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Efficacy of new insecticide molecules on jasmine budworm *Hendecasis Duplifascialis* Hampson (Lepidoptera: Crambidae)

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Abstract
Jasmine bud worm, *Hendecasis duplifascialis* Hampson (Lepidoptera: Crambidae) becoming major threat in the recent years in all jasmine growing areas irrespective of cultivars. In this view the study was aimed to manage bud worm, therefore field experiment was conducted in Koppal district, Karnataka – India during kharif season in 2015-16 and 2016-17. Eight insecticides including control were evaluated for bio efficacy against jasmine bud worm. The results indicated that among the insecticides during first and second spray significantly lowest per cent of bud worm damage on jasmine at 3 DAS, 7 DAS and 10 DAS was noticed in the treatment T_1- Emamectin Benzoate (5 % SG) @ 0.25 gm / lit 8.08, 2.33, 2.00 & 5.75, 2.33, 1.42 respectively in pooled data and followed by this application of Flubendiamide (39.35 % SC) @ 0.2 ml / lit 9.17, 3.50, 2.75 & 6.50, 2.83, 1.67 during first and second spray respectively. All the insecticides showed positive effect on the control of bud worm than control. Whereas, untreated control recorded significantly highest per cent of bud damage at all intervals during both the spray (20.25, 19.00, 18.83, 17.75 & 16.17, 15.17, 15.17 & 14.58 during first and second spray respectively on pooled basis). Significant difference was noticed in flower yield indicating varied effects of treatments. T_1 and T_2 receiving Emamectin Benzoate (5 % SG) @ 0.25 gm / lit & Flubendiamide (39.35% SC) @ 0.2ml / lit respectively registered significantly higher flower yield (8119 and 7855 kg / ha). Whereas, control recorded significantly lowest flower yield of 3985 kg per ha^{-1}.

Keywords*:* Bio efficacy, botanicals, budworm, insecticides, jasmine

Introduction
Jasmine (*Jasminum sambac* Aiton.) is one of the most important fragrant flower crops grown commercially for loose flowers. Jasmine buds are used for making garlands, bouquets, decorating women's hair, for religious offerings and for the production of perfumed oils and attars. It has got importance in all religious, social and cultural ceremonies. In India, the largest area under jasmine cultivation is in Tamil Nadu and Karnataka from where it is distributed to metropolitan cities. Jasmine is cultivated in an area of more than 8,000 ha with an annual production of flowers worth Rs. 80-100 million in India. Tamil Nadu is the leading producer of jasmine in the country with an annual production of 77, 247 tonnes in an area of 9,360 ha. The production of jasmine is affected by various factors, among which, insect pests are the most divesting factor. There are about 50 different insect pest species belonging to more than eight orders harbour the varied microhabitats of the jasmine plants. The most devastating pest of jasmine is bud worm, *H Duplifascialis* and others are blossom midge (*Contarinia maculipennis* Felt.), leaf webworm (*Nausinoe geometralis* Guenee.), gallery worm (*Elasmopalpus jasminophagus* Hampson.), leaf roller, (*Glyphodes unionalis* Hubner.), and the two spotted mite (*Tetranychus urticae*. Koch.) (Lanfang *et al.*, 2007) [6]. These, leaf webworm gains major economic importance, as they cause excessive damage to silky foliage and hence the plant vitality. Jasmine leaf webworm, *Nausinoe geometralis* (Guenee) (Lepidoptera: Pyralidae) is a defoliator, reported as a serious pest in India. The caterpillars web the leaves and nibble to make holes in the leaves which are quite often reduced to mere veins. It occurred from April to October, with the OVI positional peaks in July, August and September. The severely attacked plant has the presence of 'burnt appearance' because the damaged and dried leaves remain entrapped in the web (Gunasekaran, 1989) [4]. This results in reduced vitality of plant which affects the growth of the bush and consequently the production of flower buds/flowers reduction in the subsequent year.

At present, farmers depend mostly on conventional insecticides and acaricides for managing the jasmine insect pests. This can lead to problems like resurgence, residue and resistance on jasmine ecosystem. In recent days bud worm causes greater damage by their voracious feeding habit and reduce the yield, which eventually reflects on the economy of the farmers. The budworm infestation coincides with the flowering period of *J Multiflorum* in winter. In recent years the loss of flower buds increased to the tune of 40-50 per cent, which demands special attention. Farmers of the major jasmine growing areas are approaching the agricultural universities and extension agencies for the best management of the jasmine bud worm hence there is need to give the real management of bud worm in a parcel basis. Hence present study was undertaken in Koppal, Karnataka during 2015-16 and 2016-17 to evaluate the best insecticide for the management of jasmine bud worm.

Material and methods

Investigations were carried out at Koppal Karnataka, India falling in Tunga Bhadra irrigation command under deep black soil under irrigation during 2015-16 and 2016-17. The experiment was laid out using randomized block design consisting of eight chemicals and one control. Treatments comprising of eight Insecticides T_1- Emamectin Benzoate (5 % SG) @ 0.25 gm / lit, T_2- Flubendiamide (39.35 % SC) @ 0.2ml / lit, T_3- Spinosad (2.5 % SC) @ 0.2 ml / lit, T_4- Rynaxypyr (coragen-18.5 % SC) @ 0.2 ml / lit, T5- Lambda cyhalothrin (4.9 % CS) @ 0.5ml / lit, T_6- Indoxacarb (14.5 % SC) @ 0.3ml / lit, T_7- Quinalphos (25 % EC) @ 2 ml / lit, T_8- Profenophos (50% EC) @ 2 ml / lit and one control T_9- Control (UTC).

A total number of two sprays were applied at an interval of 20 days between two sprays. The time interval was occasionally altered between sprays to 'synchronise with the flowering periods. Spraying was carried our using knapsack sprayer. Pest activity and plant damage were the two parameters considered for observation. Ten flowers from each treatment were selected randomly and the number was observed. Observations were made on the number of bud worms from each treatment, by opening the bored flower bud by hand. Observations were made on pest activity to arrive to flower damage. The observations were recorded one day before spraying and 3rd, 4^{th}, 10^{th} day after spraying for that, total number of flowers and the number of damaged flowers / plant due to bud worm. Bud worm from each treatment was counted and mean was calculated using the formula.

$$\text{Percent bored buds} = \frac{\text{Total Number of buds with bored holes}}{\text{Total number of buds collected}} \text{x } 100$$

Observations on the per cent of bud worm damage were taken up and the data were subjected to statistical analysis (Gomez and Gomez, 1984) [3], and the means were compared using Duncan's Multiple Range Test (DMRT) using SPSS 16.0 version at p= 0.05. Values are subjected to angular transformation.

Result and Discussion

Percentage of bud worm damage decreased with the advancement of spraying reaching the lowest at 10 days after spraying and was significantly influenced by insecticides. Application of the insecticides for the control of jasmine bud worm resulted in significant variations during both the spray (Table 1 & 2). The pooled data of the two year revealed that Significantly lowest percent of bud worm damage maximum with the application of Emamectin Benzoate (5 % SG) @ 0.25 gm / lit during both the years at all observations (18.83, 8.08, 2.33, 2.00 & 15.33, 5.75, 2.33 & 1.42 during 1 DBS, 3DAS, 7 DAS & 10 DAS Respectively during both years on pooled basis). Insecticides screened bud worm revealed that the synthetic Emamectin Benzoate (5 % SG) @ 0.25 gm / lit was efficient in bringing down the bud worm infestation 4.3 % & 3.16 % mean damage followed by Flubendiamide (39.35 % SC) @ 0.2 ml / lit 5.14 & 3.66 % mean damage during both the spray and both the years. 18.52 % and 14.97 % of mean incidence during both the spray (Table l & 2). Percent of reduction in the damage of bud worm by the use of Emamectin Benzoate (5 % SG) @ 0.25 gm / lit & by Flubendiamide (39.35 % SC) @ 0.2 ml / lit is 77.70, 78.90 & 72.25, 75.55 over control on pooled basis. Similar results were recorded by Dahandapani *et al.* (1989) [2], where much higher dosage level of cypermethrin 150 g A.I. / ha and deltamethrin 25 g A.I. / ha reduced the infestation by 90.1 % and 92.2 %, 81.9 % and 86.9 % in the first and second spray respectively on jasmine bud worm. On the other hand Chandramohan and Manoharan (1990) [1] reported that endosulfan at 0.07% alternated with fenvalerate at 0.015 % was effective against the jasmine budworm. The avoidable per cent of bud damage was when treated with the insecticide Profenophos (50 % EC) @ 2 ml/lit (12.47 & 9.67 % damage) and closely followed by the spray with Quinalphos (25 EC) @ 2 ml / lit and Lambda cyhalothrin (4.9 % CS) @ 0.5 ml / lit (11.42 %, 8.55%, 11.44 %, 7.80% on pooled basis during both the spray and both the years). Experimental results also documented that application of Spinosad (2.5 % SC) @ 0.2 ml / lit and Indoxacarb (15 EC) @ 0.3 ml / lit, are similar effect and on par with the control of bud worm (9.52 %, 9.80 %, 6.99%, 7.66% respectively on pooled basis). Application of Rynaxypyr (coragen-18.5% sc) @ 0.2 ml / lit also found to be best insecticide to control the jasmine bud worm in the absence of Emamectin Benzoate (5 SG) @ 0.25 gm / lit & Flubendiamide (39.35 SC) @ 0.2 ml / lit and recorded significantly on par lowest bud damage per cent (5.47 % & 4.64 % on pooled basis).

Interestingly, all the insecticides used for the control of bud worm recorded lowest per cent of damage over control (UTC) whereas the treatment control recorded significantly highest percentage of mean damage 18.52 % and 14.97 % over the insecticides during all the stages of spray and both the years on pooled basis as well.

Significant variations on yield and economics (Table 3.) also observed in the experiment by the spray of insecticides. Application of Emamectin Benzoate (5 % SG) @ 0.25 gm / lit; it recorded significantly highest yield, gross returns, net returns and B: C ratio (8119 kg / ha, Rs. 974280, Rs. 686668 & 1: 3.36 on pooled basis) compared to untreated check (5997 kg / ha, Rs. 478200, Rs. 189628 & 1:1.65 on pooled basis). Flubendiamide 39.35 SC was the next best treatment in the yield and economics of jasmine (7855 kg / ha, Rs. 942600, Rs. 650188 & 1: 3.22 on pooled basis).

Bio-Efficacy study with synthetic insecticides against budworm is exhibited in Table 1.2 & 3. The statistical scrutiny conceded the impact of treatments, spray rounds and period of observations on the insect pest's infestation on buds.

Budworm damage ranged from 4.13 to 18.52 % during first spray and 3.16 to 14.97 % during second spray. Considering the overall mean infestation over spray rounds as well as period of observations during Bothe years on pooled basis affirmed most effectiveness of Emamectin Benzoate (5 % SG) @ 0.25 gm / lit; it recorded the least infestation and highest flower yield and more B: C ration and it was able to reduce the infestation by more than 77 & 78.90 per cent compared to untreated check. Flubendiamide 39.35 SC (72.25 & 75.55 per cent) was the next best treatment followed by Rynaxypyr (coragen-18.5 % SC) @ 0.2 ml / lit (70.47 % & 69.00 %) and Spinosad (2.5 % SC) @ 0.2 ml / lit (48.60 % & 53.30 %) over untreated control. Other treatments could reduce the infestation by less than 40 percent only.

Flubendiamide 39.35 SC @ 0.0.2 ml / lit and Emamectin Benzoate (5 % SG) @ 0.25 gm / lit belongs to the main group of Ryanodine receptor modulators and chemical sub group of diamide (IRAC, 2009) [5]. They inhibit the nerve and muscle action in insects. These two insecticides were used against broad spectrum of lepidopterous insects. These molecules affect intercellular Ca2 + channels (Omkar Gavkare *et al.*, 2013) [8]. Earlier reports of effectiveness of Flubendiamide 39.35 SC @ 0.0.2 ml / lit and Emamectin Benzoate (5 % SG) @ 0.25 gm / lit against bud worm, *H Duplifascialis* (Hampson) infesting *Jasminum multiflorum* (Reddy *et al.*, [9] 2016) was recorded lowest larval population with higher yield. (Merlin Kamala, 2017; Samata *et al.*, 2019) [7, 10] reported that flubendiamide 480 SC @ 0.5 ml / lit proved its superiority in managing budworm against leaf and flower feeders in jasmine.

Table 1: Effect of newer insecticide molecules against jasmine budworm (pooled data 2015-16 and 2016-17), (I spray)

Treatments	Per cent Bud Worm Damage				Mean damage	% reduction over control
	1DBS	3 DAS	7 DAS	10 DAS		
T_1- Emamectin Benzoate (5% SG) @ 0.25 gm / lit	18.83 (27.14)	8.08 (17.94)^a	2.33 (7.85)^a	2.00 (7.33)^a	4.13	77.70
T_2- Flubendiamide (39.35% SC) @ 0.2ml / lit	18.83 (27.85)	9.17 (18.72) ^{ab}	3.50 (8.45)a	2.75 (9.26) ^{ab}	5.14	72.25
T_3- Spinosad (2.5% SC) @ 0.2ml / lit	20.08 (27.13)	11.83 (21.82)^{cd}	7.83 (15.06)^b	8.92 (14.76)c	9.52	48.60
T_4- Rynaxypyr(coragen-18.5%sc) @ 0.2ml / lit	19.75 (27.73)	9.33 (19.06)^{bc}	3.92 (9.68)a	3.17 (10.04)^b	5.47	70.47
T_5- Lambda cyhalothrin (4.9% CS) @ 0.5ml / lit	19.42 (27.27)	14.83 (24.84)^{cde}	8.58 (17.11) ^{bc}	10.00 (17.56)^{cd}	11.14	39.90
T_6- Indoxacarb (14.5% SC) @ 0.3ml / lit	19.33 (26.79)	12.92 (22.09) cd	7.08 (15.27)bc	9.42 (17.40)cd	9.80	47.08
T_7- Quinalphos (25% EC) @ 2 ml / lit	19.50 (28.29)	14.58 (23.57)^{de}	9.00 (17.90)^{cd}	10.67 (19.04)^{de}	11.42	38.33
T_8- Profenofos (50% EC) @ 2 ml / lit	20.92 (27.37)	14.92 (24.71)^e	10.25 (19.39) ^{d}	12.25 (20.97)^e	12.47	32.66
T_9- Control (UTC)	20.25 (26.78)	19.00 (25.84)^f	18.83 (25.95)^e	17.75 (24.21)^f	18.52	-
S.Em ±	-	0.41	0.96	0.95		-
C.D. at 5%	NS	1.25	2.94	2.86		-
CV%	-	8.27	11.19	10.57		-

Data in the parentheses are angular transformed values, DBS - Day before Spray, DAS - Days after Spray

Table 2: Effect of newer insecticide molecules against jasmine budworm (pooled data 2015-16 and 2016-17), (II spray)

Treatments	Per cent Bud Worm Damage				Mean Damage	% reduction over control	Yield (Kg/ha)
	1DBS	3 DAS	7 DAS	10 DAS			
T_1- Emamectin Benzoate (5% SG) @ 0.25 gm / lit	15.33 (25.34)	5.75 (16.94)^a	2.33 (8.74)^a	1.42 (7.65)^a	3.16	78.90	8119a
T_2- Flubendiamide (39.35% SC) @ 0.2ml / lit	15.00 (25.82)	6.50 (18.10)^{ab}	2.83 (10.73)^a	1.67 (9.34)^{ab}	3.66	75.55	7855b
T_3- Spinosad (2.5% SC) @ 0.2ml / lit	16.17 (26.43)	7.83 (20.11)^{cd}	6.08 (15.31)^b	7.08 (16.57)^c	6.99	53.30	6788d
T_4- Rynaxypyr (coragen-18.5%sc) @ 0.2ml / lit	15.58 (26.79)	7.25 (19.21)^{bc}	3.67 (11.47)^a	3.00 (9.58)^b	4.64	69.00	7572c
T_5- Lambda cyhalothrin (4.9% CS) @ 0.5ml / lit	15.33 (27.03)	9.00 (24.21)^{cd}	7.00 (16.42)^{bc}	7.42 (18.57)^{cd}	7.80	47.89	6137g
T_6- Indoxacarb (14.5% SC) @ 0.3ml / lit	15.50 (27.09)	8.33 (21.68)^{cd}	6.83 (13.92)^{bc}	7.83 (17.40)^{cd}	7.66	48.83	7233e
T_7- Quinalphos (25% EC) @ 2 ml / lit	15.08 (26.20)	9.25 (23.70)^{de}	7.92 (16.73)^{cd}	8.50 (19.33)^{de}	8.55	42.88	6637f
T_8- Profenofos (50% EC) @ 2 ml / lit	15.25 (27.13)	10.50 (23.31)^e	8.92 (18.68)^d	9.67 (20.82)^e	9.69	35.27	5997h
T_9- Control (UTC)	16.17 (27.03)	15.17 (26.20)^f	15.17 (26.08)^e	14.58 (24.85)^f	14.97	-	3985i
S. Em ±	-	0.36	0.69	1.18	-	-	49.94
C.D. at 5%	NS	1.08	2.08	3.54	-	-	155.90
CV%	-	7.92	7.86	12.79	-	-	7.90

Data in the parentheses are angular Transformed Values, DBS - Day before Spray, DAS - Days after Spray

Table 3: Yield and economics of jasmine influenced by effect of newer insecticide molecules against jasmine budworm (pooled data 2015-16 and 2016-17)

Treatments	Mean yield (kg / ha)	Gross income	Net income	C: B ratio
T_1- Emamectin Benzoate (5% SG) @ 0.25 gm / lit	8119	974280.00	686668.00	1:3.36
T_2- Flubendiamide (39.35% SC) @ 0.2ml / lit	7855	942600.00	650188.00	1:3.22
T_3- Spinosad (2.5% SC) @ 0.2ml / lit	6788	814560.00	525528.00	1:2.81
T_4- Rynaxypyr(coragen-18.5% SC) @ 0.2ml / lit	7572	908640.00	616548.00	1:3.11
T_5- Lambda cyhalothrin (4.9% CS) @ 0.5ml / lit	6137	736440.00	447532.00	1:2.54
T_6- Indoxacarb (14.5% SC) @ 0.3ml / lit	7233	867960.00	579028.00	1:3.00
T_7- Quinalphos (25% EC) @ 2 ml / lit	6637	796440.00	506188.00	1:2.74
T_8- Profenofos (50% EC) @ 2 ml / lit	5997	719640.00	429508.00	1:2.48
T_9- Control (UTC)	3985	478200.00	189628.00	1:1.65
S.EM±	49.94	-	-	-
C.D. at 5%	155.90	-	-	-
CV%	7.90	-	-	-

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