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Compatibility of pesticides with *Beauveria bassiana* (Balsamo) Vuillemin

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Abstract
The present investigation was carried out at Biocontrol Laboratory, Agricultural Entomology Section, College of Agriculture, Dhule during Jan 2018 to Dec 2018. The pure culture of *Beauveria bassiana* was maintained at Agricultural Entomology Section, College of Agriculture, Dhule on PDA slants. The compatibility of nineteen pesticides were evaluated by employing 'Poisoned food technique' and their effect on growth characteristic of *Beauveria bassiana* was studied. All the insecticidal treatments were recorded reduction in vegetative growth of *B. bassiana.* Among all the tested insecticide, the treatment with thiamethoxam recorded the highest vegetative growth of *B. bassiana* followed by imidacloprid indicating their compatibility with *B. bassiana*. Among the tested fungicides all three *viz.,* carbendazim, copper oxychloride and propiconazole did not showed any vegetative growth of *B. bassiana*. The rest of the insecticidal treatments in descending order are thiamethoxam 25% WG - imidacloprid 17.8% SL - fipronil 5% SC - emamectin benzoate 5% SG - spiromesifen 22.9% SC - flubendamide 39.35% SC - Azadirachtin 3000 ppm - spinosad 45% SC- clorantraniliprole 18.5% SL - lambdacyhalothrin 5% EC - deltamethrin 2.8% EC - flupyridifurone 17.09% - acetamiprid 20% SP - diafenthiuron 50% WP- flonicamid 50% WG - triazophos 40% EC.

Keywords: *Beauveria bassiana*, compatibility

Introduction
Many chemical insecticides are recommended for control of the pest. Growing awareness about the health hazards have compelled the agricultural entomologists to developed sustainable pest management strategies which are economically viable and eco-friendly. Bassi (1835) [4] was the first one to demonstrate that entomopathogenic fungus, *B. bassiana* could cause an infectious disease in silkworm and suggested the concept that, an infectious micro-organism might be used to control insect pests. Biological control, in particular when accomplished by entomopathogens, is a technique that should be considered an important pest population density reduction factor in IPM programs. Therefore, the conservation of such entomopathogens whether they occur or when they are applied or introduced to control insects, is an interesting practice. However, the use of incompatible insecticides may inhibit the development and reproduction of these pathogens, affecting IPM. The entomopathogenic fungus *Beauveria bassiana* (Balsamo) Vuillemin is a capable alternative control agent against the important pests. Looking to the potential of these organisms for pest control, commercial products have been developed with entomopathogenic fungi (McCoy, 1990) [12]. The pesticides and herbicides may antagonize or synergize efficacy and potential insecticidal activity of *B. bassiana* and may disrupt natural epizootics of this pathogen. Hence, this knowledge should facilitate the choice of chemicals compatible with or less harmful to naturally occurring or artificially inoculated beneficial fungi. If *B. bassiana* is to be incorporated into a pest management programme, it is necessary to determine the effects of pesticides on it

Material and Methods
The study was conducted under laboratory condition at Agricultural Entomology Section, College of Agriculture, Dhule during Jan 2018 to Dec 2018 in completely randomized design with three replications. The pure cultures of *B. bassiana* was collected from Bio-agent production laboratory of Agricultural Entomology Section, College of Agriculture, Dhule and maintained on PDA slants and Petri plates. The fungi was cultured on PDA medium autoclaved at 1210C (15 Psi) for 15-20 min and poured in sterilized petri plates. Total sixteen insecticides and three fungicides were evaluated by employing 'Poisoned food technique' and their effect on growth characteristic of *B. bassiana* were studied.

Statistical analysis was carried out by analyzing the available data in Completely Randomized Design (CRD) and the data was subjected to arcsin transformation, prior to analysis

Results and Discussion

Compatibility of *B. bassiana with pesticides*

At 3rd day after inoculation

Among the pesticides tested for their compatibility with *B. bassiana* the highest (8.33 mm) mycelial growth was observed in diafenthiuron 50% WP and it was at par with acetamiprid 20% SP (8.17 mm) indicating the compatibility with *B. bassiana*. The next superior treatment for their compatibility was thiamethoxam 25% WG (7.67 mm) and imidacloprid 17.8% SL (7.67 mm). The fungicide carbendazim 50% WP, copper oxychloride50% WP and propiconazole 25% WP did not recorded the mycelia growth. It indicates the incompatibility with *B. bassiana* as no mycelial growth was observed at 3rd day of inoculation.

At 6th day after inoculation

Among the various pesticides tested for there compatibility with *B. bassiana* revealed that the maximum (18.67 mm) mycelial growth was observed in untreated control and was significantly higher over rest of the treatments. Among the various pesticides tested for their compatibility with *B. bassiana* the highest (14.50 mm) mycelial growth was observed with treatment of thiamethoxam 25%WG and spinosad 45% SC and it was at par with flonicamid 50%WG (14.17 mm) which showed compatibility with *B. bassiana.* The next superior treatments for their compatibility were diafenthiuron 50% WP (13.5 mm), deltamethrin 2.8% EC (13.5 mm), azadirechtin 3000 ppm (13.5 mm), acetamiprid 20% SP (13.00 mm), imidacloprid 17.8%SL (13.00 mm) and spiromesifen 22.9% SC (13.00 mm). The fungicides carbendazim 50%WP, copper oxychloride 50%WP and propiconazole 25% EC were incompatible with *B. bassiana.* because mycelial growth was not observed in poisoned medium after 6th day of inoculation

At 9th day after inoculation

Among the various pesticides tested for their compatibility with *B. bassiana* Among the various pesticides tested for their compatibility with *B. bassiana*, the highest (18.17 mm) mycelial growth was observed with treatment of deltamethrin 2.8% EC and it was at par with fipronil 5% SC (18.00 mm) and spinosad 45% SC (18.00 mm) which indicated the compatibility with *B. bassiana.* The next superior treatments for their compatibility were thiamethoxam 25% WG (17.83 mm), flonicamid 50% WG (17.83 mm), azadirechtin 3000ppm (17.50 mm), lambda cyhalothrin 5% EC (17.33 mm), acetamiprid 20% SP (17.17 mm), flubendamide 39.35% SC (17.17 mm), Imidacloprid 17.8% SL (17.00 mm), chlorantraniliprole 18.5%EC (17.00 mm), emamectin benzoate 5% SG (17.00 mm). The fungicides viz. carbendazim 50% WP, copper oxychloride 50% WP and propiconazole 25% EC are incompatible with *B. bassiana.*

At 12th day after inoculation

At 12 day's after inoculation among the various pesticides tested for their compatibility with *B. bassiana* expressed that the maximum (32.66 mm) mycelial growth was observed in untreated control and was significantly superior over rest of the treatments. Among the various pesticides tested for their compatibility with *B. bassiana*, the highest (30.33 mm) mycelial growth was observed in treatment of thiamethoxam 25%WG and was at par with imidacloprid 17.8% SL (29.17). Both these showed compatibility with *B. bassiana.* The next superior treatments for their compatibility were fipronil 5% SC (28.50 mm), emamectin benzoate 5% SG (28.30 mm) and spiromesifen 22.9% SC (28.00 mm). The tested fungicides viz. carbendazim 50% WP, copper oxychloride 50% WP and propiconazole 25% EC were not compatible with *B. bassiana*, as no mycelial growth was observed at 12th day of inoculation

Percent growth inhibition

At 3rd day after inoculation

At 3 days after inoculation, data on effect of percent growth inhibition of fungus *B. bassiana* revealed the significant difference for growth inhibition. The treatment with diafenthiuron 50% WP recorded significantly minimum of 8.96% growth inhibition of *B. bassiana* and showed its superiority over rest of the treatments, however it was at par with acetamiprid 20% SP (10.91%). The next effective treatments for growth inhibition of *B. bassiana*were thiamethoxam 25% WG (16.27%), imidacloprid 17.8% SL (16.27%), chlorantraniliprole 18.5% SC (18.02%), Spinosad 45% SC (18.02%) and Spiromesifen 22.9% SC (18.22%). The maximum growth inhibition of *B. bassiana* was observed in all the fungicides *viz*., carbendazim 50% WP, copper oxychloride 50% WP and propiconazole 25% WP with 45.41% growth inhibition

At 6th day after inoculation

At 6 days after inoculation, the growth inhibition in all the treatments were revealed significant differences for percent growth inhibition of fungus. The growth inhibition was minimum in the insecticidal treatment with thiamethoxam 25% WG (22.29%) and was significantly superior over the remaining treatments except spinosad 45% SC (22.30%) which indicated more compatibility with *B. bassiana.* The percent inhibition of growth of *B. bassiana* with increasing order of sequence were recorded in treatments as flonicamid 50% WG (24.13), diafenthiuron 50% WP (27.69), azadirachtin 3000 ppm (27.66), deltamethrin 2.8% EC (27.66), spiromesifen 22.9% SC (30.30), acetamiprid 20% SP (30.34), imidacloprid 17.8% SL (30.34), emamectin benzoate 5% SG (31.26), fipronil 5% SC (32.14), lambda cyhalothrin 5% EC (32.77), chlorantraniliprole 18.5% SC (33.00), flubendamide 39.35% SC (45.56), flupyridifurone 17.09%SL (50.02) and triazophos 40% EC (55.31). The maximum growth suppression of *B. bassiana* was observed in all three fungicides tested viz. carbendazim 50% WP (79.87%), copper oxychloride 50% WP (79.87%) and propiconazole 25% EC (79.87%) which indicated the incompatibility with *B. bassiana.*

At 9th day after inoculation

At 9 days after inoculation, the growth inhibition in all the treatments were revealed significant differences for percent growth inhibition of fungus. Considering percent reduction in growth of the mycoagent by various insecticides over untreated control, deltamethrin 2.8% EC emerged as most compatible insecticide with *B. bassiana* as it showed least (17.34%) average reduction in the growth but was significantly superior over rest of the insecticides andat par

with fipronil 5% SC (18.13%), spinosad 45% SC (18.10%), thiamethoxam 25%WG (18.79%), flonicamid 50% WG (18.93%), azadirachtin 3000 ppm (20.41%), lambda cyhalothrin 5% EC (21.10%), acetamiprid 20% SP (21.78%), flubendamide 39.35% SC (21.83%), imidacloprid 17.8% SL (22.54%) and emamectin benzoate 5% SG (22.55%) which showed compatibility with *B. bassiana*. The highest growth reduction of *B. bassiana* was recorded in all three fungicides viz. carbendazim 50% WP (77.24%), copper oxychloride 50% WP (77.24%) and propiconazole 25% EC (77.24%) indicating incompatibility with *B. bassiana.*

At 12th day after inoculation

At 12 days after inoculation, the growth inhibition in all the treatments were revealed significant differences for percent growth inhibition of fungus. The lowest (7.12%) growth reduction of *B. bassiana* was observed in insecticidal treatment with thiamethoxam 25% WG which was significantly superior over the rest of pesticides. Imidacloprid 17.8% SL (10.72%) was at par with this treatment. Fipronil 5% SC (12.72%) and spiromesifen 22.9% SC (14.25%) indicated more compatibility. The maximum (84.69%) growth suppression of *B. bassiana* was observed in all three fungicides tested viz. carbendazim 50% WP, copper oxychloride 50% WP and propiconazole 25% EC indicating the incompatibility with *B. bassiana*

The present findings of this investigation are in conformity with those reported by Batista *et al*. (2001) [5] who reported that the thiamethoxam did not affected the inoculum potential of *B. bassiana.*

The results of present findings are in agreements with those reported by Neves *et al*. (2001) [13] who reported that the neonicotinoid insecticide (acetamiprid, imidacloprid, thiamethoxam) had no effect on vegetative growth of *B. bassiana.*

The present findings are in corroboration with results reported by Andolo *et al*. (2004) [4], Rajnikanth *et al*. (2010) [15].

The present findings are in conformity with results of Batista *et al*. (2001) [5] reported the compatibility of *B. bassiana* with thiamethoxam.

Almedia & Diniz (1998) [1] reported that colony diameter of fungus was significantly reduced with lambda cyhalothrin in comparison with an untreated control.

This work is similar with results of present findings. Puzari *et al*. (2006) [14] reported the growth inhibition of *B. bassiana* less than 50 percent in treatment with deltamethrin.

Haseeb (2009) [9] found that percent inhibition was significantly low in deltamethrin.

Azhar *et al*. (2017) [3] reported the compatibility results of deltamethrin and imidacloprid with *B. bassiana* by recording the highest vegetative (mycelial) growth of *B. bassiana.* Fipronil did not decrease spore production and average diameter of colony (Batista et al. 1996) [6].

Quintela & McCoy (1990) [12] reported that the imidacloprid increased the conidial germination of *B. bassiana.* Moino & Alves (2) [2] evaluated the toxic effect of imidacloprid and fipronil on *B. bassiana* and reported that both are less toxic to *B. bassiana.*

Li and Zang (2005) [11] and Rajnikanth *et al*. (2010) [15] reported the compatibility of *B.bassiana* with spinosad. Xu *et al*. (2003) [16] reported that the imidacloprid and fipronil exhibited the compatibility of *B. bassiana.*

The results of present findings of compatibility of azadirachtin are in conformity with those reported by Gupta *et al*. (1999) [7], Gupta *et al*. (2002) [8], Isaiah *et al*. (2005) [10] and Haseeb (2009) [9].

Table 1: Compatibility of pesticides with *B. bassiana* at 3rd, 6th, 9th and 12th day of inoculation

Sr. No.	Treatment	Dose (gm or	Mean Mycelial growth (mm)				Mean Growth inhibition (%)			
			3rd	6th	9th	12th	3rd	6th	9th	12th
1	Acetamiprid 20% SP	0.20	8.17	13.00	17.17	21.50	10.91 (19.29)*	30.34 (33.41)*	21.78 (27.46)*	34.17 (35.77)*
2	Diafenthiuron 50% WP	1.20	8.33	13.50	16.00	21.00	8.96 (16.89)	27.69 (31.74)	27.10 (31.29)	35.71 (36.70)
3	Deltamethrin 2.8% EC	0.89	6.83	13.50	18.17	23.33	25.43 (30.26)	27.66 (31.70)	17.34 (24.51)	28.55 (32.28)
4	Thiamethoxam 25%WG	0.20	7.67	14.50	17.83	30.33	16.27 (23.62)	22.29 (28.18)	18.79 (25.57)	7.12 (15.25)
5	Imidacloprid 17.8% SL	0.23	7.67	13.00	17.00	29.17	16.27 (23.62)	30.34 (33.41)	22.54 (28.13)	10.72 (19.02)
6	Fipronil 5% SC	3.00	6.83	12.67	18.00	28.50	25.34 (30.14)	32.14 (34.53)	18.13 (25.11)	12.72 (20.69)
7	Spiromesifen 22.9% SC	0.84	7.50	13.00	16.50	28.00	18.22 (25.21)	30.30 (33.34)	24.92 (29.92)	14.28 (22.01)
8	Triazophos 40 %EC	2.00	6.50	8.33	10.17	13.50	28.94 (32.43)	55.31 (48.06)	53.68 (47.12)	58.67 (50.02)
9	Flonicamid 50% WG	0.30	7.00	14.17	17.83	19.33	23.68 (29.08)	24.13 (29.39)	18.93 (25.67)	40.78 (39.66)
10	λ cyhalothrin 5% EC	1.00	7.33	12.50	17.33	24.67	19.88 (26.35)	32.77 (34.90)	21.10 (27.27)	24.41 (29.54)
11	Flupyridifurone 17.09% SL	0.20	6.67	9.33	14.00	22.67	27.28 (31.49)	50.02 (45.01)	36.31 (37.05)	30.60 (33.55)
12	Chlorantraniliprole 18.5% SC	0.32	7.50	12.50	17.00	24.83	18.02 (24.81)	33.00 (35.01)	22.58 (28.29)	23.98 (29.27)
13	Spinosad 45% SC	0.44	7.50	14.50	18.00	25.67	18.02 (24.81)	22.30 (28.15)	18.10 (25.12)	21.42 (27.56)
14	Flubendamide	0.30	6.83	10.17	17.17	26.67	25.43	45.56	21.83	15.59

	39.35% SC						(30.26)	(42.45)	(27.74)	(22.90)
15	Emamectin benzoate 5% SG	0.40	6.67	2.83	17.00	28.30	27.19 (31.37)	31.26 (33.98)	22.55 (28.22.)	13.27 (21.20)
16	Azadirachtin 3000 ppm	4.00	6.67	13.50	17.50	26.33	27.19 (31.37)	27.66 (31.70)	20.41 (26.85)	19.36 (26.02)
17	Carbendazim 50 %WP	0.20	5.00	5.00	5.00	5.00	45.41 (42.37)	79.87 (64.14)	77.24 (61.51)	84.69 (66.96)
18	Copper oxychloride 50 WP	2.50	5.00	5.00	5.00	5.00	45.41 (42.37)	79.87 (64.14)	77.24 (61.51)	84.69 (66.96)
19	Propiconazole 25% EC	1.00	5.00	5.00	5.00	5.00	45.41 (42.37)	79.87 (64.14)	77.24 (61.51)	84.69 (66.96)
20	Untreated control	-	9.17	18.67	22.00	32.66	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
	S.E.±		0.19	0.33	0.43	0.63	1.91	2.32	1.83	1.59
	CD at 5%		0.55	0.94	1.24	1.80	5.46	6.65	5.25	4.55

Note: *Fig in parenthesis is arc sin transformed values

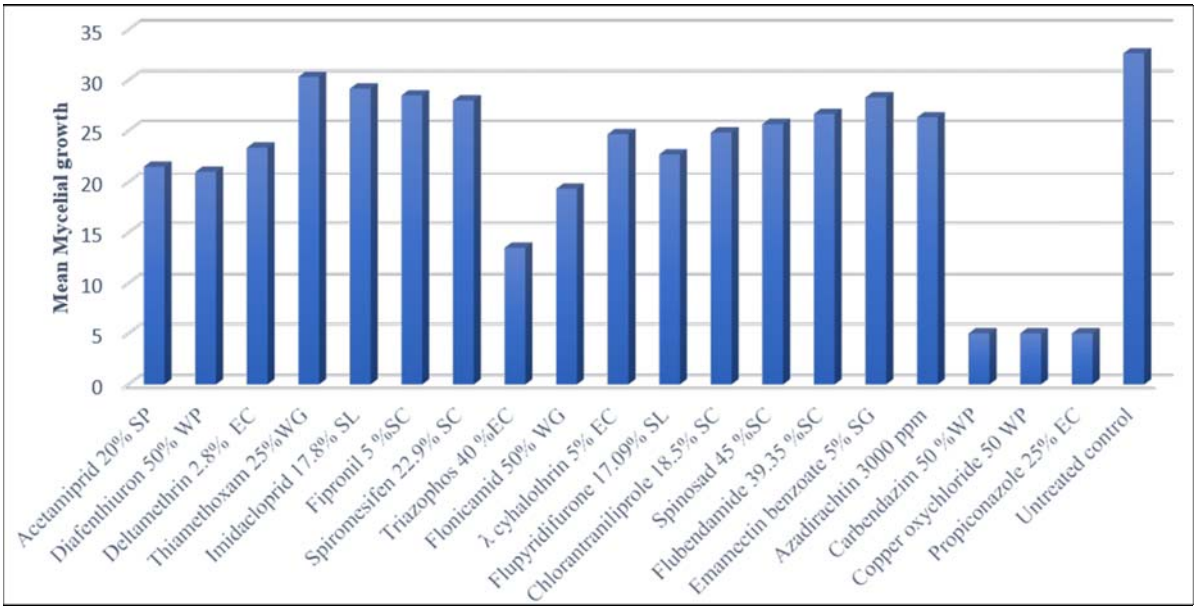

Fig 1: Compatibility of *B. bassiana* with pesticides after 12 days of inoculation

Conclusion

Mycelium growth and percent growth inhibition of *B. bassiana* is considered as the compatibility factor, it can be observed that the maximum (8.33) mycelial growth was observed with treatment of diafenthiuron 50% WP followed by acetamiprid 20% SP (8.17 mm), thiamethoxam 25%WG (7.67 mm) and imidacloprid 17.8%SL (7.67 mm) at 3 days after inoculation. The minimum of 8.96% growth inhibition of *B. bassiana* was recorded among all pesticides and it was followed by acetamiprid 20%SP (10.91%), thiamethoxam 25%WG (16.27%) and imidacloprid 17.8% SL (16.27%). From the result it is concluded that the insecticides viz., diafenthiuron 50%WP, acetamiprid 20%SP, thiamethoxam 25%WG, and imidacloprid 17.8% SL can be deemed as compactible with *B. bassiana.*

At 6 days after inoculation the insecticide thiamethoxam 25%WG, spinosad 45%SC and flonicamid 50%WG were found to be more compatible with *B. bassiana* by recording more mycelial growth and less growth inhibition of fungus over other pesticide.

At 9 days after inoculation, the insecticide deltamethrin 2.8% EC recorded highest mycelial growth and less percent growth inhibition of *B. bassiana* and it was followed by fipronil 5% SC and spinosad 45% SC. From this result it is concluded that deltamethrin 2.8% EC, fipronil 5%SC and spinosad 45% SC were found most compatible.

From data of 12 days of inoculation, it is concluded that the insecticide viz., thiamethoxam 25% WG, imidacloprid 17.8% SL, fipronil 5% SC, emamectin benzoate 5% SG, spiromesifen 22.9% SC, flubendamide 39.5% SC and azadirachtin 3000 ppm were found highly compatible insecticides with entomopathogenic fungus *B. bassiana* by recording growth inhibition of fungus less than 20 percent. While spinosad 45% SC, chlorantraniprole 18.5% SC, lambda cyhalothrin 5% EC, deltamethrin 2.8% EC, flupyridifurone 17.09% SL, acetamiprid 20% SP and diafenthiuron 50% WP were found moderately compatible as it recorded growth inhibition of fungus between 20.01 to 40.00 percent.

Trizophos 40% EC was found less compatible with *B. bassiana.* All the insecticides except triazophos 40% EC could be used with entomopathogenic fungus *B. bassiana.*

The fungicides viz., carbendazim 50%WP, copper oxychloride 50%WP and propiconazole 25% EC were significantly or totally inhibited the growth of *B. bassiana.* Hence, these fungicides were found to be incompatible with *B. bassiana* fungicides and could not be used with entopathogenic fungus *B. bassiana* in integrated test management programme.

Thus when an IPM strategy is devised, it is important to take into account the compatibility of products spread on the crop for avoiding the ill effects of products mixed together

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