



## Research Article

# Biointensive pest management strategies for the control of bud borer and blossom midge in jasmine

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**ABSTRACT:** The bud borer and blossom midge are the major pests that attack buds of jasmine, this study represents the effort to demonstrate the potential of biocontrol agents and botanicals on bud damaging insect pests of jasmine at field level. The flower bud damage due to jasmine bud borer and blossom midge were assessed at the bud initiation stage before imposing treatment. Various treatments involving botanicals, biocontrol agents and chemicals were applied to the crop during March month. Application of *Beauveria bassiana* (NBAIR formulation) at 5g/litre of water three times along with 6 releases of *Trichogramma chilonis* @100,000/ha at 7 days interval from bud initiation stage was superior in checking the bud borer damage (50 to 86%) and blossom midge (61 to 79 %). Regarding yield, treatment with *B. bassiana* (NBAIR formulation) at 5g/litre of water along with 6 releases of *T. chilonis* at 7 days interval was superior and gave 2000 kg ha<sup>-1</sup> with a cost benefit ratio of 2.50. The study revealed that integrated use of biocontrol agents and biopesticides can provide reliable and effective pest control in jasmine, while reducing pest management cost and chemical exposure to the growers and workers.

**KEY WORDS:** *Beauveria*, blossom midge, budworm, jasmine, *Metarhizium*, *Trichogramma*

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## INTRODUCTION

Tamil Nadu stands first in jasmine production and it is also an exporter (Prakash and Muniandi, 2014). The insect pests that affect the production of jasmine are bud borer, *Hendecasis duplifascialis* Hampson and blossom midge, *Contarinia maculipennis* Felt (Diptera: Cecidomyiidae) which attacks the buds (Kamala and Kennedy, 2017; Vanitha, 2001), the economic part of the crop. Bud borers bore into the unopened tight buds, reducing its size and quality. The presence of jasmine blossom midge results in necrosis of the bud stalk and dropping of the bud (David *et al.*, 1990; Kiran *et al.*, 2017; Neelima, 2005). Buds severely damaged by midge are discoloured and falls within a couple of days, reducing the productivity.

Since jasmine from Tamil Nadu is supplied all over India and exported to other countries like France, Europe, Singapore, USA, quality flowers are highly remunerative (Thakur *et al.*, 2014; Bose *et al.*, 1989) and so farmer on an average goes for seven to ten pesticide sprays during a flowering season coinciding with festive seasons. Concrete extracted from the flowers are also exported and fetches a high price. Jasmine flower is also used for flavouring tea in

countries like Thailand and Taiwan. Though a flower crop, jasmine is not preferred by pollinator like honeybees and so in the absence of this bioindicator, the ill effects of pesticides go unnoticed. The heavy use of pesticides for containing the pests costs more to the farmers and the other concern is worker safety after pesticide application as they are involved in harvesting the flower buds every day (Dhandapani *et al.*, 1989; Chandramohan and Manoharan, 1990).

With respect to flower crops, many studies are done on a small scale, in controlled conditions. The level of interaction between jasmine pests, their natural enemies and fungal pathogens is less studied. A lack of knowledge of fungal ecology, life cycles and trophic interactions is still hampering their exploitation in augmentative biological control. This study is an attempt to implement biological control programs in large scale in commercial situations with an unexploited flower crop jasmine. Since jasmine crop requires lot of labourers for harvesting, only small farmers usually take up jasmine cultivation. Such small land holdings are conducive for scouting the pest and release of biocontrol agents in appropriate time. While selecting the biological control agents for use in jasmine crop, it was ensured that the biological control agents are compatible with the conditions

in which the crop was grown. This study also represents the effort to demonstrate the potential of biocontrol agents and botanicals on jasmine crops in sub-tropical conditions of Tamil Nadu.

## MATERIALS AND METHOD

The field experiments were conducted for three consecutive years in farmer's holding at Bhavanisagar, Erode district, which is the hot spot area, to evaluate the bio-control agents against bud borer and blossom midge damage in jasmine, with eight treatments and three replications following randomised block design. Formulations of entomofungal pathogens namely ICAR-NBAIR *Beauveria bassiana* Bb-5a (GenBank JF837134) and ICAR-NBAIR *Metarhizium anisopliae* Ma-4 (GenBank JF837157) were supplied by ICAR-National Bureau of Agricultural Insect Resources, Bengaluru. The treatment details are as follows: T<sub>1</sub>- NSKE 5%/Azadirachtin 1500 ppm @ 2ml/lt, T<sub>2</sub>- *Trichogramma chilonis* @100,000/ha, T<sub>3</sub>- T<sub>2</sub> + *B. bassiana* (NBAIR formulation, 1 x 10<sup>8</sup> spores/g) @ 5g/l, T<sub>4</sub>- T<sub>2</sub> + *M. anisopliae* (NBAIR formulation, 1 x 10<sup>8</sup> spores/g) @ 5g/l, T<sub>5</sub>- Soil drenching *M. anisopliae* (NBAIR formulation, 10<sup>8</sup> spores 1 Kg/ha- two times at fifteen days interval), T<sub>6</sub>- Soil application of neem cake @ 250 kg/ha, T<sub>7</sub>- Soil application of carbofuran @ 20g/plant, T<sub>8</sub> - Untreated control.

Treatments T<sub>5</sub> to T<sub>7</sub> were implemented after pruning of the crop. Other treatments were imposed at the initiation of flowering during first week of March during 2015 to 2017 and the treatments were repeated at 7 days interval for three times. The occurrence of bud borer and blossom midge were recorded prior to treatment application and at 7 days after the application of treatments. For assessing the damage by budworm, pre-count data was recorded on total number of buds and infested buds showing holes in three randomly selected branches of each of ten plants per replication and per cent damage was worked out. The damage of bud worm was assessed by counting the flower buds with bore holes, whether buds remain white or seen with purple discoloration while that of blossom midge was determined by sampling purple coloured shriveled flowers with necrosis in the stalk from three randomly selected branches in a plant involving 10 plants per replication. Care was taken to distribute the egg cards of *Trichogramma* covering every alternate row of the plant considering the short flying distance of *T. chilonis* adults.

### Statistical analysis

The per cent flower bud infestation was calculated for bud worm and midge by using the following formula.

$$\text{Per cent flower bud infestation} = \frac{\text{Total no. of infested buds} \times 100}{\text{Total no. of buds}}$$

The data obtained from the field experiment were subjected to statistical analysis following the method suggested by Gomez and Gomez (1984). Prior to analysis, the data were subjected to  $\sqrt{x}$  transformation and the mean values of treatments were then compared using DMRT.

## RESULTS AND DISCUSSION

There were no pre-treatment differences in the numbers of bud worm and blossom midge on the jasmine plants to be sprayed or those to be left unsprayed. The data collected during 2015-16 revealed that use of *Trichogramma chilonis* @ 100,000/ha and foliar application of *Beauveria bassiana* @5g/l effectively checked the bud borer and blossom midge infestation with damage reduction of 84.19 and 68.71 % over control (Table 1). Carbofuran was found on par to this treatment in reducing blossom midge damage (71.94%) but less superior with respect to budworm. The next best bio-intensive treatment was release of *Trichogramma* and application of *Metarhizium anisopliae* @ 5g/l with 66.98 and 61.87 per cent reduction of budworm and blossom midge damage over control. Soil application of neem cake also showed similar effectiveness as that of *Trichogramma* + *M. anisopliae* application in checking the budworm (68.84%) and blossom midge (62.23%) damage over control.

The performance of the treatments in the same field during subsequent season also gave consistent results. The trials conducted during 2016-17 also revealed that T<sub>3</sub> treatment involving release of *T. chilonis* + application of *B. bassiana* caused significantly higher damage reduction amounting to 86.51 and 66.54 per cent with respect to bud borer and blossom midge, respectively (Table 2). In the second season also, carbofuran was found on par with T<sub>3</sub> treatment in managing blossom midge damage but significantly less effective for bud worm. *T. chilonis* + *M. anisopliae* application emerged as next best treatment with 70.70 and 68.87 percent reduction of bud worm and blossom midge damage and was found on par with NSKE treatment.

Similar results were also observed during the year 2017-18 (Table 3). Spraying with *B. bassiana* at 5g/litre of water three times along with 6 releases of *T. chilonis* at 7 days interval from bud initiation stage was superior in checking the bud borer with highest damage reduction of 50.18 while 79.06 per cent damage reduction was recorded with blossom midge. Other treatments recorded 23.06 to 32.27 per cent bud worm damage including chemical treatment with carbofuran granule whereas in control, the damage was 36.15 per cent. Application of Azadirachtin @ 1500 ppm @ 2ml/L, three

**Table 1. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine during 2015-16**

Treatments	Pre-Treatment		Per cent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7days after III spray		Per cent reduction over control	
	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M
T1- NSKE 5%	12.3 <sup>a</sup>	16.4 <sup>a</sup>	11.6 <sup>bc</sup>	15.2 <sup>c</sup>	9.8 <sup>ab</sup>	13.8 <sup>bc</sup>	8.4 <sup>c</sup>	11.2 <sup>c</sup>	60.93	59.71
T2 - <i>T. chilonis</i> @ 100,000/ha	14.6 <sup>a</sup>	20.5 <sup>a</sup>	12.3 <sup>c</sup>	21.6 <sup>d</sup>	9.4 <sup>ab</sup>	23.4 <sup>d</sup>	7.2 <sup>b</sup>	22.8 <sup>c</sup>	66.51	17.99
T3 – T2+ <i>B. bassiana</i> (NBAIR) @5g/l	10.5 <sup>a</sup>	15.8 <sup>a</sup>	8.4 <sup>a</sup>	13.6 <sup>b</sup>	7.2 <sup>a</sup>	11.3 <sup>b</sup>	3.4 <sup>a</sup>	8.7 <sup>a</sup>	84.19	68.71
T4 – T2+ <i>M.anisopliae</i> (NBAIR) @5g/l	16.8 <sup>a</sup>	18.4 <sup>a</sup>	12.6 <sup>c</sup>	15.8 <sup>c</sup>	9.6 <sup>ab</sup>	12.4 <sup>b</sup>	7.1 <sup>b</sup>	10.6 <sup>b</sup>	66.98	61.87
T5 –Soil drenching <i>M. anisopliae</i> (NBAIR) @ 1 Kg/ha	13.5 <sup>a</sup>	23.6 <sup>a</sup>	12.5 <sup>c</sup>	20.8 <sup>d</sup>	10.3 <sup>b</sup>	18.6 <sup>c</sup>	9.2 <sup>d</sup>	15.3 <sup>d</sup>	57.21	44.96
T6 – Soil application of Neem cake @ 250 kg/ha	12.4 <sup>a</sup>	17.5 <sup>a</sup>	10.6 <sup>b</sup>	14.8 <sup>bc</sup>	8.6 <sup>ab</sup>	11.8 <sup>b</sup>	6.7 <sup>b</sup>	10.5 <sup>b</sup>	68.84	62.23
T7- Soil application of carbofuran @ 20g/plant	15.6 <sup>a</sup>	12.8 <sup>a</sup>	12.3 <sup>c</sup>	10.5 <sup>a</sup>	9.5 <sup>ab</sup>	8.7 <sup>a</sup>	8.2 <sup>c</sup>	7.8 <sup>a</sup>	61.86	71.94
Control	14.2 <sup>a</sup>	18.3 <sup>a</sup>	17.3 <sup>d</sup>	21.6 <sup>d</sup>	18.8 <sup>c</sup>	24.5 <sup>d</sup>	21.5 <sup>c</sup>	27.8 <sup>f</sup>	-	-
SEd	NS	NS	1.79	2.03	1.57	2.54	1.23	2.06	-	-
CD (0.05%)	NS	NS	3.91	4.43	3.42	5.52	2.68	4.48	-	-

Means followed by a common letter in a column are not significantly different by DMRT at P = 0.05%; \*Mean of three replications

**Table 2. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine during 2016-17**

Treatments	Pre-Treatment		Per dent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7days after III spray		Per cent reduction over control	
	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M
T1- NSKE 5%	9.6 <sup>a</sup>	12.5 <sup>a</sup>	8.2 <sup>a</sup>	10.3 <sup>a</sup>	6.9 <sup>a</sup>	9.5 <sup>a</sup>	5.8 <sup>b</sup>	7.2 <sup>a</sup>	73.02	71.98
T2 - <i>T. chilonis</i> @ 100,000/ha	13.5 <sup>a</sup>	17.4 <sup>a</sup>	11.8 <sup>b</sup>	18.2 <sup>c</sup>	9.6 <sup>b</sup>	16.8 <sup>d</sup>	6.9 <sup>bc</sup>	15.6 <sup>c</sup>	67.91	39.30
T3 – T2+ <i>B. bassiana</i> (NBAIR) @5g/l	10.5 <sup>a</sup>	18.5 <sup>a</sup>	8.4 <sup>a</sup>	14.8 <sup>c</sup>	6.7 <sup>a</sup>	10.6 <sup>b</sup>	2.9 <sup>a</sup>	8.6 <sup>ab</sup>	86.51	66.54
T4 – T2+ <i>M.anisopliae</i> (NBAIR) @5g/l	15.6 <sup>a</sup>	16.8 <sup>a</sup>	12.1 <sup>bc</sup>	13.6 <sup>c</sup>	8.9 <sup>ab</sup>	11.2 <sup>bc</sup>	6.3 <sup>b</sup>	8.5 <sup>ab</sup>	70.70	68.87
T5 – Soil drenching <i>M. anisopliae</i> (NBAIR) @1 Kg/ha	17.2 <sup>a</sup>	14.7 <sup>a</sup>	14.6 <sup>c</sup>	12.3 <sup>b</sup>	12.8 <sup>c</sup>	10.5 <sup>b</sup>	10.7 <sup>d</sup>	8.2 <sup>ab</sup>	50.23	68.09
T6 – Soil application of Neem cake @ 250 kg/ha	14.4 <sup>a</sup>	23.4 <sup>a</sup>	11.6 <sup>b</sup>	18.3 <sup>d</sup>	9.2 <sup>b</sup>	15.6 <sup>c</sup>	7.1 <sup>c</sup>	12.4 <sup>b</sup>	66.98	51.75
T7- Soil application of carbofuran @ 20g/ plant	11.6 <sup>a</sup>	14.7 <sup>a</sup>	10.1 <sup>b</sup>	11.4 <sup>a</sup>	7.6 <sup>ab</sup>	9.9 <sup>b</sup>	5.4 <sup>b</sup>	7.2 <sup>a</sup>	74.88	71.98
Control	15.3 <sup>a</sup>	19.2 <sup>a</sup>	16.8 <sup>d</sup>	21.3 <sup>c</sup>	19.1 <sup>d</sup>	23.4 <sup>d</sup>	21.5 <sup>c</sup>	25.7 <sup>f</sup>	-	-
SEd	NS	NS	2.20	1.73	0.86	1.69	1.90	2.84	-	-
CD (0.05%)	NS	NS	5.21	4.08	2.02	3.99	4.42	6.72	-	-

Means followed by a common letter in a column are not significantly different by DMRT at P = 0.05%; \*Mean of three replications

**Table 3. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine during 2017-18**

Treatments	Pre-Treatment		Per dent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7days after III spray		Per cent reduction over control	
	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M	Bud borer	B.M
T1- Azadirachtin 1500 ppm @ 2ml/L	64.68	9.89	48.17	17.36 <sup>b</sup>	22.43 <sup>bc</sup>	8.18 <sup>a</sup>	29.71 <sup>cd</sup>	9.25 <sup>a</sup>	17.81	81.10
T2 - <i>T. chilonis</i> @ 100,000/ha	62.88	11.03	51.57	17.68 <sup>b</sup>	20.29 <sup>bc</sup>	10.59 <sup>a</sup>	29.73 <sup>cd</sup>	12.44 <sup>b</sup>	17.76	74.59
T3 – T2+ <i>B. bassiana</i> (NBAIR) @ 5g/l	61.79	10.63	46.82	17.40 <sup>b</sup>	10.17 <sup>a</sup>	9.11 <sup>a</sup>	18.01 <sup>a</sup>	10.25 <sup>ab</sup>	50.18	79.06
T4 – T2+ <i>M.anisopliae</i> (NBAIR) @5g/l	64.47	10.76	44.60	17.63 <sup>b</sup>	15.35 <sup>ab</sup>	9.46 <sup>a</sup>	23.06 <sup>ab</sup>	10.18 <sup>ab</sup>	36.21	79.20
T5 – Soil drenching <i>M. anisopliae</i> (NBAIR) @ 1 Kg/ha	64.10	10.32	45.97	17.51 <sup>b</sup>	23.07 <sup>c</sup>	32.90 <sup>c</sup>	28.53 <sup>bc</sup>	27.77 <sup>d</sup>	21.08	43.27
T6 – Soil application of Neem cake @ 250 kg/ha	63.80	10.33	47.01	16.69 <sup>b</sup>	26.56 <sup>c</sup>	37.85 <sup>c</sup>	32.27 <sup>cd</sup>	37.85 <sup>c</sup>	10.73	22.68
T7- Soil application of Carbofuran @ 20g/plant	62.02	11.16	45.72	13.24 <sup>a</sup>	25.17 <sup>c</sup>	22.13 <sup>b</sup>	30.94 <sup>c</sup>	17.77 <sup>c</sup>	14.41	63.70
Control	63.83	10.43	48.69	19.49 <sup>c</sup>	46.76 <sup>d</sup>	45.89 <sup>d</sup>	36.15 <sup>d</sup>	48.95 <sup>f</sup>	-	-
SEd	NS	NS	NS	0.3529	2.4798	1.5664	1.9168	1.3946	-	-
CD (0.05%)	NS	NS	NS	0.7569	5.3191	3.3600	4.1115	2.9915	-	-

Means followed by a common letter in a column are not significantly different by DMRT at P = 0.05%; \*Mean of three replications

times starting from bud initiation stage at 7 days interval proved significantly superior by showing only 9.25 per cent bud damage by blossom midge but was less effective with bud worm. The performance of treatment with *Trichogramma* release + *Metarhizium* application was found on par in reducing the damage by blossom midge. The remaining treatments recorded 10.18 to 37.85 per cent blossom midge damage, while it was 48.95 per cent in control.

In these trials, the potential of *Trichogramma* against budworm was augmented with the application of beneficial fungi *B. bassiana*/*M. anisopliae*. For the effective germination and infection of the entomopathogens, the highest concentration of  $10^8$  conidia/mL was used. Foliar application of *B. bassiana* and *M. anisopliae* gave effective control of both budworm and blossom midge which could be due to their infectivity on budworm larva and adults of blossom midge. Maggot of blossom midge has a concealed habit. The efficacy of *M. anisopliae* against adults of *Culicoides* midge was also reported by Ansari *et al.* (2011). Narladkar (2015) also reported the efficacy of fungal spores of *M. anisopliae* and

*B. bassiana* against larval and adult *Culicoides* midges. The results of laboratory and field studies carried out by Kamala and Kennedy (2018) showed highest maggot mortality of blossom midge with *M.anisopliae* @  $1 \times 10^8$  spores ml<sup>-1</sup> followed by *B. bassiana* @  $1 \times 10^8$  spores ml<sup>-1</sup>. Lacey *et al.* (2009) have also reported the efficacy of *B. bassiana* and *M. anisopliae* against another soft bodied insect, potato psyllid. Fungal isolates belonging to *M. anisopliae* was reported to cause higher mortality of onion fly larvae than *B. bassiana* (Davidson and Chandler, 2005).

The significant control of blossom midge achieved in the treatment involving application of *Metarhizium* may also be due to its spill over on soil or direct soil application and further effect on blossom midge pupa found in soil as it is also a rhizosphere colonizing fungi (Glare *et al.*, 2010; Lacey *et al.*, 2015). Larvae of gall midges are rarely seen in opened flowers. The flower buds dies without unfolding and the maggots pupate in the soil. Midges in the genus *Contarinia* are reported to attack a wide range of hosts. Hence soil application can be included as an effective

treatment in the management of this pest in other host crops too. As the midges overwinter in soil, their management will also reduce the risk of pest introduction during the next flowering season.

The season for jasmine crop is sunny days with humid conditions. But with intermittent rains, the pest attack increases. This ideal agroclimatic condition for jasmine might have also contributed to the success of biocontrol agents. The mean minimum and maximum temperatures and % RH of the study area during March were 22 and 34 C and 90% RH which is optimal for the germination and growth of most *B. bassiana* and *M. anisopliae* isolates.

Higher benefit: cost ratio was obtained after the application of biopesticides. The yield parameters showed that treatment with *B. bassiana* (NBAIR formulation) at 5g/litre of water along with 6 releases of *T. chilonis* at 7 days interval was superior and gave 2000 kg ha<sup>-1</sup> with a C: B ratio of 2.50 (Table 4). Though the productivity of buds was higher in chemical treatment and comparable to treatments T2 and T3, but a low B: C ratio was obtained with chemical treatment. This might be due to the higher costs of synthetic insecticides and cost of application. Being a flower crop, the integrated management practices have not kicked off in jasmine in the field conditions because of the reluctance of the farmers. This

**Table 4. Yield and Cost benefit ratio of biointensive pest management in jasmine**

Treatments	Yield Kg/ha	C: B ratio
T1- Azadirachtin 1500 ppm @ 2ml/L	1750.0 (41.83) <sup>c</sup>	2.06
T2 - <i>T. chilonis</i> @ 1,00,000/ha	1883.3 (43.40) <sup>abc</sup>	2.38
T3 – T2+ <i>B. bassiana</i> (NBAIR) @5g/l	2000.0 (44.72) <sup>a</sup>	2.50
T4 – T2+ <i>M. anisopliae</i> (NBAIR) @5g/l	1933.3 (43.97) <sup>ab</sup>	2.38
T5 – Soil drenching <i>M. anisopliae</i> (NBAIR)@ 1 Kg/ha	1583.3 (39.79) <sup>d</sup>	1.77
T6 – Soil application of Neem cake @ @ 250 kg/ha	1616.7 (40.21) <sup>d</sup>	1.69
T7- Soil application of Carbofuran @ 20g/plant	1800.0 (42.43) <sup>bc</sup>	1.93
Control	1233.3 (35.21) <sup>c</sup>	1.27
SE d	0.7337	-
CD (0.05%)	1.5738	-

Means followed by a common letter in a column are not significantly different by DMRT at P = 0.05%; \*Mean of three replications

study revealed that integrated use of biocontrol agents and biopesticides can provide reliable and effective pest control in jasmine, while reducing pest management cost and chemical exposure to the growers and workers.

The results showed that integrated use of bioagents and biopesticides can provide reliable and effective pest control in jasmine. The cost on pesticides and pest management is reduced. The environmental spill over of pesticides is reduced and there is lesser no exposure of the growers and workers to dislodgeable pesticide residues. This successful demonstration of biocontrol agents on jasmine crop leads way to the induction of biological control into mainstream floriculture

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