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Field evaluation of insecticides for the management of cucumber moth, *Diaphania indica* (Saunders) (Lepidoptera: Crambidae) on bitter gourd

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Abstract
An experiment was conducted on the efficacy of selective insecticides against cucumber moth, *Diaphania indica* Saunders on bitter gourd under randomized block design at student farm, College of Agriculture, Raichur, Karnataka during rabi, 2016-2017. The objective of this study was to investigate the most effective insecticide against the *Diaphania indica* population. Different groups of chemicals were selected and the treatments were imposed as foliar sprays by using a hand compression knapsack sprayer of about 500 lit/ ha spray fluids against the cucumber moth. Among the different newer molecules, chlorantraniliprole 18.5% SC at 0.2ml/l, flubendiamide 48% SC at 0.15 ml/l and spinosad 45 SC at 0.12ml/l recorded high per cent reduction of *D. indica* population of 86.85, 79.36 and 75.22 per cent, respectively when compared to emamectin benzoate 5% SG at 0.2g/l (64.17%), dichlorvos 76% EC at 0.5ml/l (61.08%), Azadirachtin 1500 ppm at 3ml/l (53.09%) and *Bacillus thuringiensis* 2ml/l (49.48%) after third spray. Thus chlorantraniliprole 18.5% SC (0.2ml/l) was adjudged as the best and effective treatment in checking *D. indica* population.

Keywords: bitter gourd, cucumber moth, *Diaphania indica***,** insecticides

Introduction
Bitter gourd (*Momordica charantia* L.) a member of cucurbitaceae is a cross-pollinated plant. It is a common vegetable grown in Asia and other parts of the world. Bitter gourd is one of the most popular vegetables in Southeast Asia and native to India. The fast growing vine is grown throughout Asia and is becoming popular worldwide. Bitter gourd is an important commercial vegetable in selected pockets of Karnataka, where it is cultivated in large areas. *Diaphania indica* Saunders, *Liriomyza trifolii* Burgess, *Bactrocera cucurbitae* Conquillett, *Aphis gossypii* Glover and *Thrips palmi* Koch were identified as main pests of bitter gourd. Among these, *D. indica* (Crambidae: Lepidoptera) is a serious pest on bitter gourd during June and October [23]. Cucumber moth is posing serious threat to bitter gourd cultivation [8, 1]. Cucumber moth damaging other cucurbits such as Gherkins (*Cucumis anguria*), watermelon (*Citrullus lanatus*), musk melon (*Cucumis me/o*), squash (*Curcubita maxima, I moschata*), cucumber (*Cucumus salivus*), pumpkin (*Curcurbila moschata*), bottle gourd (*Lagenaria* siceraria), sponge gourd (*Luffa* aegyptiaca), ridge gourd (*Luffa acutangu/a*), coccinia (*Coccinia grandis*) and snake gourd (*Trichosanthes cucumerina*) [29].
The cucumber moth, *Diaphania indica* (Saunders) (Lepidoptera: Crambidae), is a polyphagous pest and is particularly serious on cucurbits. Larvae mainly attack leaves, but also infest flowers and fruits, and cause considerable yield loss during outbreak. It is also known as the cotton caterpillar and pumpkin caterpillar [4, 21, 27]. This species is mostly distributed in Pakistan, India, Japan, Pacific Islands, Australia, Africa, and South America.
On hatching, larvae feed on leaves where they cluster and fold and weave the leaves together. They can also feed on and puncture the skin of young fruit, especially the fruits that touch leaves. The damage by larvae has been reported to be restricted to leaves of pointed gourd which ranged from 25 to 30 per cent while in bitter gourd it was 3 to14 per cent. The incidence of *Diaphania nitidalis* (Stoll) and aphids as major pests in bitter gourd crop from Suriname. In view of increasing pest attack of bitter gourd, the present study was undertaken to investigate the efficacy of selective insecticides against cucumber moth was carried out at student farm, College of Agriculture, Raichur, Karnataka during rabi, 2016-2017.

Materials and Methods

A field experiment was laid out in a simple randomized block design with eight treatments and three replications during rabi, 2016-17 at the Student's Farm, College of Agriculture, Raichur, Karnataka, India to study the efficacy of eight insecticides viz., chlorantraniliprole 18.5% SC at 0.2ml/l, flubendiamide 48% SC at 0.15 ml/l, spinosad 45% SC at 0.12ml/l, emamectin benzoate 5% SG at 0.2g/l, dichlorvos 76% EC at 0.5ml/l, Azadirachtin 1500 ppm at 3ml/l and *Bacillus thuringiensis* 2ml/l against cucumber moth, *Diaphania indica* on bitter gourd. The bitter gourd crop variety Green long was sown during September 2016 and all the agronomic practices were followed to raise the crop [2]. A plot size of 5 m x 5 m having 5 rows spaced at 1 m and between plants 1 m was maintained for each treatment. The bitter gourd crop was sprayed thrice at 50, 70 and 90 days after sowing. Treatments were imposed as foliar sprays after taking pretreatment counts and coinciding substantial level of infestation and repeated depending on necessity.

Preparation of spray fluid

A measured quantity of insecticide was mixed with a little quantity of water and stirred well, after which the remaining quantity of water was added to obtain the required concentration of spray fluid. In case of wettable granules the required quantities were taken first and mixed with a little quantity of water to dissolve and then the remaining quantity of water was added to obtain the desired concentration and stirred well.

Application of treatments

Sprayings were given by using a hand compression knapsack sprayer with spray fluid of 500 lit/ha during morning hours. The plants in each treatment were sprayed with respective insecticide ensuring uniform coverage of insecticide. The sprayer and the accessories were thoroughly washed before changing the insecticides and also rinsed with the spray fluid of the chemical to be applied next.

Field observations and recording of data

Regular counts of insect population were recorded in each plot on 10 randomly selected labeled plants for each observation. Observations on the pest incidence were recorded one day before the spraying as pre-treatment counts and on first, third, seventh and tenth days after spraying as the post-treatment counts. Three sprays were given at an interval of twenty days and data on the overall efficacy of three sprays were present. The number of larvae was recorded on each of the ten randomly selected plants from each plot.

Statistical analysis

The per cent reduction of the population of cucumber moth over untreated control in different treatments was calculated using the Abbott's formula [7] as given below:

$$\text{Per cent population reduction} = \left[1 - \left[\frac{\text{Post - treatment population in treatment}}{\text{Pre - treatment population in treatment}} \text{X} \frac{\text{Pre treatment population in control}}{\text{Post treatment population in control}}\right]\right] \text{X100}$$

These values were transformed to the corresponding angular values and the data were subjected to statistical scrutiny.

From each plot 10 plants were selected randomly and after harvesting the fruits were sorted out as good fruits and damaged fruits and per cent damage was computed using the formula given below.

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits observed in 10 plants}}{\text{Total number of fruits in 10 plants}} \times 100$$

Data was analyzed statistically after subjecting to square root transformation

(F-test) for larval population and angular transformation for per cent damage to determine the effective insecticide and the per cent reduction over control in each treatment. Fruit yield for each treatment was converted to tons per hectare and subjected to statistical analysis. The data was analyzed by following the statistical procedure suggested by Gomez and Gomez [9].

Results and Discussion

The larval population of *D. indica* varied from 3.10 to 3.40 a day before the third spray. However, no significant difference was observed among the treatments (Table 1). The data recorded three days after spray indicated that all treatments were significantly superior over the untreated control in recording minimum larval population which ranged from 0.60 to 3.80. The treatment with chlorantraniliprole 18.5 SC was found to be superior by recording lowest larval population (0.60/plant) and was on par with flubendiamide 48 SC (0.90/plant) and spinosad 45 SC (1.00/plant). This was followed by emamectin benzoate 5 SG (1.50/plant) and dichlorvos 76 EC (1.60/plant) and these were found at par with each other and superior over control. Larval population varied significantly among the treatment after seven days of third spray (0.50 to 3.88/plant). Among these chlorantraniliprole 18.5 SC excelled by recording minimum larval population (0.50/plant) and was at par with flubendiamide 48 SC (0.80/plant), spinosad 45 SC (0.97/plant). This was followed by emamectin benzoate 5 SG and dichlorvos 76 EC (1.37 and 1.50 larva/plant respectively).Ten days after spraying number of larvae per plant ranged from 0.43 to 3.97 larvae in different treatments. Significantly lowest number of 0.43 larva per plant was noticed in chlorantraniliprole 18.5 SC and this was on par with flubendiamide 48 SC (0.67/plant) and spinosad 45 SC (0.90/plant). This was followed by emamectin benzoate 5 SG, dichlorvos 76 EC, Azadirachtin 1500 ppm and *Bacillus thuringiensis* with a larval population of 1.30, 1.43, 1.77 and 1.83 larvae per plant respectively.

These results were in agreement with Vinod [28]. These results were also in agreement with Hosamani *et al.* [11] who reported that rynaxypyr at 30 g a.i/ha recorded minimum larval population of *Spodoptera litura*, *Spodoptera exigua* and *Helicoverpa armigera*) in chilli. According to Bhosale *et al.* [3] rynaxypyr at 30 g a.i/ha was found to be most effective in controlling the pod borer, *Helicoverpa armigera*, plume moth, *Exelastis atomosa* and was on par with its higher dose of rynaxypyr at 40 g a.i/ha. Similarly results were also in line with the work of Jarrod *et al.* [13]; Misra [20]; Rajavel *et al.* [22]; Singh *et al.* [24] and Kalita and Ahmed [15]. Fanigliulo *et al.* [6] treatment with chlorantraniliprole + lambda-cyhalothrin mixture was significantly more effective than the one with emamectin benzoate in reducing the attack of *T. absoluta* on tomato fruits.

The observations recorded third spray which was considered as cumulative effect of all the sprays (Table 1). The observations made with regard to the reduction of *D. indica* population at ten days after spraying indicated that all the treatments were significantly superior to control. Among the insecticides which were evaluated for its efficacy on the larval population of *D. indica* during third spray chlorantraniliprole 18.5 SC recorded highest per cent reduction (86.85%) over untreated control and was at par with flubendiamide 48 SC (79.63%) which recorded the higher per cent reduction over untreated control The next best treatments which recorded higher larval reduction were spinosad 45 SC (75.22%), emamectin benzoate 5 SG (64.17%) and dichlorvos 76 EC (61.00%) and these were found superior over rest of the treatments. However, Azadirachtin 1500 ppm and *Bacillus thuringiensis* also recorded 53.09 and 49.48 per cent larval reduction respectively. This statement was in agreement with the findings of Hirooka *et al.* [10] and Tohinshi *et al.* [26]. The results are also in agreement with the findings of Ebbinghaus *et al.* [5] against *H. armigera* and *S. exigua* on tomato, Jagginavar *et al* [12] against *L. orbanalis* on brinjal, Tatagar *et al.* [25] against *H. armigera* and *S. litura* on chilli, and Latif *et al.* [17] against *L. orbanalis* on brinjal.

Jyothsna *et al.* [14] reported that among the different newer molecules, flubendiamide 480 SC at 60 g a.i. ha^{-1}, combination product of flubendiamide 480 SC + thiacloprid 240 SC at 48 + 48 g a.i. ha^{-1} and lambdacyhalothrin 5 SC at 18.75 g a.i. ha^{-1} recorded high per cent reduction of *D. indica* population to 65.50, 62.12 and 59.22 per cent, respectively. Lenin [18] reported that flubendiamide 0.004 per cent and spinosad 0.015 per cent proved to be the better treatments, registering mortality of the pest up to 15 days after treatment.

The observation on per cent fruit damage revealed significant differences among the treatments (Table 2). Among the various treatments chlorantraniliprole 18.5 SC recorded significant minimum fruit damage (9.50%) followed by flubendiamide 48 SC (10.33%) and these were found significantly superior over the the treatments. However spinosad 45 SC, emamectin benzoate 5 SG, dichlorvos 76 EC, Azadirachtin 1500 ppm and *Bacillus thuringiensis* recorded 11.26, 13.61, 15.45, 16.57 and 18.91 per cent fruit damage respectively and these were superior over untreated control (23.51%).

Significantly higher fruit yield of 8.40 t/ha was recorded in chlorantraniliprole 18.5 SC at 0.20 ml/l. The next best treatment was flubendiamide 48 SC 0.15 ml/l and spinosad 45 SC at 0.12 ml/l which recorded 8.13 t/ha and 7.90 t/ha fruit yield which were on par with each other. This was followed by emamectin benzoate 5 SG, dichlorvos 76 EC, Azadirachtin 1500 ppm and *Bacillus thuringiensis* which recorded 7.67, 7.50, 7.27 and 7.07 t/ha of fruit yield respectively Significantly lowest yield was recorded in untreated control (6.33t/ha). According to Kameshwaran and Kumar [16] the highest yield was observed in the treatment with chlorantraniliprole 20 SC at 40 g a.i./ha (27.08 t/ha) against brinjal fruit shoot borer. Similarly Mainali [19] reported that chlorantraniliprole treated plot recorded the maximum marketable yield (32.03 t/ha) followed by Spinosad (30.93 t/ha) with 34.39 percent and 29.77 percent increase in marketabl fruit yield over untreated check, respectively in brinjal fruits. No earlier reports are available on fruit yield on cucurbits.

Conclusion

Chlorantraniliprole 18.5% SC (0.2ml/l) was adjudged as the best and effective treatment in checking *D. indica* population followed by flubendiamide 48% SC at 0.15 ml/l and spinosad 45 SC at 0.12ml/l.

Table 1: Efficacy of different insecticides against *Diaphania indica* on bitter gourd after third spray.

Sl. No.	Treatments	Dosage (ml/g/l)	Number of larvae per plant				Mean	Per cent reduction over control
			Third spray					
			1 DBS	3 DAS	7 DAS	10 DAS		
1	Flubendiamide 48% SC	0.15 ml	3.20(1.92)	0.90(1.17)	0.80(1.13)	0.67(1.08)	0.79	79.63
2	Spinosad 45% SC	0.12 ml	3.00(1.85)	1.00(1.21)	0.97(1.20)	0.90(1.18)	0.96	75.22
3	Chlorantraniliprole 18.5% SC	0.2 ml	3.10(1.88)	0.60(1.03)	0.50(1.00)	0.43(0.96)	0.51	86.85
4	Emamectin benzoate 5% SG	0.2 g	3.13(1.91)	1.50(1.41)	1.37(1.36)	1.30(1.34)	1.39	64.17
5	Dichlorvos 76% EC	0.5 ml	3.17(1.91)	1.60(1.46)	1.50(1.41)	1.43(1.38)	1.51	61.08
6	Azadirachtin 1500 ppm	3 ml	3.28(1.91)	1.90(1.55)	1.80(1.50)	1.77(1.50)	1.82	53.09
7	*Bacillus thuringiensis* (NBAII *Bt* G4)	2 ml	3.37(1.94)	2.07(1.60)	2.00(1.59)	1.83(1.52)	1.96	49.48
8	Untreated control		3.40(1.97)	3.80(2.07)	3.88(2.07)	3.97(2.11)	3.88	
S.Em.±				0.06	0.09	0.06		
CD @ 5%			NS	0.18	0.28	0.19		

DBS – Day before spraying; DAS – Days after spraying; NS – Non significant
Figures in the parenthesis are √x+0.5 transformed values.

Table 2: Efficacy of different insecticides on fruit damage and fruit yield by *D. indica*

Sl. No.	Treatment	Dosage (g or ml/l)	Per cent fruit Damage	Fruit yield (t/ha)
1	Flubendiamide 48% SC	0.15 ml	10.33(18.73)	8.13
2	Spinosad 45% SC	0.12 ml	11.26(19.56)	7.90
3	Chlorantraniliprole 18.5% SC	0.2 ml	9.50(17.91)	8.40
4	Emamectin benzoate 5% SG	0.2 g	13.61(21.63)	7.67
5	Dichlorvos 76% EC	0.5 ml	15.45(23.11)	7.50
6	Azadirachtin 1500 ppm	3 ml	16.57(23.96)	7.27
7	*Bacillus thuringiensis*	2 ml	18.91(23.74)	7.07
8	Untreated control		23.51(28.97)	6.33
	S.Em.±		0.80	0.43
	CD @ 5%		2.46	1.30

Figure in parentheses are arcsine transformed values

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