{b}(74.93)	24.15^{e}(16.74)	1
5.	Chlorantraniliprole18.5 SC	0.0058	0.24 ml	59.46^{b}(74.19)	24.77^{e}(17.55)	1
6.	Profenofos 40 + Cypermethrin 4 EC	0.107	1.875 ml	21.35^{f}(13.26)	67.43^{a}(85.27)	2
7.	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.0056	0.39 ml	57.30^{c}(70.82)	27.49^{d}(21.31)	1
8.	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5 ZC	0.020	0.877 ml	55.92^{c}(68.60)	29.18^{d}(23.77)	1
9.	Flubendiamide 20 WG	0.0075	0.375 g	52.26^{d}(62.54)	33.53^{c}(30.50)	1
10.	Control	-	-	71.14^{a}(89.55)	4.05^{f}(0.50)	-
	S.Em. ±	-	-	0.73	0.82	
	C.D. at 5 %	-	-	2.15	2.43	
	C.V. %	-	-	2.53	4.07	

Figures in parenthesis are retransformed values of angular transformation
Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
Grades*: 1 = harmless (<50% reduction in beneficial capacity), 2 = slightly harmful (50-79%), 3 = moderately harmful (80-90%), 4 = harmful (>90%)

against *B. bassiana* at 25 per cent lower than recommended dose revealed that almost all insecticides were significantly inhibited fungal development. The data on per cent growth inhibition are presented in Table 1 and illustrated in Fig. 1 indicated that emamectin benzoate 5 SG 0.0007 % showed significantly lowest (16.74 per cent) growth inhibition of *B. bassiana* at lower dose. It was at par with chlorantraniliprole 18.5 SC 0.0058% which recorded only 17.55 per cent radial inhibition, followed by chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC 0.0056 % (21.31 per cent) which was at par with thiomethoxam 12.6 + lambda cyhalothrin 9.5 ZC 0.020 % as it inhibited 23.77 per cent growth of *B. bassiana*.

The treatments of flubendiamide 20 WG 0.0075 % (30.50 per cent), azadirachtin 1500 ppm 0.0005 % (34.30 per cent) and lambda cyhalothrin 5 EC 0.0037 % (34.99 per cent) exhibited moderate growth inhibition of *B. bassiana*. The highest (85.53 per cent) growth inhibition was recorded in profenofos 50 EC 0.075 % which was at par with profenofos 40 + cypermethrin 4 EC 0.107 % (85.27 per cent).

The above results indicated that among the insecticides tested, emamectin benzoate, chlorantraniliprole, chlorantraniliprole + lambda cyhalothrin, thiomethoxam + lambda cyhalothrin, flubendiamide, *azadirachtin*, lambda cyhalothrin were relatively harmless (Grade 1) to *B. bassiana* as they showed less than 50 per cent growth inhibition at lower dose. Two insecticides (profenofos and profenofos + cypermethrin) were slightly harmful (Grade 2) to *B. bassiana*.

Compatibility at recommended dose (1 × RD)

A significant radial growth reduction of *B. bassiana* was seen in all tested insecticides doses and their impact was dependent on dose (Table 2).

The radial growth at recommended dose of chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC was 73.80 mm at par with chlorantraniliprole 18.5 SC which recorded 74.32 mm radial growth over untreated check which recorded 89.60 mm. Thiomethoxam 12.6 + lambda cyhalothrin 9.5 ZC recorded 60.20 mm radial growth which was at par with flubendiamide 20 WG, which recorded 59.71 mm radial growth (Fig. 2). The radial growth of emamectin benzoate 5 SG, azadirachtin 1500 ppm, lambda cyhalothrin 5 EC, profenofos 40 + cypermethrin 4 EC and profenofos 50 EC were recorded 45.86, 43.76, 15.66, 11.66 and 6.87 mm, respectively.

The results on the compatibility of different

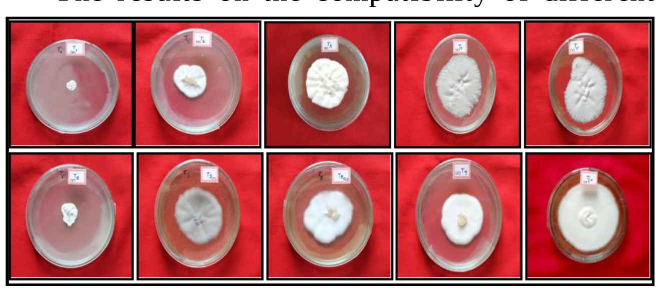

Fig. 1: *In vitro* compatibility of *B. bassiana* with chemical insecticides at lower dose (0.75 ×RD).

Table 2: Effect of different insecticides on the growth of *B. bassiana* at recommended dose (1 × RD).

Sr. No.	Treatments	Conc. (%)	Dose (g or ml /litre)	Colony diameter (mm)	Growth inhibition (%)	Grade *
1.	Profenofos 50 EC	0.1	2.00 ml	15.20[g](6.87)	73.98[a](92.38)	4
2.	Lambda cyhalothrin 5 EC	0.005	1.00 ml	23.31[e](15.66)	65.35[c](82.60)	3
3.	Azadirachtin 1500 ppm	0.0007	5.00 ml	41.41[d](43.76)	45.79[d](51.37)	2
4.	Emamectin benzoate 5 SG	0.001	0.3 g	42.63[d](45.86)	44.44[d](49.02)	1
5.	Chlorantraniliprole18.5 SC	0.006	0.32 ml	59.55[b](74.32)	24.66[f](17.40)	1
6.	Profenofos 40 + Cypermethrin 4 EC	0.11	2.5 ml	19.96[f](11.66)	68.92[b](87.06)	3
7.	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.0075	0.53 ml	59.21[b](73.80)	25.07[f](17.96)	1
8.	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5 ZC	0.026	1.17 ml	50.89[c](60.20)	35.13[e](33.11)	1
9.	Flubendiamide 20 WG	0.01	0.5 g	50.60[c](59.71)	35.44[e](33.63)	1
10.	Control	-	-	71.79[a](89.60)	4.05[g](0.50)	-
	S.Em. ±	-	-	0.94	1.07	
	C.D. at 5 %	-	-	2.78	3.14	
	C.V. %	-	-	3.76	4.36	

Figures in parenthesis are retransformed values of angular transformation
Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
Grades*: 1 = harmless (<50% reduction in beneficial capacity), 2 = slightly harmful (50-79%), 3 = moderately harmful (80-90%), 4 = harmful (>90%)

insecticides with *B. bassiana* at recommended dose revealed that almost all insecticides studied significantly inhibited fungal development. The effect of insecticides on the growth of *B. bassiana* at recommended dose is shown in Table 2 and Plate II. The results clearly indicated that the lowest growth inhibition (17.40 per cent) was observed due to chlorantraniliprole 18.5 SC 0.006 % followed by chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC 0.0075 % (17.96 per cent). The insecticides thiomethoxam 12.6 + lambda cyhalothrin 9.5 ZC 0.026% (33.11 per cent) and flubendiamide 20 WG 0.01 % (33.63 per cent) were found next in order to inhibit the growth of *B. bassiana*. Emamectin benzoate 5 SG 0.001% (49.02 per cent) and *azadirachtin* 1500 ppm 0.0007% (51.37 per cent) were moderately affected the growth of the fungus.

The results showed that profenofos 50 EC 0.1 % caused the highest reduction in mycelial growth of *B. bassiana* with 92.38 per cent inhibition, which was followed by profenofos 40 + cypermethrin 4 EC 0.11 % (87.06 per cent) and lambda cyhalothrin 5 EC 0.005 % (82.60 per cent).

The results on compatibility of *B. bassiana* with different insecticides at their recommended dose revealed that the insecticides *viz.*, chlorantraniliprole, chlorantraniliprole + lambda cyhalothrin, thiomethoxam + lambda cyhalothrin, flubendiamide, emamectin benzoate were relatively harmless (Grade 1) to *B. bassiana* as they showed less than 50 per cent growth inhibition at recommended dose. The growth inhibition was rated slightly harmful (Grade 2) with the insecticide, *azadirachtin*, lambda cyhalothrin and profenofos + cypermethrin were rated moderately harmful (Grade 3) while profenofos was rated harmful (Grade 4) to the *B. bassiana*.

Compatibility at higher dose (1.25 × RD)

The data on influence of selected chemical insecticides at higher dose (0.75 × RD) on radial growth of the *B. bassiana* are presented in Table 3 and in Plate III.

Out of the nine insecticides tested, chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC recorded highest colony diameter of 62.19 mm, which was at par with chlorantraniliprole 18.5 SC (59.18 mm). Average radial growth of 42.29 mm was recorded in flubendiamide 20 WG followed by 40.80 mm in emamectin benzoate 5 SG. 19.86 mm radial growth was recorded in thiomethoxam 12.6 + lambda cyhalothrin 9.5 ZC. All the insecticides tested have different compatible levels with *B. bassiana*

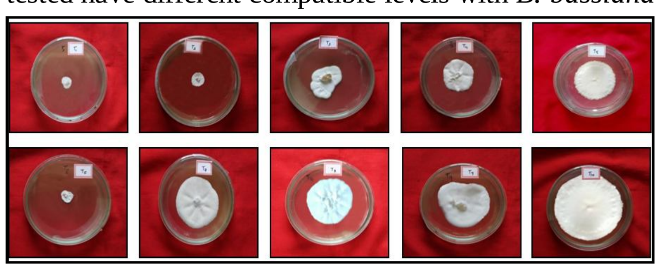

Fig. 2: *In vitro* compatibility of *B. bassiana* with chemical insecticides at recommended dose (1×RD).

Table 3: Effect of different insecticides on the growth of *B. bassiana* at 25 per cent higher than recommended dose (1.25 × RD).

Sr. No.	Treatments	Conc. (%)	Dose (g or ml /litre)	Colony diameter (mm)	Growth inhibition (%)	Grade *
1.	Profenofos 50 EC	0.125	2.50 ml	7.99[f](1.93)	81.57[a](97.85)	4
2.	Lambda cyhalothrin 5 EC	0.00625	1.25 ml	12.73[f](4.85)	76.57[b](94.61)	4
3.	Azadirachtin 1500 ppm	0.0008	6.75 ml	24.65[d](17.39)	63.92[d](80.68)	3
4.	Emamectin benzoate 5 SG	0.0012	0.375 g	39.70[c](40.80)	47.67[e](54.66)	2
5.	Chlorantraniliprole18.5 SC	0.0061	0.4ml	50.29[b](59.18)	35.81[f](34.24)	1
6.	Profenofos 40 + Cypermethrin 4 EC	0.112	3.125 ml	20.67[e](12.46)	68.15[c](86.15)	3
7.	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.0093	0.662ml	52.05[b](62.19)	33.76[f](30.89)	1
8.	Thiomethoxam 12.6 + Lambda cyhalothrin 9.5 ZC	0.033	1.462ml	26.46[d](19.85)	61.99[d](77.94)	2
9.	Flubendiamide 20 WG	0.0125	0.625 g	40.57[c](42.29)	46.72[e](53.00)	2
10.	Control	-	-	71.14[a](89.55)	4.05[g](0.50)	-
	S.Em. ±	-	-	1.21	1.31	
	C.D. at 5 %	-	-	3.58	3.86	
	C.V. %	-	-	6.07	4.36	

Figures in parenthesis are retransformed values of angular transformation
Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
Grades*: 1 = harmless (<50% reduction in beneficial capacity), 2 = slightly harmful (50-79%),
3 = moderately harmful (80-90%), 4 = harmful (>90%)

at higher dose. Perusal of data on growth inhibition sign posted that chlorantraniliprole 9.30 + lambda cyhalothrin 4.60 ZC 0.0093 % recorded the lowest inhibition (30.89 per cent) followed by chlorantraniliprole 18.5 SC 0.0061 % (34.24 per cent) (Fig. III). The treatments flubendiamide 20 WG 0.0125 % and emamectin benzoate 5 SG 0.0012 % remained next in order, which registered 53.00 and 54.66 per cent growth inhibition, respectively. The growth inhibition was moderately increased in thiomethoxam 12.6 + lambda cyhalothrin 9.5 ZC 0.033 % (77.94 per cent), *azadirachtin* 1500 ppm 0.0008 % (80.68 per cent) and profenofos 40 + cypermethrin 4 EC 0.112 % (86.15 per cent). The least growth was obtained in profenofos 50 EC 0.125 % as it showed 97.85 per cent growth inhibition of *B. bassiana* followed by lambda cyhalothrin 5 EC 0.00625 % (94.61 per cent).

The higher dose of tested insecticides showed more adverse effect on the growth inhibition of tested fungus as compared to lower and recommended doses. The present findings showed that the insecticides, *viz.*, chlorantraniliprole and chlorantraniliprole + lambda cyhalothrin were remained harmless (Grade 1) to *B. bassiana*. The rating of the insecticides, flubendiamide, emamectin benzoate and thiomethoxam + lambda cyhalothrin remained slightly harmful (Grade 2) as their growth inhibition was found between 50 to 79 per cent. *Azadirachtin* and profenofos + cypermethrin have registered as moderately harmful (Grade 3) whereas, profenofos and lambda cyhalothrin highly inhibited the growth of *B. bassiana* and distinguished as harmful (Grade 4).

The result of present finding are in close agreement with Khorasiya *et al.*, (2018) revealed that chlorantraniliprole 0.006 % recorded the highest radial growth and found most compatible with *B. bassiana*. According to Faraji *et al.*, (2016) found that *azadirachtin* (at all the three concentrations) totally prevented fungal sporulation (100 per cent reduction). Ismail *et al.*, (2017) found chlorantraniliprole showed highest mortality. Joshi *et al.*, (2018) found that profenophos 50 EC was the most toxic insecticide to the linear growth, percent inhibition and spore germination. Tekam *et al.*, (2018) found emamectin benzoate 5 SG was found to be most compatible with least inhibition percentage followed by Flubendiamide 20 WG. Ibrahim and Gabr (2019) observed that thiamethoxam recorded minimum growth inhibition (17.22 %). Nasiya-Beegum and Subramanian (2019) reported 68 per cent inhibition with lambda cyhalothrin.

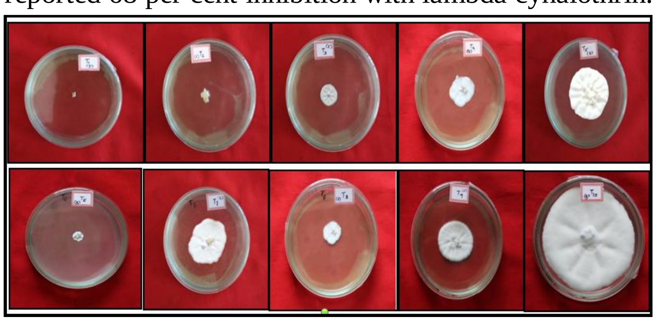

Fig. 3: *In vitro* compatibility of *B. bassiana* with chemical insecticides at higher dose (1.25×RD).

Hirapara *et al.*, (2023) found that emamectin benzoate 5 SG 0.00125% and chlorantraniliprole 18.5 SC 0.003 % were relatively harmless (Grade 1) at lower dose. Savariya and Jethva (2023) recorded that lambda cyhalothrin 5 EC @ 0.001 % at lower dose was rated as relatively harmless and it compatible with *B. bassiana*. Nirgude *et al.*, (2023) found that thiamethoxam recorded the highest vegetative growth of *B. bassiana*.

Conclusion

The present study showed that the insecticide emamectin benzoate 5 SG 0.0007 % and chlorantraniliprole 18.5 SC 0.006 % with 16.74 and 17.55 per cent growth inhibition (74.93- and 74.32-mm radial growth) were found to be the most compatible with *B. bassiana*, as it as categorized as harmless (Grade 1) to *B. bassiana*. Highest per cent growth inhibition was recorded in profenofos 50 EC at all doses.

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