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EVALUATION OF *BEAUVERIA BASSIANA* (BB 112) AND DELIVERY EQUIPMENTS AGAINST *BEMISIA TABACI* IN BRINJAL

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ABSTRACT

The efficacy of formulations of entomopathogenic fungi, *Beauveria bassiana* (Bb 112) against *Bemisia tabaci* in brinjal was evaluated under microplot condition. The best one was evaluated in brinjal under field condition using various delivery equipment in Kumarapalayam village of Coimbatore district and Ambillikai village of Dindigul district using randomized block design. The results revealed that the oil formulation of *B. bassiana* (Bb 112) gave maximum control (46.10%) when compared to talc (34.34%) and crude formulations (27.77%). Oil formulation of *B. bassiana* (Bb 112) sprayed with Controlled Droplet Applicator (CDA) gave the maximum population reduction (45.36% in Kumarapalayam; and 38.47% in Ambillikai) under field conditions. Hence, the present study implies that the improved formulations applied using improved delivery systems is effective.

Key words: *Beauveria bassiana*, Bb 112, oil formulation, *Bemisia tabaci*, Controlled Droplet Applicator, delivery methods

Sucking pests cause serious damage to several agricultural, horticultural and plantation crops, and many of these have developed resistance to insecticides. Biological control using microbial pathogens can be the alternative pest management strategy. *Beauveria bassiana* is a cosmopolitan entomopathogenic fungus effective against a wide variety of pests, *viz.*, caterpillars, bugs, whitefly, thrips. It has been used for management of pests belonging to insect orders such as Lepidoptera (Pilz et al., 2007), Coleoptera (Liu and Bauer, 2008), Hemiptera (Torrado et al., 2006), Diptera (Lecuona et al., 2005) and Thysanoptera (Castineiras et al., 1996). Recent advances in production, formulation, and application of insect pathogenic fungi have resulted in improvements in longstanding whitefly mycoinsecticide products. These products provide good control of whiteflies in both greenhouse and field crops. Oil formulations have been found to be more effective against target pests even under low RH and also possess good shelf life. Keeping these in view, present study evaluates the efficacy of formulations of *B. bassiana* (Bb 112) available at the Department of Agricultural Entomology, TNAU, Coimbatore against brinjal whitefly *Bemisia tabaci* under microplot and field condition.

MATERIALS AND METHODS

Crude formulation of *B. bassiana* (Bb 112) was prepared as follows: Two hundred and fifty ml of Sabouraud's Maltose with Yeast extract (SMY) broth was poured in round bottom flask (500 ml capacity) and autoclaved at 121°C for 20 min. After cooling, 1 ml of spore suspension (10^8 spores/ ml) was inoculated in flask and kept in orbitrary shaker for three days and incubated at room temperature for 10 days. After sporulation, fungal isolate was ground in a blender and filtered through double layered muslin cloth. The suspension was shaken thoroughly with a drop of Tween 80 to evenly disperse the spores in solution. The conidial suspension was vortexed for 5 minutes to produce a homogenous conidial suspension (Saranya et al., 2013). Talc based formulation was prepared after multiplication of *B. bassiana* in SMY broth, mixed with powdered talc at 1:2 ratios (500 ml: 1 kg). To the mixture, 5 g of carboxy methyl cellulose was added as sticker and dried in shade for 72 h, powdered and stored in polypropylene bags (Jeyarajan et al., 1994). Oil based formulation was prepared as per the methodology devised by Sangamithra (2015) and used for microplot and field studies. Studies were conducted in microplots (4 x 3 m^2) at the insectary of Department of Agricultural Entomology, TNAU, Coimbatore. Formulations of *B. bassiana* (Bb112) at 10^8 spores ml^{-1} in comparison

with standard insecticide checks (imidacloprid 17.8 SL and dimethoate 30 EC). The experiment included seven treatments with four replications. Two rounds of treatments were imposed at fortnightly interval with the help of a hand sprayer. Observation on live *B. tabaci* in brinjal was recorded from randomly selected five plants per plot. The treatment details for microplot studies in brinjal are given below: T1- *B. bassiana* (Bb 112) @10^8 spores ml^{-1} (oil formulation); T2- same in talc formulation; T3- same in crude formulation; T4- *B. bassiana* (B2)@10^8 spores ml^{-1}@ 5g l^{-1} (commercial talc formulation); T5- dimethoate 30 EC @ 0.7 ml l^{-1}; T6- imidacloprid 17.8 SL @ 0.5 ml l^{-1}; and T7- control (water spray).

Field experiments were conducted in two trials at Kumarapalayam village of Coimbatore district and Ambillikai village of Dindigul district. The experiments were carried out in a randomized block design with the plot size of 4 x $5m^2$ area with three replications. The treatment details are: *B. bassiana* (Bb 112) oil formulation - 4ml l^{-1} in @ 10^8 spores ml^{-1} in delivery systems of ASPEE Maruyama engine sprayer, Avenger ULV sprayer, ASPEE Battery sprayer, ASPEE Knapsack hand sprayer, ASPEE Hitech hand sprayer, and CDA sprayer; and *B. bassiana* (B 2)- talc based formulation - 5g l^{-1} at 10^8 spores ml^{-1} dimethoate 30 EC at 0.7 ml l^{-1}, imidacloprid 17.8 SL at 0.5 ml l^{-1}, and control (water spray) in knapsack hand sprayer. The pre and post treatment observations on live whiteflies were assessed on 0, 3, 7, 10 and 14 days after application from five plants selected randomly in each plot in the morning hours between 7-9 am. Three leaves one each from top, middle and bottom canopies of each plant were assessed for the live insects. The observations were made on the place where maximum population was noticed.

RESULTS AND DISCUSSION

Talc, crude and oil formulations of *B. bassiana* (Bb 112) were evaluated for their efficacy against *B. tabaci* in brinjal microplots. Result of first round of spraying revealed that the oil based formulation of *B. bassiana* (Bb 112) was significantly superior compared to other *B. bassiana* treatments with lowest whitefly population of 20.90, 16.80, 11.17, 13.66 and 16.12 numbers/leaf at 3, 5, 7, 10 and 14 days after treatment, respectively. Talc based formulation of *B. bassiana* (Bb 112) recorded 25.64% reduction. Standard checks, imidacloprid 17.8 SL (0.5ml l^{-1}) and dimethoate 30 EC (0.7 ml l^{-1}) were significantly superior. The commercial talc formulation of *B. bassiana* (B2) as check recorded the least population reduction compared to the oil based formulation.

In second round of treatment, a similar trend was observed. Application of oil based formulation of *B. bassiana* (Bb 112) was highly effective, after two rounds of spraying. This was followed by talc based and crude formulations of *B. bassiana* (Bb 112). The standard insecticide checks, imidacloprid and dimethoate were significantly superior.

Initial population of whiteflies per leaf was not significant before the first spraying and it ranged from 27.25 to 28.64. CDA sprayer with Bb 112 @ 10^8 spores ml^{-1} oil-based formulation was significantly superior. This was followed by the one delivered with Avenger® ULV sprayer and Aspee Maruyama® Engine sprayer. Imidacloprid and dimethoate led to maximum reduction. Similar results were recorded in second round of spraying too. Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer and Avenger ULV sprayer were more effective.

After third round of spraying, the cumulative mean% reduction of *B. tabaci* indicated that Bb 112 @ 10^8 spores ml^{-1} in oil-based formulation sprayed with CDA sprayer and Avenger ULV sprayer was significantly superior. The next in the order of efficacy was spray with Aspee Maruyama Engine sprayer (38.33%). The pretreatment population ranged from 24.94 to 26.88/ leaf. Significant reduction in population was observed at three days after spraying, and spray with CDA sprayer was significantly superior. Except imidacloprid and dimethoate. Similar trend was noticed on seventh and tenth day after spraying. The results were observed to be same after second round of spraying, with maximum reduction being in plots sprayed with CDA sprayer, followed by Avenger ULV sprayer (36.44%). Imidacloprid 17.8 SL and dimethoate 30 EC were significantly superior. The standard biocontrol agent *B. bassiana* (B2) was the least effective.

The results of present study corroborate those of Fargues et al. (1992) who reported the potential of *B. bassiana* and *Lecanicillium lecanii* based formulations against *Trialeurodes vaporariorum* in Mediterranean tomatoes. The efficacy of oil formulations against whiteflies is known- Malsam et al. (2002) observed the synergistic effect of conidia formulated with sunflower oil Biola® at 50% on whiteflies resulting in 97.8% mortality. Manjula et al. (2003) evaluated oil formulations of *B. bassiana* against *B. tabaci*,

Table 1. Efficacy of *B. bassiana* (Bb 112) formulations against *Bemisia tabaci* in brinjal (cv. CO 2) – Microplot

Treatments	PTC (No. of whiteflies / leaf)		Days after spray (No. of whiteflies / leaf)					Mean no. of whiteflies/ leaf	% reduction over control
			3	5	7	10	14		
B. bassiana (Bb 112) 10^8 spores ml^{-1} (oil formulation)	25.65		20.90 (4.57)^{b}	16.80 (4.10)^{b}	11.17 (3.34)^{b}	13.66 (3.70)^{b}	16.12 (4.01)^{b}	15.73	38.28
B. bassiana (Bb 112) 10^8 spores ml^{-1} (talc formulation)	26.02		22.45 (4.74)^{cd}	19.32 (4.40)^{cd}	15.72 (3.96)^{d}	17.72 (4.21)^{d}	19.56 (4.42)^{d}	18.95	25.64
B. bassiana (Bb 112) 10^8 spores ml^{-1} (crude formulation)	25.57		23.58 (4.86)^{d}	21.95 (4.69)^{d}	17.62 (4.20)^{e}	19.78 (4.45)^{e}	21.23 (4.61)^{e}	20.83	18.27
B. bassiana (B 2) 10^8 spores ml^{-1} (talc formulation)	24.96		21.39 (4.62)^{c}	18.73 (4.33)^{c}	13.21 (3.63)^{c}	15.46 (3.93)^{c}	18.97 (4.36)^{c}	17.55	31.14
Dimethoate 30 EC 0.7 ml l^{-1}	25.62		15.14 (3.89)^{a}	12.35 (3.53)^{a}	10.16 (3.19)^{a}	8.19 (2.86)^{a}	13.05 (3.61)^{a}	11.78	53.79
Imidacloprid 17.8 SL 0.5 ml l^{-1}	26.39		14.80 (3.85)^{a}	11.92 (3.32)^{a}	9.92 (3.15)^{a}	7.78 (2.79)^{a}	12.69 (3.56)^{a}	11.42	55.19
Control (water spray)	24.86		25.13 (5.01)^{e}	24.75 (4.97)^{e}	25.10 (5.01)^{f}	25.65 (5.06)^{f}	26.81 (5.18)^{f}	25.49	-
SE (d)		NS	0.17	0.23	0.14	0.20	0.18	-	-
C.D (P=0.05)		-	0.35	0.47	0.29	0.43	0.38	-	-
Second round of treatment									
B. bassiana (Bb 112) - 10^8 spores ml^{-1} (oil formulation)	14.98 (3.87)^{b}	12.74 (3.57)^{b}	9.61 (3.10)^{b}	11.28 (3.36)^{c}	15.39 (3.92)^{bc}	12.80	53.91	14.27	46.10
B. bassiana (Bb 112) - 10^8 spores ml^{-1} (talc formulation)	17.64 (4.20)^{cd}	15.31 (3.91)^{d}	13.37 (3.66)^{d}	14.65 (3.83)^{e}	18.13 (4.26)^{de}	15.82	43.04	17.39	34.34
B. bassiana (Bb 112) - 10^8 spores ml^{-1} (crude formulation)	18.49 (4.30)^{d}	16.43 (4.05)^{e}	14.90 (3.86)^{e}	16.97 (4.12)^{f}	20.32 (4.51)^{e}	17.42	37.27	19.13	27.77
B. bassiana (B 2) - 10^8 spores ml^{-1} (talc formulation)	16.96 (4.12)^{c}	14.59 (3.82)^{c}	11.76 (3.43)^{c}	13.80 (3.71)^{d}	17.96 (4.24)^{d}	15.01	45.94	16.28	38.54
Dimethoate 30 EC 0.7 ml l^{-1}	10.27 (3.20)^{a}	7.32 (2.71)^{a}	4.67 (2.16)^{a}	4.16 (2.04)^{a}	9.72 (3.12)^{b}	7.23	73.97	9.50	63.88
Imidacloprid 17.8 SL 0.5 ml l^{-1}	9.78 (3.13)^{a}	6.73 (2.59)^{a}	4.18 (2.04)^{a}	3.31 (1.82)^{a}	7.97 (2.82)^{a}	6.39	76.98	8.91	66.08
Control (water spray)	27.16 (5.21)^{e}	27.54 (5.25)^{f}	27.92 (5.28)^{f}	28.01 (5.29)^{g}	28.23 (5.31)^{f}	27.77	-	26.63	-
SE (d)	0.26	0.31	0.24	0.19	0.16	-	-	-	-
C.D (P=0.05)	0.54	0.65	0.51	0.40	0.33	-	-	-	-

Values mean of four replications; Figures in the parentheses are $\sqrt{x+0.5}$ transformed values; Means followed by common letter (s) not significant at p=0.05 by LSD

Table 2. Evaluation of delivery equipments of oil formulation of *B. bassiana* against *B. tabaci* in brinjal - Kumarapalayam

Treatment	Dose	Delivery equipments	PTC (No. of whiteflies / leaf)	Days after spray (No. of whiteflies / leaf) 3	7	10	14	Mean no. of whiteflies / leaf	% reduction over control
B. bassiana (Bb 112)- oil based formulation - 10^8 spores ml^{-1}	4ml l^{-1}	Aspee Maruyama engine sprayer	28.35	24.69 (4.97)^{d}	19.85 (4.46)^{cd}	20.72 (4.55)^{d}	22.23 (4.71)^{cd}	21.87	22.96
	4ml l^{-1}	Avenger ULV sprayer	28.64	23.52 (4.85)^{c}	18.41 (4.29)^{c}	19.66 (4.43)^{c}	21.99 (4.69)^{d}	20.90	26.40
	4ml l^{-1}	Aspee battery sprayer	27.85	26.78 (5.17)^{de}	22.85 (4.78)^{f}	23.91 (4.89)^{f}	25.85 (5.08)^{f}	24.85	12.48
	4ml l^{-1}	Aspee Knapsack hand sprayer	27.65	25.82 (5.08)^{d}	20.38 (4.51)^{de}	21.86 (4.68)^{e}	23.74 (4.87)^{d}	22.95	19.16
	4ml l^{-1}	Aspee Hitech hand sprayer	28.53	26.43 (5.14)^{de}	21.65 (4.65)^{e}	22.02 (4.69)^{ef}	24.78 (4.98)^{e}	23.72	16.45
	4ml l^{-1}	CDA sprayer	27.75	22.34 (4.73)^{b}	16.89 (4.11)^{b}	18.26 (4.27)^{b}	20.52 (4.53)^{c}	19.50	31.31
B. bassiana (B2) – Talc based formulation - 10^8 spores ml^{-1}	5g l^{-1}	Knapsack hand sprayer	28.15	27.39 (5.23)^{e}	23.91 (4.89)^{g}	24.47 (4.95)^{g}	26.48 (5.15)^{g}	25.56	9.96
Dimethoate 30 EC	0.7 ml l^{-1}	Knapsack hand sprayer	28.35	13.05 (3.61)^{a}	7.12 (2.67)^{a}	6.27 (2.50)a	12.03 (3.47)^{b}	9.62	66.12
Imidacloprid 17.8 SL	0.5ml l^{-1}	Knapsack hand sprayer	27.69	12.76 (3.57)^{a}	6.94 (2.63)^{a}	5.88 (2.42)^{a}	10.75 (3.28)^{a}	9.08	68.01
Control (water spray)		-	27.25	27.46 (5.24)^{f}	28.17 (5.31)^{h}	28.79 (5.37)^{h}	29.14 (5.40)^{h}	28.39	-
SE (d)			NS	0.14	0.12	0.19	0.18	-	-
C.D (P=0.05)			-	0.29	0.25	0.38	0.39	-	-
Second round of treatment									
B. bassiana (Bb 112)- oil based formulation - 10^8 spores ml^{-1}	4ml l^{-1}	Aspee Maruyama engine sprayer		18.83 (4.34)^{d}	14.79 (3.85)^{c}	15.51 (3.94)^{d}	19.58 (4.42)^{de}	17.18	42.74
	4ml l^{-1}	Avenger ULV sprayer		17.96 (4.24)^{c}	13.32 (3.65)^{bc}	14.25 (3.77)^{c}	18.85 (4.34)^{d}	16.10	46.35
	4ml l^{-1}	Aspee battery sprayer		21.85 (4.67)^{e}	17.87 (4.23)^{e}	18.02 (4.24)^{fg}	22.31 (4.72)^{f}	20.01	33.29
	4ml l^{-1}	Aspee Knapsack hand sprayer		19.05 (4.36)^{de}	15.56 (3.94)^{d}	16.93 (4.11)^{e}	20.89 (4.57)^{e}	18.11	39.64
	4ml l^{-1}	Aspee Hitech hand sprayer		19.40 (4.40)^{de}	16.73 (4.09)^{de}	17.54 (4.19)^{f}	21.45 (4.63)^{ef}	18.78	37.39
	4ml l^{-1}	CDA sprayer		16.78 (4.10)^{b}	12.86 (3.59)^{b}	13.41 (3.66)^{b}	17.73 (4.21)^{c}	15.20	49.35
B. bassiana (B2) – Talc based formulation - 10^8 spores ml^{-1}	5g l^{-1}	Knapsack hand sprayer		22.39 (4.73)^{f}	18.25 (4.27)^{f}	19.63 (4.43)^{g}	23.42 (4.84)^{g}	20.92	30.25

Dimethoate 30 EC		0.7 ml l^{-1}	Knapsack hand sprayer			7.15 (2.67)^{a}	6.02 (2.45)^{a}	4.26 (2.06)^{a}	10.32 (3.21)^{b}	6.94	76.87
Imidacloprid 17.8 SL		0.5ml l^{-1}	Knapsack hand sprayer			6.78 (2.60)^{a}	5.86 (2.42)^{a}	3.98 (1.99)^{a}	8.93 (2.99)^{a}	6.39	78.71
Control (water spray)			-			28.78 (5.36)^{g}	29.35 (5.42)^{g}	30.74 (5.54)^{h}	31.12 (5.58)^{h}	30.62	-
SE (d)						0.19	0.14	0.17	0.15	-	-
C.D (P=0.05)						0.39	0.30	0.38	0.31	-	-
Third round of treatment											
B. bassiana (Bb 112)-oil based formulation - 10^{8} spores ml^{-1}	4ml l^{-1}	Aspee Maruyama engine sprayer	17.69 (3.78)^{d}	13.98 (3.46)^{d}	15.81 (3.72)^{d}	17.39 (3.75)^{cd}	16.22	49.30	18.42	38.33
	4ml l^{-1}	Avenger ULV sprayer	16.71 (3.57)^{c}	12.27 (3.20)^{c}	14.88 (3.45)^{c}	16.93 (3.60)^{c}	15.20	52.49	17.40	41.75
	4ml l^{-1}	Aspee battery sprayer	19.52 (4.30)^{f}	16.78 (3.84)^{fg}	18.12 (4.26)^{f}	20.01 (4.36)^{f}	18.61	41.83	21.16	29.20
	4ml l^{-1}	Aspee Knapsack hand sprayer	18.37 (3.92)^{e}	14.79 (3.58)^{e}	16.26 (3.88)^{de}	18.43 (3.93)^{d}	16.96	46.98	19.34	35.26
	4ml l^{-1}	Aspee Hitech hand sprayer	18.75 (4.09)^{ef}	15.97 (3.74)^{f}	17.28 (4.03)^{e}	19.12 (4.14)^{e}	17.78	44.43	20.09	32.76
	4ml l^{-1}	CDA sprayer	15.82 (3.33)^{b}	11.68 (3.11)^{b}	13.89 (3.31)^{b}	15.87 (3.44)^{b}	14.32	55.25	16.34	45.36
B. bassiana (B2) – Talc formulation - 10^{8} spores ml^{-1}	5g l^{-1}	Knapsack hand sprayer	21.95 (4.58)^{g}	17.36 (4.05)^{fg}	19.75 (4.44)^{g}	21.24 (4.50)^{fg}	20.08	37.25	22.19	25.82
Dimethoate 30 EC	0.7 ml l^{-1}	Knapsack hand sprayer	7.05 (2.82)^{a}	4.43 (2.13)^{a}	3.10 (1.76)^{a}	7.89 (2.81)^{a}	5.62	82.44	7.39	75.15
Imidacloprid 17.8 SL	0.5ml l^{-1}	Knapsack hand sprayer	6.69 (2.62)^{a}	4.02 (2.00)^{a}	2.76 (1.54)^{a}	7.55 (2.75)^{a}	5.26	83.57	6.91	76.76
Control (water spray)		-	30.86 (5.62)^{h}	31.42 (5.64)^{g}	32.56 (5.72)^{h}	33.12 (5.79)^{g}	31.99	-	30.13	-
SE (d)			0.19	0.22	0.17	0.18	-	-	-	-
C.D (P=0.05)			0.38	0.44	0.35	0.37	-	-	-	-

Values mean of three replications; Figures in parentheses $\sqrt{x+0.5}$ transformed values; Means followed by common letter (s) not significantly different at p=0.05 by LSD

Table 3. Evaluation of delivery equipments of oil formulation of *B. bassiana* against *B. tabaci* in brinjal - Ambillikai

Treatment	Dose	Delivery equipments	PTC (No. of whiteflies / leaf)	Days after first spray (No. of whiteflies / leaf)				Mean no. of whiteflies / leaf	% reduction over control
				3	7	10	14		
B. bassiana (Bb 112)- oil based formulation - 10^8 spores ml^{-1}	4ml l^{-1}	Aspee Maruyama engine sprayer	26.10	23.52 (4.85)^{d}	21.05 (4.59)^{cd}	21.24 (4.61)^{c}	23.66 (4.86)^{d}	22.37	24.19
	4ml l^{-1}	Avenger ULV sprayer	24.94	22.34 (4.73)^{c}	20.56 (4.53)^{c}	20.69 (4.55)^{bc}	22.54 (4.75)^{cd}	21.53	27.02
	4ml l^{-1}	Aspee battery sprayer	25.30	24.61 (4.96)^{e}	23.84 (4.88)^{f}	24.43 (4.94)^{f}	25.08 (5.01)^{f}	24.49	17.00
	4ml l^{-1}	Aspee Knapsack hand sprayer	25.95	23.97 (4.90)^{d}	21.72 (4.66)^{d}	22.32 (4.72)^{d}	23.93 (4.89)^{de}	22.99	22.10
	4ml l^{-1}	Aspee Hitech hand sprayer	26.14	24.25 (4.92)^{de}	22.93 (4.79)^{e}	23.74 (4.87)^{e}	24.56 (4.96)^{e}	23.87	19.10
	4ml l^{-1}	CDA sprayer	25.22	21.79 (4.67)^{b}	19.87 (4.46)^{b}	20.16 (4.49)^{b}	22.02 (4.69)^{c}	20.96	28.96
B. bassiana (B2) – Talc based formulation - 10^8 spores ml^{-1}	5g l^{-1}	Knapsack hand sprayer	26.42	25.76 (5.08)^{f}	24.92 (4.99)^{g}	25.07 (5.01)^{fg}	25.39 (5.04)^{fg}	25.29	14.30
Dimethoate 30 EC	0.7 ml l^{-1}	Knapsack hand sprayer	25.83	15.91 (3.99)^{a}	12.28 (3.50)^{a}	10.08 (3.17)^{a}	16.19 (4.02)^{b}	13.62	53.86
Imidacloprid 17.8 SL	0.5ml l^{-1}	Knapsack hand sprayer	26.88	15.36 (3.92)^{a}	11.92 (3.45)^{a}	9.85 (3.14)^{a}	14.76 (3.84)^{a}	12.97	56.03
Control (water spray)	-		26.12	27.04 (5.20)^{g}	28.33 (5.32)^{h}	30.16 (5.49)^{g}	32.49 (5.70)^{g}	29.51	-
SE (d)			NS	0.27	0.18	0.12	0.15	-	-
C.D (P=0.05			-	0.54	0.37	0.26	0.32	-	-
Second round of treatment									
B. bassiana (Bb 112)- oil based formulation - 10^8 spores ml^{-1}	4ml l^{-1}	Aspee Maruyama engine sprayer	20.51 (4.53)^{cd}	18.65 (4.32)^{c}	19.92 (4.46)^{c}	21.41 (4.63)^{e}	17.15	46.76	21.25	33.52
	4ml l^{-1}	Avenger ULV sprayer	19.84 (4.45)^{c}	17.47 (4.18)^{bc}	18.56 (4.31)^{bc}	20.38 (4.51)^{d}	16.06	50.12	20.30	36.44
	4ml l^{-1}	Aspee battery sprayer	23.73 (4.87)^{f}	21.34 (4.62)^{d}	22.61 (4.75)^{ef}	23.02 (4.80)^{g}	19.68	38.91	23.58	26.29
	4ml l^{-1}	Aspee Knapsack hand sprayer	21.02 (4.58)^{cde}	19.33 (4.40)^{cd}	20.76 (4.56)^{d}	21.87 (4.68)^{ef}	17.75	44.90	21.87	31.59
	4ml l^{-1}	Aspee Hitech hand sprayer	22.84 (4.78)^{e}	19.97 (4.47)^{cd}	21.85 (4.67)^{e}	22.23 (4.71)^{f}	18.72	41.86	22.80	28.70
	4ml l^{-1}	CDA sprayer	18.91 (4.35)^{b}	16.78 (4.10)^{b}	17.93 (4.23)^{b}	19.64 (4.43)^{c}	15.32	52.45	19.64	38.47

B. bassiana (B2) – Talc based formulation - 10^8 spores ml^{-1}	5g l^{-1}	Knapsack hand sprayer	24.03 (4.90)^{fg}	22.69 (4.76)^{e}	23.77 (4.88)^{f}	24.31 (4.93)^{gh}	20.70	35.72	24.49	23.49
Dimethoate 30 EC	0.7 ml l^{-1}	Knapsack hand sprayer	11.47 (3.39)^{a}	10.31 (3.21)^{a}	9.60 (3.10)^{a}	13.35 (3.65)^{b}	8.73	72.88	12.40	60.34
Imidacloprid 17.8 SL	0.5ml l^{-1}	Knapsack hand sprayer	11.02 (3.32)^{a}	9.96 (3.16)^{a}	9.12 (3.02)^{a}	12.81 (3.58)^{a}	8.21	74.51	11.85	62.10
Control (water spray)	-		33.24 (5.77)^{g}	34.62 (5.88)^{f}	35.94 (5.99)^{g}	37.02 (6.08)^{h}	32.21	-	32.36	-
SE (d)			0.23	0.15	0.12	0.11	0.13	-	-	-
C.D (P=0.05)			0.47	0.33	0.25	0.23	0.29	-	-	-

Values mean of three replications; Figures in parentheses $\sqrt{x+0.5}$ transformed values; Means followed by common letter (s) not significantly different at p=0.05 by LSD

and observed that ground nut oil formulation was the best. These findings are in concordance with the present findings, wherein, oil formulation was superior. Oil based formulations have an added advantage of better adhesion of conidia to the hydrophobic cuticle of insects and reported to have better conidial survival in oil than in water (Prior et al., 1988). Because of the lipophilic nature of conidia that do not have a mucus coating, they can be easily suspended in oils to achieve greater efficacy than when used in water (David et al., 1998).

Bateman et al. (1993) reported that the use of entomopathogenic fungal oil formulations in ultra-low-volume application resolved many problems for use of *M. anisopliae* to control locusts. CDA represents a very specialised mycopesticide delivery system, with limited opportunities for development of similar techniques since oil formulations can only be used with specialised application equipment (often rotary atomisers) (Bateman and Alves, 2000). This outcome was found to be in concordance with results of present study where, ultralow volume application using CDA was more effective. The present results agree with those of Murugasridevi et al. (2018a) on the oil formulation of *B. bassiana* (Bb 112) and when sprayed with CDA sprayer against chilli thrips, *Scirtothrips dorsalis.* Murugasridevi et al. (2018b) observed similar results on the efficacy of *B. bassiana* oil formulation against chilli mite *Polyphagotarsonemus latus.*

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