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EFFECTS OF MICROBIAL, BOTANICAL AND SYNTHETIC INSECTICIDES AGAINST BUD BORER, *HELICOVERPA ARMIGERA* ON MARIGOLD

V. Sridhar, N.S. Nagegowda*, S. Onkaranaik and C. Manasa

Division of Crop Protection, ICAR-Indian Institute of Horticultural Research, Hessaraghatta Lake P.O, Bengaluru-560 089.Karnataka India

*Corresponding author E-mail: nsngowda2192@gmail.com

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ABSTRACT

Field trials were conducted to evaluate the effect of microbials, botanicals and synthetic insecticides against bud borer, *Helicoverpa armigera* infesting chick pea *viz.,* Bt, Azadirachtin 1% EC, NSPE 5%, thiodicarb 75 WP, spinosad 45 SC, chlorantraniliprole 18.5SC,emamectin benzoate 5SG, lambda cyhalothrin 5 EC. The experiment was laid out in Randomized Block Design with three replications for three consecutive years (2018-19, 2019-20 and 2020-21).The results revealed that thiodicarb 75 WP, spinosad 45 SC, chlorantraniliprole 18.5 SC were found to be best by registering minimum bud borer incidence *i.e.* 89.87, 83.65 and 80.35 per cent reduction over control, respectively. This was followed by emamectin benzoate 5 SG (75.75 %), lambda cyhalothrin 5EC (74.17 %), Bt (71.26 %). The botanicals, NSPE 5% and Azadirachtin 1% EC were found to be least effective with lesser reduction (57.14 and 55.99 %, respectively). The plot treated with thiodicarb 75 WP and chlorantraniliprole 18.5 SC recorded the maximum flower yield and B: C ratio in all three consecutive years followed by spinosad 45 SC and emamectin benzoate 5 SG.

***Keywords*:** Marigold, Bud borer, *Helicoverpa armigera*, Bt, botanicals and synthetic insecticides

Introduction

Marigold is one of the most commonly grown flowers for garden decoration and extensively used as loose flowers for making garlands for religious and social functions. African Marigolds [*Tagetes erecta*] and French Marigolds [*Tagetes patula*] are common types commercially cultivated. Marigolds are ideal for making garlands. The demand for Marigold flowers during Dussehra and Diwali is very high (Singh *et al*., 2019). Marigold gained popularity amongst of its easy culture and wide adaptability. Its habit of free flowering, short duration to produce marketable flowers, wide spectrum of colour, shape, size and good keeping quality make marigold as acceptable commercial crop. Marigold had an important economic values, its cropping knew a continuous increase in the last years due to its usage in a more and more large area in the pharmaceutics and cosmetic domain (Coradini *et al*., 2012). In India, marigold is one of the most commonly grown cut flower and extensively used in religious and social occasions in the one form or other. In spite its uses are well known to decorate the marriage homes, restaurant, temples, receptions, farewells, birthday occasion, wedding ceremonies and various public and social events. Large scale intensive cultivation of marigold has destabilized the crop-pest equilibrium and invited a number of problems. Attack by insect pests is one of the important bottlenecks for successful production of these crops.

The attack by insects and mite pests increased manifold in the recent past. Various species of insect-pests *viz.* thrips, aphids, leaf hoppers, scale insects, bugs, leaf miners mealy, caterpillars, cut worms and chaffer beetles attack marigold (Anon, 2014). Moreover, some new pests are appearing to invade the crop mainly due to the recent climate change and shift in crop culture methods. Several workers have reported a number of pests infesting the crop from various parts of the country, among them bud borer is causing major damage to marigold. Information on pests infesting a crop is an essential prerequisite for developing a suitable pest management strategy particularly in the context of ever changing pest scenario. Since, very little information is available on the pests of marigold, the present study was proposed to investigate the bud borer infestation in marigold.

Material and Methods

The field experiments were conducted for three consecutive years at ICAR- Indian Institute of Horticultural Research, Bengaluru. The bioefficacy of Neem, Bt and synthetic insecticides were evaluated against bud borer in marigold. The experiment was laid out in randomised block design with nine treatments and three replications. The treatment details are represented in Table 1. The treatments T1 to T3 (Azadiracthin 1%, NSPE 5% and Bt) were scheduled at 10 days interval while other insecticide treatments, T4 to T8 applied at 14 days intervals. The observation was recorded after 3, 7, 10 and 14 days after the application of treatments. Ten random plants per replication were selected and the observations were made on no. of damaged flowers and total flowers from randomly picked three branches of the plant. The per cent flower bud infestation was calculated for bud worm by using the following formula.

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

The mean original data of per cent bud damage was calculated as percentage reduction over control with following formula (Abbott's, 1925)

$$\text{Per cent reduction} = \frac{\text{Percentage flower bud damage in control} - \text{Per cent flower bud damage in control}}{\text{Percentage flower bud damage in control}} \times 100$$

Statistical Analysis

The data obtained from the field experiment were subjected to statistical analysis using WASP 2.0 software package following the method suggested by Gomez and Gomez (1984). Prior to analysis, the data were subjected to arc sine transformation and the mean values of treatments were then compared using DMRT.

Table 1: Treatment details and dosages

Tr. No.	Treatments	Dose
T1	Azadirachtin 1% EC	3ml/l
T2	Bt (Dipel)	1ml/l
T3	NSPE 5%	50ml/l
T4	Spinosad 45 SC	0.25ml/l
T5	Thiodicarb 75 WP	1g/l
T6	Lambda Cyhalothrin 5EC	0.5ml/l
T7	Emamectin Benzoate 5SG	0.4g/l
T8	Chlorantraniliprole 18.5SC	0.3ml/l
T9	Control	-

Results and Discussion

The analysis of the data revealed a significant reduction of bud borer infestation across the treatments over control in all three consecutive years. The results pertaining to borer incidence, yield and Benefit: Cost (B: C) ratio are represented here.

The results of the year 2018-19 revealed that, thiodicarb 75 WP @ 1g /l was most effective across the treatments by recording a significant maximum per cent larval population reduction (93.34 %) (Table 2). The next best treatment was spinosad 45 SC at 0.25 ml/l that registered 81.62 % reduction of borer incidence over control. This was followed by chlorantraniliprole 18.5 SC (0.3 ml/l) with 79.03 per cent reduction, emamectin benzoate 5 SC (78.55 %), lambda cyhalothrin 5 EC (75.33 %). Bt @ 1 ml/l recorded percent borer reduction of 75.09 and was found on par with lambda cyhalothrin 5 EC. The botanicals NSPE 5% @ 50 ml/l and azadirachtin 1% EC recorded the minimum per cent borer population reduction (66.53 and 58.7 %, respectively) and was found to have lesser efficacy against borer, *H. armigera* incomparison to synthetic and microbial insecticide.

The yield data indicates, that the plots treated with thiodicarb 75 WP registered highest yield (19.27 t/ha) of flowers and this was followed by chlorantraniliprole 8.5 SC with 19.27 t/ha. The next best was spinosad 45 SC and emamectin benzoate 5 SG which recorded 17.04 t/ha (16.79 t/ha) and was followed by lambda cyhalothrin 5 EC (15.56 t/ha). The bio pesticide Bt registered yield of 13.34 t/ha followed botanical treated plots registering lesser yield (azadirachtin 1% EC- 10.37 and NSPE 5 % -9.63 t/ha), however significantly superior over control.

The B: C ratio followed similarly with the trend of yield and bud borer incidence (Table 2). The plots treated with the thiodicarb 75 WP recorded the highest B:C ratio of 2.89 wherein minimum was reported in control. The trend of B:C ratio across the treatments is thiodicarb 75 WP> chlorantraniliprole 8.5 SC> emamectin benzoate 5 SG> spinosad 45 SC> lambda cyhalothrin 5 EC>Bt> azadirachtin 1% EC> NSPE 5 %.

The trend of borer population in the year 2019-20 across the treatments was similar to the population developed during the year 2018-19 (Table 3). The larval population reduction ranged from 52.39 to 92.88 per cent. The efficacy of synthetic insecticide, thiodicarb 75 WP was significantly higher in comparison to other insecticides as it registered the maximum reduction of borer incidence *i.e.* 92.88 per cent. This was followed by spinosad 45 SC with 87.49 per cent population reduction. The next best treatment was cholrantraniloprole 18.5 SC with 73.21 per cent, Bt (71.52 %), lambda cyhalothrin 5 EC (70.82%), azadirachtin 1% EC (54.09). NSPE 5% recorded the lowest population reduction by displaying 52.39 per cent reduction over control.

The yield across the treatments registered a similarity with the borer incidence where in plots treated with thiodicarb 75 WP and chlorantraniliprole 18.5 SC registered highest yield with 18.52 t/ha and was followed by spinosad 45 SC and emamectin benzoate 5 SG with 16.30 t/ha. The next best yield was recorded by lambda cyhalothrin 5 EC with 14.82 t/ha. Bt recorded 12.60 t/ha and was followed by NSPE 5% (12.60 t/ha) and Azadirachtin 1 % EC (9.63 t/ha).

From table 2, it is evident that thiodicarb 75 WP and chlorantraniliprole 18.5 SC recorded highest B: C ratio *i.e.*, 2.90 and 2.84, respectively against control (1.07). Emamectin benzoate 5SG and spinosad 45 SC followed chlorantraniliprole 18.5 SC by registering 2.56 and 2.51. The other treatments in order of B: C ratio were lambda cyhalothrin 5 EC>Bt>NSPE> Azadirachtin 1% EC.

The results of the experiment conducted revealed that, chlorantraniliprole 18.5 SC was significantly superior over other treatments by recording 88.80 per cent reduction in bud borer population. This was followed by thiodicarb 75 WP and spinosad 45 SC which recorded 83.38 and 81.84 per cent reduction, respectively. Emamectin benzoate 5 SG, lambda cyhalothrin 5 EC recorded a population reduction of 79.09 and 76.35 per cent. The botanicals, azadirachtin 1 % EC and NSPE 5 % were least effective against borer and registered 55.14 and 52.49 per cent reduction over control.

The table 4 reveals that thiodocarb 75 WP treated plots recorded higher yields (19.27 t/ha) and was found superior to other treatments. This was followed by chlorantraniliprole 18.5 SC with 18.52 t/ha and was on par with thiodicarb 75 WP. The order of yield with other treatments is emamectin benzoate 5 SG > spinosad 45 SC = lambda cyhalothrin 5 EC> Bt>NSPE 5 %=azaditachtin 1% EC.

The B: C ratio was found higher in thiodicarb 75 WP and chlorantraniliprole 18.5 SC (2.78 and 2.62, respectively).This was followed by emamectin benzoate 5 SG (2.45), lambdacyhalothrin 5 EC (2.38), spinosad 45 SC (2.29), Bt (1.86), NSPE 5 % (1.66) and Azadirachtin (1.27). All the treatments had significantly superior B: C ratio when compared to control (1.27).

Pooled mean of three consecutive years

The pooled mean of evaluation of bioefficacy of insecticides against bud borer for three consecutive years revealed that thiodicarb 75 WP (1 g/l) was more effective than other insecticides (Table 5). It recorded a population reduction of 89.87 per cent and was followed by spinosad 45 SC with 83.65 per cent reduction. Spinosad 45 SC was found to be on par with thiodicarb 75 WP and was equally good against bud borer. Chlorantraniliprole 18.5 SC followed spinosad 45 SC by reducing 80.35 per cent of larval population. The efficacy of the treatments, emamectin benzoate 5 SG, lambda cyhalothrin 5 EC and Bt were on par with each other by recording a population reduction of 75.75, 74.17 and 71.26 per cent, respectively. NSPE 5 % and azadirachtin 1 % EC recorded the minimum population reduction *viz*., 57.14 and 55.99 per cent and was considered to be least effective. However, these were significantly superior to control. The order of efficacy was thiodicarb 75 WP>spinosad 45 SC> chlorantraniliprole 18.5SC> emamectin Benzoate 5SG> lambda cyhalothrin 5EC> Bt> NSPE 5 % > azadirachtin 1 %.

The insecticides evaluated for the management of bud borer in marigold for three consecutive years were significantly superior to the control. Based on the population reduction yield and B:C ratio, thiodicarb 75 WP, spinosad 45 SC and chlorantraniliprole 18.5 SC were considered to be effective against bud borer, *H. armigera* (Fig. 1). The effectiveness of thiodicarb 75 WP in the present study was in agreement with the study of Patil *et al*., 2017 who recorded a minimum population of fruit borer, *H. armigera* (0.73/plant) in chilli with the application of thiodicarb 75 SP. Zahid and Hamed (2003) reported a maximum efficacy of 72 % interms of mortality after 24 hrs with the application of Larvin 80DF (thiodicarb). Divya Reddy *et al*., 2021, findings clearly indicated superiority of the spinosad 45% SC by recording a percent population reduction of 63.85 % and an yield of 220 kg/ ha with B: C ratio of 1:9.6. Harshitha *et al*. (2018) reported spinosad 45 SC to be the most effective chemical in reducing the fruit borer in Tomato. Baikar and Naik (2016) findings reported highest per cent corrected mortality (92.59) of chilli fruit borer with the application of spinosad (0.014%). The findings are also inagreement with Ghosal *et al.* (2012), Kumar and sarada (2015), Nitharwal *et al*. (2017) Sreekanth *et al.* (2010). Al-Tememi (2014) reported that spinosad, and thiodicarb were quite effective in reducing the population of *H. armigera* on cotton. Similarly, Kulhari *et al*., 2009 revealed that spinosad (0.01%) and thiodicarb (0.07%) were effective insecticides against *H. armigera* and resulted in higher chickpea yield with 59.75 and 46.78 per cent increase over control. Effectiveness of Larvin 80 DF and tracer 240 SC (spinosad) against American bollworm has been reported by Aslam *et al*., 2004. Kushal and Kumar (2023) reported cholrantraniliprole 18.5 % SC (8.5%) as the best chemical against the Tomato fruit borer, *H. armigera* by registering a minimum per cent infestation of fruit borer (8.5 %) followed by spinosad 45 SC (10.66 %). Sudha Rani *et al*., 2018 reported significantly lesser larval population in redgram in plots treated with chlorantraniliprole 20 SC (0.62 larvae/plant) exhibiting 63.65 per cent reduction of pod damage over control. Similarly, Sapkal *et al*., 2018, Mohanraj *et al.* (2012), Gadhiya *et al.* (2014) proved the effectiveness of chlorantraniliprole 20 per cent SC against *H. armigera.* The microbial pesticides, Bt displayed a significant reduction of the bud borer population. This was in accordance with findings of Raghavendra and Shamshad (2005) who reported 80 per cent larval mortality in *H. armigera*

Conclusion

From the thorough analysis of the present findings, it can be concluded that Insecticides like thiodicarb 75 WP, spinosad 45 SC, chlorantraniliprole 18.5 SC are effective in reducing the population of bud borer *H. armigera* and its impact on the flowers by increasing yield. The microbial Bt serves as an excellent alternative to the synthetic insecticide for the management of the insect. Hence, these molecules could be considered as effective molecules for the management of the insect in marigold cultivation.

Table 2: Evaluation of microbial, botanical and synthetic insecticides against bud borer, *Helicoverpa armigera* in marigold in the year 2018-19

Tr.No.	Treatments	Dose	% Reduction over control	Yield (t/ha)	BCR
T1	Azadirachtin 1% EC	3ml/l	58.73 (50.01)	10.37	1.56
T2	Bt (Dipel)	1ml/l	75.09 (60.04)	13.34	1.97
T3	NSPE 5%	50ml/l	66.53 (54.63)	9.63	1.43
T4	Spinosad 45 SC	0.25ml/l	81.62 (64.59)	17.04	2.50
T5	Thiodicarb 75 WP	1g/l	93.34 (75.01)	19.27	2.89
T6	Lambda Cyhalothrin 5EC	0.5ml/l	75.33 (60.19)	15.56	2.38
T7	Emamectin Benzoate 5SG	0.4g/l	78.55 (62.38)	17.04	2.56
T8	Chlorantraniliprole 18.5SC	0.3ml/l	79.03 (62.72)	19.27	2.84
T9	Control	-	0.00 (0.00)	8.15	1.16
CV (%)			6.11	9.03	-
CD @5%			5.86	2.52	-

Table 3: Evaluation of microbial, botanical and synthetic insecticides against bud borer, *Helicoverpa armigera* in marigold in the year 2019-20

Tr.No.	Treatments	Dose	% Reduction over control	Yield (t/ha)	BCR
T1	Azadirachtin 1% EC	3ml/l	54.09 (47.33)	9.63	1.37
T2	Bt (Dipel)	1ml/l	71.52 (57.72)	12.60	1.97
T3	NSPE 5%	50ml/l	52.39 (46.35)	10.37	1.44
T4	Spinosad 45 SC	0.25ml/l	87.49 (69.26)	16.30	2.51
T5	Thiodicarb 75 WP	1g/l	92.88 (74.49)	18.52	2.90
T6	Lambda Cyhalothrin 5EC	0.5ml/l	70.82 (57.28)	14.82	2.38
T7	Emamectin Benzoate 5SG	0.4g/l	69.62 (56.53)	16.30	2.56

T8	Chlorantraniliprole 18.5SC	0.3ml/l	73.21 (58.81)	18.52	2.84
T9	Control	-	0.00 (0.00)	8.89	1.07
CV (%)			**4.73**	**10.71**	**-**
CD @5%			**5.03**	**2.59**	**-**

Table 4: Evaluation of microbial, botanical and synthetic insecticides against bud borer, *Helicoverpa armigera* in marigold in the year 2020-21

Tr.No.	Treatments	Dose	% Reduction over control	Yield (t/ha)	BCR
T1	Azadirachtin 1% EC	3ml/l	55.14 (47.93)	10.37	1.27
T2	Bt (Dipel)	1ml/l	67.16 (55.01)	13.34	1.86
T3	NSPE 5%	50ml/l	52.49 (46.41)	10.37	1.66
T4	Spinosad 45 SC	0.25ml/l	81.84 (64.75)	16.30	2.29
T5	Thiodicarb 75 WP	1g/l	83.38 (65.91)	19.27	2.78
T6	Lambda Cyhalothrin 5EC	0.5ml/l	76.35 (60.88)	16.30	2.38
T7	Emamectin Benzoate 5SG	0.4g/l	79.09 (62.76)	17.04	2.45
T8	Chlorantraniliprole 18.5SC	0.3ml/l	88.80 (70.42)	18.52	2.62
T9	Control	-	0.00 (0.00)	9.63	1.27
CV (%)			**4.66**	**9.17**	**-**
CD @5%			**5.81**	**2.31**	**-**

Table 5: Pooled mean of efficacy of microbial, botanical and synthetic insecticides against bud borer, *Helicoverpa armigera* in marigold for three consecutive years

Tr. No.	Treatments	Dose	% Reduction over control			
			2018-19	**2019-20**	**2020-21**	**Mean**
T1	Azadirachtin 1% EC	3ml/l	58.73 (50.01)	54.09 (47.33)	55.14 (47.93)	55.99d (48.42)
T2	Bt (Dipel)	1ml/l	75.09 (60.04)	71.52 (57.72)	67.16 (55.01)	71.26c (57.56)
T3	NSPE 5%	50ml/l	66.53 (54.63)	52.39 (46.35)	52.49 (46.41)	57.14d (49.08)
T4	Spinosad 45 SC	0.25ml/l	81.62 (64.59)	87.49 (69.26)	81.84 (64.75)	83.65ab (66.12)
T5	Thiodicarb 75 WP	1g/l	93.34 (75.01)	92.88 (74.49)	83.38 (65.91)	89.87a (71.41)
T6	Lambda Cyhalothrin 5EC	0.5ml/l	75.33 (60.19)	70.82 (57.28)	76.35 (60.88)	74.17c (59.43)
T7	Emamectin Benzoate 5SG	0.4g/l	78.55 (62.38)	69.62 (56.53)	79.09 (62.76)	75.75c (60.48)
T8	Chlorantraniliprole 18.5SC	0.3ml/l	79.03 (62.72)	73.21 (58.81)	88.80 (70.42)	80.35b (63.66)
T9	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00e (0.00)
CV (%)			6.11	4.73	4.66	5.16
CD @5%			5.86	5.03	5.81	5.57

In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

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