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Research Article

Evaluation of oil based formulation of *Beauveria bassiana* (Bb 112) (Bals.) Vuill. and delivery methods for the management of chilli thrips, *Scirtothrips dorsalis* Hood

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ABSTRACT: In recent years, increased interest has been shown towards biological control based management practices following the unsatisfactory results with the application of conventional insecticides. In Integrated Pest Management, selection of right plant protection methods coupled with right appliance is important to tackle the target pest in an effective manner. In this context, microplot and field trials were carried out to evaluate the efficacy of the oil based formulation of *B. bassiana* (Bb 112) against chilli thrips, *Scirtothrips dorsalis* Hood to identify an effective delivery method among different sprayers used (ASPEE Maruyama Engine sprayer, Avenger ULV sprayer, ASPEE Battery sprayer, ASPEE Knapsack hand sprayer, ASPEE Hitech hand sprayer and CDA sprayer). Microplot experiment on chilli thrips, *S. dorsalis* revealed that the oil based formulation of *B. bassiana* (Bb 112) was significantly superior to all other treatments and recorded the highest cumulative mean population reduction of 47.54 per cent. The cumulative mean per cent reduction in first (at Kumarapalayam) and second field trial (at Ambilikkai) against Chilli thrips showed that, oil based formulation of *B. bassiana* (Bb 112) @ 10^8 spores ml^{-1} sprayed with CDA sprayer was significantly superior to other treatments with 43.01 and 46.65 per cent reduction, respectively.

KEY WORDS: *Beauveria bassiana*, chilli thrips, CDA sprayer, field, microplot, oil based formulation

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INTRODUCTION

Chilli (*Capsicum annum* L.), is one of the important crop grown for green and ripe dry fruits throughout the tropics and warm temperate regions of the world. According to a survey by the Asian Vegetable Research and Development Committee, *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera) is one of the most important limiting factors for chilli production in India. This crop mainly suffers from leaf curl symptoms, which affect the pod yield (Rai et al., 2009) to the tune of 60 to 74 per cent (Patel and Gupta, 1998; Patel *et al*., 2009). In India, growers manage thrips with several applications of insecticides in a growing season. Also, the use of conventional synthetic insecticides to manage thrips population poses great difficulties owing to their cryptic nature and hence, led to growing interest in novel and effective alternatives like microbial bio-control agents. Microbial biological control with entomopathogenic fungi has potential for thrips management in developed countries (Arthurs *et al*., 2013). Entomopathogenic fungi, particularly *Beauveria bassiana* (Bals.) Vuill. (Hypocreales: Cordycipitaceae) is an attractive bio-pesticide for use in integrated pest management, as they have host specificity with proven safety (Bateman *et al*., 1993). Successful usage of entomopathogenic fungi for pest control under field conditions includes delivery techniques, infectivity and persistence of their inoculum in the environment. The investigation was undertaken to identify the efficacy of oil based formulation of *B. bassiana* (Bb 112) against chilli thrips and test delivery systems of the fungi under microplot and field conditions.

MATERIALS AND METHODS

Preparation of oil based formulation of *Beauveria basssiana* (Bb 112)

Oil based formulation of *B. bassiana* (Bb 112) was prepared as per the protocol developed by Sangamithra (2015). Oil based formulation was prepared by dissolving 1 g of pure conidia (10^{10} conidia g^{-1}) of Bb 112 in 100 ml of paraffin oil, along with adjuvants to enhance the efficacy of the formulation.

Microplot and field evaluation against chilli thrips

One microplot experiment (at Insectary, Department of Agricultural Entomology, TNAU, Hyb. Bullet) and two field experiments (at Kumarapalayam- Hyb. Bullet, Ambilikkai- Var. K2) were conducted to evaluate the performance of oil based formulation of *B. bassiana* (Bb 112) delivered through different delivery equipments *viz.,* ASPEE Maruyama Engine sprayer (T1), Avenger ULV sprayer (T2), ASPEE Battery sprayer (T3), ASPEE Knapsack hand sprayer (T4), ASPEE Hitech hand sprayer (T5) and CDA (Controlled Droplet Applicator) sprayer (T6) against chilli thrips in comparison with the talc based formulation of *B. bassiana* (B2) (T7) available at the Department of Plant Pathology, TNAU and with insecticide check (imidacloprid) (T8). The experiments were carried out during the period of 2016 in a randomized block design with the plot size of 2.5 m × 2.5 m for microplots and 4 m × 5m for field trials.

Each treatment was replicated three times. Two rounds of treatments were imposed at fortnightly interval. The pre and post treatment counts on live thrips population were made on 3, 7, 10 and 14 days after application from five plants selected randomly in each plot. Chilli thrips population was counted from top, middle, bottom leaves and the population was expressed as number of thrips per leaf. Yield data was also recorded during each picking and analysed after pooling in field trial.

The thrips population and per cent reduction in population over control observed from both micro plot and field experiments were subjected to square root (X+0.5) and *arc sine transformation* and the analysis of variance for different experiments was carried out in AGRES and the means were separated by Least Significant Difference (LSD) available in the package. The yield data were analyzed statistically after pooling the yield data from all the pickings in chilli.

RESULTS AND DISCUSSION

Microplot experiments on chilli thrips, *Scirtothrips dorsalis*

In the experiment evaluating the delivery system, the initial population of thrips per leaf was low in all treatments before the first application. After the first round of spraying, the oil formulation of *B. bassiana* (Bb112) sprayed with CDA sprayer was found to be significantly superior to

Table 1. Efficacy of oil formulation of *Beauveria bassiana* (Bb 112) against chilli thrips, *Scirtothrips dorsalis* (Hyb. Bullet) using different delivery equipments – Microplot

Treatments	Delivery equipments	PTC (No. of thrips / leaf)	Days after first spraying (No. of thrips / leaf)				Mean no. of thrips/ leaf	% reduction over control
			3	**7**	**10**	**14**		
Oil formulation of *B. bassiana* (Bb 112 – 10^8 spores ml^{-1}) @ 4 ml lit^{-1}	Aspee Maruyama engine sprayer	9.15	8.04 (2.83)^{cd}	7.62 (2.76)^{d}	7.51 (2.74)^{d}	7.84 (2.8)^{c}	7.75 (2.78)^{cd}	35.36
	Avenger ULV sprayer	9.00	7.89 (2.80)^{c}	6.96 (2.63)^{c}	6.85 (2.61)^{c}	7.20 (2.68)^{b}	7.22 (2.68)^{bc}	39.78
	Aspee battery sprayer	9.40	8.67 (2.94)^{e}	8.25 (2.87)^{e}	8.18 (2.86)^{e}	8.34 (2.88)^{d}	8.36 (2.89)^{de}	30.27
	Aspee Knapsack hand sprayer	8.97	8.22 (2.86)^{cd}	7.73 (2.78)^{d}	7.58 (2.75)^{d}	8.12 (2.84)^{cd}	7.84 (2.80)^{cde}	34.61
	Aspee hitech hand sprayer	9.34	8.26 (2.87)^{d}	8.11 (2.84)^{e}	8.04 (2.83)^{e}	8.29 (2.87)^{d}	8.17 (2.85)^{de}	31.81
	CDA sprayer	8.81	7.15 (2.67)^{b}	6.24 (2.49)^{b}	6.20 (2.48)^{b}	7.09 (2.66)^{b}	6.67 (2.58)^{b}	44.37
Talc based formulation of *B. bassiana* (B2) @ 5g lit^{-1} (10^8 spores ml^{-1})	Knapsack hand sprayer	9.27	9.12 (3.01)^{f}	9.00 (3.00)^{f}	8.97 (2.99)^{f}	9.33 (3.05)^{e}	9.10 (3.01)^{e}	24.10
Imidacloprid 17.8 SL @ 0.5 ml lit^{-1}	Knapsack hand sprayer	8.79	6.51 (2.55)^{a}	4.02 (2.00)^{a}	3.21 (1.79)^{a}	3.60 (1.89)^{a}	4.33 (2.08)^{a}	66.02
Control (water spray)	-	9.41	11.38 (3.37)^{g}	11.47 (3.38)^{g}	12.38 (3.51)^{g}	12.76 (3.57)^{f}	11.99 (3.46)^{f}	-
SE (d)		-	0.16	0.11	0.11	0.10	0.11	-
C.D (0.05)		-	0.33	0.23	0.24	0.22	0.24	-

PTC- Pretreatment count

Figures in the parentheses are $\sqrt{x+0.5}$ transformed values

Means followed by the common letter (s) are not significantly different at P=0.05 level by LSD all other treatments and recorded the lowest thrips population of 7.15, 6.24, 6.20 and 7.09 numbers per leaf at 3, 7, 10 and 14 days after treatment, respectively with the highest per cent reduction to the tune of 44.37 per cent (Table 1). The insecticide check, imidacloprid 17.8 SL (0.5ml lit^{-1}) was significantly superior to all other treatments and recorded the highest population reduction of 66.02 per cent.

After second round of spraying, the oil formulation of *B. bassiana* (Bb112) @ 10^8 spores ml^{-1} sprayed with CDA sprayer was found to be significantly superior to all other treatments and recorded the highest per cent reduction of 50.45 per cent (Table 2). The insecticide check, imidacloprid 17.8 SL (0.5ml lit^{-1}) was significantly superior to all other treatments and recorded the highest population reduction of 73.75 per cent.

The cumulative mean per cent reduction of *S. dorsalis* after two rounds of spraying indicated that the Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer was significantly superior to all other treatments by recording a population reduction of 47.54 per cent. The next in the order of efficacy was Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with Avenger ULV sprayer (44.76%) and Aspee Maruyama Engine sprayer (41.87%) (Table 2).

Field evaluation against chilli thrips, *Scirtothrips dorsalis*

Trial I- Location: Kumarapalayam

The results of the field experiment conducted at Ku-

Table 2. Efficacy of oil formulation of *Beauveria bassiana* (Bb 112) against chilli thrips, *Scirtothrips dorsalis* (Hyb. Bullet) using different delivery equipments – Microplot

Treatments	Delivery equipments	Days after second spraying (No. of thrips / leaf)				Mean no. of thrips/ leaf	% reduction over control	Pooled mean (No. of thrips / leaf)	Cumulative % reduction over control
		3	**7**	10	14				
Oil formulation of *B. bassiana* (Bb 112 – 10^8 spores ml^{-1}) @ 4 ml lit^{-1}	Aspee Maruyama engine sprayer	7.21 (2.68)^b	6.75 (2.59)^c	6.29 (2.50)^c	7.02 (2.64)^b	6.81 (2.61)^b	47.85	7.28	41.87
	Avenger ULV sprayer	7.02 (2.64)^b	6.59 (2.56)^{bc}	6.02 (2.45)^{bc}	6.82 (2.61)^{bc}	6.61 (2.57)^{bc}	49.38	6.91	44.76
	Aspee battery sprayer	8.30 (2.88)^c	8.21 (2.86)^e	8.13 (2.85)^e	8.45 (2.90)^e	8.27 (2.87)^e	36.67	8.31	33.58
	Aspee Knapsack hand sprayer	8.11 (2.84)^c	7.82 (2.79)^d	7.31 (2.70)^d	7.64 (2.76)^d	7.72 (2.77)^d	40.88	7.78	37.88
	Aspee hitech hand sprayer	8.24 (2.87)^c	7.89 (2.80)^{de}	7.28 (2.69)^d	7.76 (2.78)^d	7.79 (2.79)^d	40.35	7.98	36.26
	CDA sprayer	6.89 (2.62)^b	6.43 (2.53)^b	5.92 (2.43)^b	6.67 (2.58)^b	6.47 (2.54)^b	50.45	6.57	47.54
Talc based formulation of *B. bassiana* (B2) @ 5g lit^{-1} (10^8 spores ml^{1})	Knapsack hand sprayer	9.30 (3.04)^d	9.27 (3.04)^f	9.24 (3.03)^f	10.44 (3.23)^f	9.56 (3.09)^f	26.78	9.44	24.56
Imidacloprid 17.8 SL @ 0.5ml lit^{-1}	Knapsack hand sprayer	3.59 (1.89)^a	3.55 (1.88)^a	3.49 (1.86)^a	3.53 (1.87)^a	3.54 (1.88)^a	73.75	3.93	68.57
Control (water spray)	-	12.82 (3.58)^e	12.89 (3.59)^g	13.06 (3.61)^g	13.49 (3.67)^g	13.06 (3.61)^g	-	12.52	-
SE (d)		0.16	0.19	0.23	0.16	0.18	-	-	-
C.D (0.05)		0.34	0.40	0.50	0.35	0.39	-	-	-

Figures in the parentheses are $\sqrt{x + 0.5}$ transformed values

Means followed by the common letter (s) are not significantly different at P=0.05 level by LSD marapalayam, Coimbatore district are presented in Figure 1.

The initial population of thrips per leaf before first spraying ranged from 10.66 to 11.45 in all the treatments. After first spraying, Bb 112 @ 10^8 spores ml^{-1} oil based formulation sprayed with CDA sprayer was significantly superior among the other treatments and recorded the lowest thrips population of 10.75, 10.66, 6.88 and 9.21 numbers per leaf on 3, 7, 10 and 14 days after spraying, respectively with the highest thrips population reduction of 36.76 per cent. However, imidacloprid 17.8 SL recorded the highest per cent reduction (60.08 %) in thrips population.

After second round of spraying, Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer and Avenger ULV sprayer recorded the population reduction of 48.18 and 46.69 per cent, respectively. The insecticide, imidacloprid 17.8 SL recorded the highest per cent reduction (77.99 %) in thrips population.

The cumulative mean per cent reduction of *S. dorsalis* after two rounds of spraying indicated that the Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer and Avenger ULV sprayer was significantly superior to all other treatments by recording a population reduction of 43.01 and 41.64 per cent, respectively. The insecticide check, imidacloprid 17.8 SL at 0.5 ml lit^{-1} was significantly superior to all other treatments and recorded 69.12 per cent reduction in thrips population.

Trial II - Location: Ambilikkai

Similar results as that of first field trial was also observed in the second field trial carried out at Ambilikkai village of Dindigul district.

Initial population of thrips before imposing the treatments ranged from 11.56 to 12.45 per leaf. Significant reduction in the thrips population was observed at three days after spraying. Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer (8.34/ leaf) was significantly superior to the rest of the treatments except imidacloprid (7.01/ leaf). Similar trend of reduction was noticed on seventh and tenth day after spraying. The highest mean population reduction was noticed in Bb 112 @ 10^8 spores ml^{-1} oil based formulation (41.07 %) sprayed with CDA sprayer followed by Avenger ULV sprayer (31.76%) after 14 days of first spraying. The insecticide check, imidacloprid 17.8 SL at 0.5 ml lit^{-1} was significantly superior to all other treatments and recorded 64.08 per cent reduction in thrips population (Fig. 1).

A similar trend was also observed after second round of spraying. The highest mean population reduction was noticed in the plots sprayed with CDA sprayer (50.93 %) which was on par with Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with Avenger ULV sprayer (50.51 %).

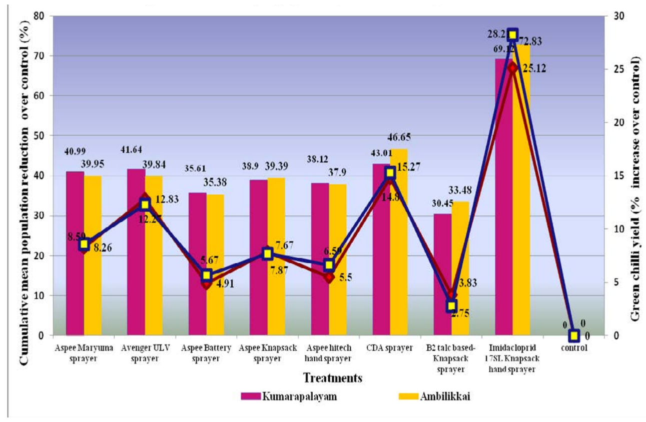

Fig. 1. Pooled efficacy of oil formulation of *Beauveria bassiana* (Bb 112) against *Scirtothrips dorsalis* on chilli using different delivery equipment (Field trial I and II).

Among the different delivery equipments tested for oil based formulation, the performance of Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer was superior with a cumulative mean reduction in thrips population of 46.65 per cent followed by Aspee Maruyama engine sprayer (39.95%). The insecticide check, imidacloprid 17.8 SL at 0.5 ml lit^{-1} was significantly superior to all other treatments and recorded 72.83 per cent reduction in thrips population.

Because insect pathogens are economically viable and more environmentally safe than other methods of pest management, they fit into the concept of integrated pest management (Narayanan, 1997).

Higher efficacy of oil formulations of *B. bassiana* (Bb 112) in the present investigation might be due to the fact that the oil could coat the dry, dusty type of conidia allowing them to suspend easily in oil and spread rapidly over the surface of leaves which helps better contact of conidia with insect cuticle. The variation in virulence may be attributed to the number of conidia received by the individual pest (Bateman *et al*., 1993). Sangeetha (2013) reported that the corn oil based formulation of *B. bassiana* (Bb 101) sprayed with ULV sprayer was most effective against *Polyphagotarsonemus latus* Banks on chilli with 57.51 per cent reduction after two rounds of spraying. The present findings are also in accordance with Nugroho and Ibrahim (2007) who reported significant reduction in the population of *P. latus* sprayed with *B. bassiana* and *Paecilomyces fumosoroseus* (Wize) Brown and Smith. The findings are in accordance with Bateman *et al.* (1993)

who reported that the use of oil formulation of *Metarhizhium anisopliae* (Metschnikoff) Sorokin in ultra low volumes (ULV) was highly effective against locusts in Africa.

Being non-evaporative, oil formulation of mycoinsecticides is readily compatible with Ultra-Low Volume (ULV) application techniques for spraying at low relative humidities (Bateman, 1997). According to Bateman and Alves (2000) CDA represents a much specialised delivery system for oil formulations which can only be used with specialised application equipments (often rotary atomisers).

In laboratory conditions, thrips acts as good host for fungal pathogens, since they are generally soft bodied and inhabit environments with humid microclimates which favour infection and disease transmission (Hajek and Ledger, 1994). Whereas the field performance of different fungal candidates was dependent on both virulence to target pests and adaptation to field condition (Luz and Fargues, 1997). Multiple applications of microbial pesticides may improve the ability of infectious inoculum, thereby providing efficient control of target pests. Nevertheless, in a single spray all the population may not be encountered by *B. bassiana* and is dependent on persistence of conidia on foliage, probably because of the limited ability of individual thrips to acquire secondary conidia from the treated surface (Gatarayiha *et al*., 2011) and perhaps the effective control by fungus is largely attributed to the favourable environmental condition. Hence, the repeated applications of *B. bassiana* with the right formulation could directly target new emerging adults, thereby would provide a better control.

Impact of *Beauveria bassiana* (Bb 112) applied through different delivery equipments on green chilli yield trial

I- Kumarapalayam

Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer and Avenger ULV sprayer registered the highest yield of 23.34 and 22.94 t ha^{-1} with an yield increase of 14.80 and 12.83 per cent over untreated check (Figure 1). This was followed by Bb 112 @ 10^8 spores ml^{-1} as oil based formulation sprayed with Aspee Maruyama engine sprayer (8.26 %), Aspee Knapsack hand sprayer (7.87 %) and Aspee hitech hand sprayer (5.50 %). The plots treated with imidacloprid 17.8 SL recorded the maximum green chilli yield of 25.44 t ha^{-1} with an increase of 25.12 per cent over untreated check (20.33 t ha^{-1}).

Trial II - Ambilikkai

The higher green chilli yield was obtained in Bb 112 @ 10^8 spores ml^{-1} in oil based formulation sprayed with CDA sprayer (13.81 t ha^{-1}) followed by Avenger ULV sprayer (13.45 t ha^{-1}). Bb 112 @ 10^8 spores ml^{-1} oil formulation sprayed with Aspee Maruyama engine sprayer and Aspee hitech hand sprayer were next in order with 13.01 and 12.77 per cent increase respectively in yield over control. The standard check imidacloprid 17.8 SL recorded the highest yield of 15.36 t ha^{-1} with a yield increase of 28.21 per cent over untreated check (11.98 t ha^{-1}) (Figure 1).

The potential entomopathogenic fungi promote plant growth and improves yield by providing effectual management against pests (Dara, 2013). Present findings were in confirmation with Mikunthan and Manjunatha (2008) who reported that oil formulation of *Fusarium semitectum* Berk. and Rav. recorded higher green chilli yield both at *Kharif* and summer seasons. Chinniah *et al.* (2016) obtained 9025 kg ha^{-1} of chilli yield when sprayed with *B. bassiana* 1 x 10^8 spores ml^{-1} against sucking pests of chilli.

CONCLUSION

Environmental safety and ecosystem stability considerations lead to the conclusion that the use of native isolates in a microbial control program is more convenient (Lockwood, 1993). In Integrated Pest Management, application of right plant protection methods through right appliance may check the pest population in an effective manner. This is proved through the present result with oil based formulation of Bb 112 against chilli thrips. Hence, application of oil based formulation of Bb 112 through CDA sprayer can be very well integrated in the pest management programmes for chilli thrips.

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