Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(3): 829-833
© 2020 JEZS
Received: 19-03-2020
Accepted: 21-04-2020

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Bio-efficacy of insecticides and bio pesticides against major sucking pests of *Bt*- cotton

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Abstract
The present experiment was carried out in insectary farm, Section of Entomology, College of Agriculture, Nagpur during 2016-2017 to evaluate the efficacy of different treatments (chemicals, botanicals and microbials *viz.* Imidacloprid 17.8 SL, Spiromesifen 22.9 SC, Neem oil 2%, Neem seed extract 5%, Tobacco leaf extract 10%, *Metarhizium anisoplie* 1x10^8 CFU/ml, *Verticillium lecanii* 1x10^8 CFU/ml and *Beauveria bassiana* 1x10^8 CFU/ml) against sucking pest complex of cotton. Highest reduction in mean nymph population of sucking pests (except whitefly) was recorded with Imidacloprid 17.8 SL (aphids-79.55%, 78.28%; jassids- 77.32%, 75.50%; thrips- 78.94%, 77.88%) followed by Spiromesifen 22.9 SC (aphids- 73.18,70.90; jassids-73.05, 71.82; thrips- 76.30,74.20) after 5 and 10 days of all three sprayings respectively. Whereas, highest reduction in the population of whitefly was observed in Spiromesifen 22.9 SC (82.27%, 80.57%) followed by Imidacloprid 17.8 SL (78.32%, 77.90%). Among botanicals, Neem oil 2 per cent, Neem seed extract 5 per cent and Tobacco leaf extract 10 per cent were found effective towards reduction of sucking pests. Whereas, amongst the microbials *Metarhizium anisoplie* 1x10^8 CFU/ml was found promising for controlling jassids and *Verticillium lecanii* 1x10^8 CFU/ml against aphids, whitefly and thrips.

Keywords: Biopesticides, insecticides, Bt cotton, sucking pests

Introduction
Cotton is one among the most important cash crop grown in our country, with an expanse of 12.35 million hector area under cultivation [31]. Major cotton producing states are Maharashtra, Gujarat, Andhra Pradesh, Telangana, Tamilnadu, Karnataka, Rajasthan, Punjab and Haryana. One among the major constraints in cotton production is higher incidence of insect and pest attack to the crop. Among the management practices used for insect pest of cotton, chemical control is the most popularized method among farmers. Highest share of pesticide consumption, amongst the crops grown in our country is received by cotton, consuming 36%–50% of the total pesticides in the country [3, 8, 9].
Highest share of damage to the cotton crop is done by cotton bollworm complex and sucking pest complex. Sucking pest complex of cotton includes aphid, jassid, white fly, thrips, red cotton bug, mealy bug and dusky cotton bug. Amongst which, first four pests are economically most important in many parts of the cotton growing region. The sucking pest population especially leafhoppers increased gradually reaching economic injury level in many parts of India [22]. Cotton leafhopper is the most important cotton pest and accounts for 11.6 per cent reduction in seed cotton yield in India [7]. In case of severe attack of thrips on cotton crop, the yield may reduce as much as 50 to 60% under uncontrolled conditions [24]. After introduction of *Bt*-cotton, population build up and incidence of sucking pests were higher, contributing to the major yield loss of the crop. Chavan *et al.* (2010) [5] reported 28.13 per cent avoidable yield loss due to major sucking pests in cotton. Therefore, appropriate management practices should be adopted for managing these sucking pests in cotton. The present study mainly focuses on finding out the efficacies of different botanicals, microbials and chemicals against sucking pest complex of cotton, keeping in mind the cost and eco-friendliness of the management practices.

Materials and Method
The present experiment was carried out during *kharif* season of 2016-2017 in the Insectary field of Entomology Section, College of Agriculture, Nagpur, Maharashtra. The experiment was laid out in randomized block design consisting of three replication and nine treatments

including control. Individual plot size of 4 m x 3.5 m was maintained. *Bt* hybrid cultivar Ankur-3028 was grown for the experiment. Three botanicals viz. Neem oil 2 per cent, Neem Seed Extract 5 per cent and Tobacco leaf extract 10 per cent were used for the study. Amongst microbials, *Beauveria bassiana* (1 x 10^8 CFU/ml), *Verticillium lecanii* (1 x 10^8 CFU/ml) and *Metarhizium anisopliae* (1 x 10^8 CFU/ml) were taken for evaluation. Two chemicals viz. Imidacloprid 17.8 SL and Spiromesifen 22.8 SC were used as check to compare their efficacies with botanicals and microbials. Spraying of water was done in control plots.

Amount of insecticides to be used for preparing the spray solution was calculated by using the following formula-

$$V = \frac{C \times A}{a.i.}$$

Where,
V = Volume or weight of commercial insecticides required
C = Concentration of commercial insecticides
A = Amount of spray required
a.i = active ingredient

Preparation and application of spray solution

Commercial formulations of the microbials viz. Matsuraksha (*Metarhizium anisopliae*), Biosuraksha (*Beuveria bassiana*), Vertisuraksha (*Verticillium lecanni*) and neem oil (locally extracted) were purchased directly from local market. Neem seed extract and tobacco leaf extract were prepared in the laboratory, one day prior to spraying by using the following methods.

Neem seed extract preparation

50 grams of neem seeds were shade dried, crushed and then soaked overnight in double the quantity of water. Later, the mixture was squeezed through muslin cloth and the volume was made up to one litre so as to obtain 5 per cent solution and 2 g/l of soap powder was mixed and stirred well which act as a surfactant.

Tobacco leaf extract Preparation

100 grams of dried tobacco leaves were thoroughly ground with the help of mixer grinder and soaked overnight in double quantity of water. Later, the mixture was squeezed through the muslin cloth and the volume was made up to one litre so as to obtain 10 per cent solution and 2 g/l of soap powder was mixed and stirred well which act as a surfactant.

Observations

Five plants from each plot was selected randomly and tagged as a representative population. Observations on pest incidence were taken from those tagged plants. Three leaves per section (upper, middle and bottom) of each selected plant were observed for population of nymphs and adults of sucking pests viz. aphids, jassid, thrips and white fly.

A total no of three sprays were carried out at an interval of fifteen days. Initiation of spraying was done upon the pest population reaching economic threshold level (ETL). Pre-treatment observations were taken 24 hours before spraying of different treatment and post-treatment observations were recorded after 5 and 10 days of each spraying. Per cent reduction in population of aphids, jassids, thrips and white flies were worked out by using the following formula.

$$\text{Per cent reduction} = \frac{\text{Pre-treatment Population} - \text{Post-treatment population}}{\text{Pre-treatment population}} \times 100$$

The population of different natural enemies were also recorded simultaneously after 5 and 10 days each spraying. The observations recorded were subjected to statistical analysis after suitable transformation by following standard procedures of R.B.D. experiment [11].

Result and Discussion

The observations recorded on population of different sucking pests before and after application of treatments are presented in Table 1. Significant difference among different treatments were recorded during the experiment.

Effects of different treatments on aphid population

The data on average per cent reduction in aphid population indicates that imidacloprid 17.8 SL (79.55%) was found most promising in reducing the nymphal population of aphids and was at par with spiromesifen 22.9 SC (73.18%) after 5 days of all the three sprayings. Amongst the botanicals, neem oil 2% (68.51%) was found at par with neem seed extract 5% (63.34%) followed by tobacco leaf extract 10% (59.36%). Whereas among the microbials, efficacy of *Verticilium lecanii* 1 x 10^8 CFU/ ml (59.28%) was found at par with *Beauveria bassiana* 1 x 108 CFU/ ml (52.91%) followed by *Metarhizium anisopliae* 1 x 10^8 CFU/ ml (47.07%).The data on average per cent reduction of aphid population 10 days after three spraying followed the same trend *i.e.* imidacloprid 17.8 SL (78.28%), spiromesifen 22.9 SC (70.90%), neem oil 2% (66.71%), neem seed extract 5% (61.76%), *Verticilium lecanii* 1 x 10^8 CFU/ ml (56.60%), tobacco leaf extract 10% (56.56%), *Beauveria bassiana* 1 x 10^8 CFU/ ml (50.19%) and *Metarhizium anisopliae* 1 x 10^8 CFU/ ml (44.98).

Table 1: Cumulative effect of different treatments on mean per cent reduction of sucking pest at 5 and 10 days after three spraying

Tr. No.	Treatments	Dose.	Aphid		Jassid		Whitefly		Thrips	
			5 DAS	10 DAS	5 DAS	10 DAS	5 DAS	10 DAS	5 Day	10 Day
T_1	Neem oil	20ml/l	68.51 (55.86)	66.71 (54.76)	65.34 (53.93)	63.58 (52.87)	65.59 (54.08)	63.37 (52.75)	65.75 (54.18)	63.80 (53.01)
T_2	Neem seed extract (NSE)	50ml/l	63.34 (52.73)	61.76 (51.80)	60.63 (51.13)	58.83 (50.08)	60.35 (50.97)	58.75 (50.03)	60.93 (51.31)	59.39 (50.41)
T_3	Tobacco leaf extract	100ml/l	59.36 (50.39)	56.56 (48.76)	54.91 (47.81)	52.90 (46.66)	54.20 (47.40)	52.27 (46.30)	56.83 (48.92)	55.06 (47.90)
T_4	*Beauveria bassiana* (1 x 10^8 cfu/ml)	4g/l	52.91 (46.66)	50.19 (45.10)	46.04 (42.72)	41.88 (40.32)	52.34 (46.34)	49.88 (44.93)	52.53 (46.45)	48.92 (44.38)

T_5	*Verticillium lecanii* (1 x 10^8 cfu/ml)	4g/l	59.28 (50.34)	56.60 (48.79)	52.56 (46.46)	48.57 (44.18)	57.09 (49.07)	55.36 (48.07)	57.18 (49.12)	52.06 (46.18)
T_6	*Metarhizium anisopliae* (1 x 10^8 cfu/ml)	4g/l	47.07 (43.32)	44.98 (42.11)	55.40 (48.10)	50.13 (45.07)	48.57 (44.18)	46.72 (43.11)	49.12 (44.49)	45.85 (42.61)
T_7	Imidacloprid 17.8 SL	0.22ml/l	79.55 (63.11)	78.28 (62.22)	77.32 (61.56)	75.70 (60.46)	78.32 (62.24)	77.90 (61.95)	78.94 (62.68)	77.88 (61.94)
T_8	Spiromesifen 22.9 SC	1.30 ml/l	73.18 (58.80)	70.90 (57.35)	73.05 (58.72)	71.82 (57.93)	82.27 (65.09)	80.57 (63.84)	76.30 (60.86)	74.20 (59.47)
T_9	Control (Water spray)	-	14.17 (22.11)	13.98 (21.91)	12.54 (20.73)	12.12 (20.37)	13.22 (21.32)	12.34 (20.56)	12.78 (20.94)	12.92 (21.06)
	SE (m) ±		2.49	2.50	2.54	2.48	2.38	2.45	2.38	2.34
	CD at 5%		7.48	7.51	7.63	7.45	7.15	7.37	7.16	7.04

(Figures in parentheses are corresponding values of arc sin transformation)

Results of the present experiment are in accordance with Ghelani *et al*. (2006) [10] and Ahmed *et al*. (2014) [1], who found imidachlorpid effective against aphids in cotton. Borkar *et al*. (2012) [4] reported that, the application of neem oil 1 per cent emerged as the most effective treatment in recording the minimum population of aphids. Mandage and Yeole (2015) [20] observed lowest infestation of sucking pests like aphids, jassids and higher yield over control with neem oil @ 1%. Nirmala *et al*. (2006) [23] found fungal isolates *viz. Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium lecanii* @ 1×10^7 spores/ml effective against *Aphis craccivora*, *Aphis gossypii* and *Rhopalosiphum maidis*. Li GuoXia *et al*. (1995) [18] reported that, a crude extract of the fungal metabolites *Verticillium lecanii* diluted 5 times gave mortalities up to 48.77 and 23.41% for *Aphis gossypii* and *Myzus persicae.*

Effects of various treatments on whitefly population

The data on cumulative per cent nymphal reduction of whiteflies presented in table 1 indicates that, Spiromesifen 22.9 SC (82.27%) recorded maximum per cent reduction and was at par with the Imidacloprid 17.8 SL (78.32%) and both were significantly superior over all the treatment. Among the bio pesticides, Neem oil 2% (T1) recorded 65.59 per cent nymphal reduction followed by Neem seed extract 5% (60.35%), *Verticilium lecanii* 1 x 10^8 CFU/ ml (57.09%), Tobacco leaf extract 10% (54.20%), *Beauveria bassiana* 1 x 10^8 CFU/ ml (52.34%), *Metarhizium anisopliae* 1 x 10^8 CFU/ml (48.57%) in comparison with 13.22 per cent reduction in control. All the treatments were significantly superior over control (water spray) in per cent nymphal reduction of white flies 10 days after three spraying. The treatment Spiromesifen 22.9 SC (80.57%) recorded maximum per cent reduction and was at par with the treatment of Imidacloprid 17.8 SL (77.90%) and both were significantly superior over all the treatment. The next better treatment of Neem oil 2% recorded 63.37 per cent nymphal reduction followed by Neem seed extract 5% (58.75%), *Verticilium lecanii* 1 x 10^8 CFU/ ml (55.36%), Tobacco leaf extract 10% (52.27%), *Beauveria bassiana* 1 x 10^8 CFU/ ml (49.88%), *Metarhizium anisopliae* 1 x 10^8 CFU/ml (46.72%), and all these treatments were statistically at par with each other. However, significantly minimum percent nymphal reduction 12.34 per cent was observed in control.

The present findings are in agreement with Mandal *et al*. (2015) [21], Shaikh and Patel (2012) [28], as spiromesifen was most effective against whitefly. Palthiya *et al*. (2015) [25] found the combination of entomopathogenic fungi as *B. bassiana* 1.15% WP + *V. lecanii* 1.15% WP effective against whitefly in okra. Karthikeyan and Selvanarayanan (2011) [15] observed highest mortality among *A. gossypii* (100.00%), *B. tabaci* (100.00%) under laboratory conditions with 0.25% *Buaveria bassiana* and *Verticillium lecanii.* Jat and Jeyakumar (2006) [14] reported 50% reduction in whitefly population with spraying of Neem oil and NSKE.

Effects of various treatments on jassids population

The cumulative data on per cent nymphal reduction of jassids presented in table 1 indicates that all the treatments were found significantly superior over control. The treatment Imidacloprid 17.8 SL was found most effective after 5 and 10 days of all three sprayings with 77.32 and 75.70 per cent reduction in nymphal population respectively. Spiromesifen 22.9 SC was found as the next best treatments after Imidacloprid during 5 and 10 days of all three sprayings with 73.05 and 71.82 per cent respectively. Amongst botanical, Neem oil 2% recorded 65.35 and 63.58 per cent nymphal reduction after 5 and 10 days respectively, followed by Neem seed extract 5% with 60.63 and 58.83 per cent respectively. Tobacco leaf extract recorded 54.91 and 52.90 per cent mortality among jassids after 5 and 10 days respectively. Among the microbials, *Metarhizium anisopliae* 1 x 10^8 CFU/ml, *Verticillium lecanii* 1 x 10^8 CFU/ml, *Beauveria bassiana* caused 55.40, 52.56 and 46.04 mortality after 5 day respectively. After 10 days, *Metarhizium anisopliae* 1 x 10^8 CFU/ml, *Verticillium lecanii* 1 x 10^8 CFU/ml and *Beauveria bassiana* caused 50.13, 48.57, 41.88 percent reduction in nymphal population of jassid. However, significantly minimum percent nymphal reduction 12.12 per cent was observed in control.

Imidacloprid was also found effective by Afzal *et al*. (2014) [2], Udikeri *et al*. (2010) [30], Rathod *et al*. (2003) [26], which are in concurrence with present experiment. Khattak *et al*. (2006) [16], Solangi *et al*. (2013) [29] reported the efficacy of neem oil at 2% and neem seed water extract at 3% against jassids on cotton. Hole *et al*. (2015) [18] found *V.lecanii* (2 x 10^{12} cfu/g) @ 2000 g/hectare + *M. anisopliae* (2 x 10^{12} cfu/g) @ 2000 g/ha effective against all major sucking pests of cotton.

Effects of various treatments on thrips population

The cumulative data on reduction of nymphal population of thrips after 5 and 10 days of all three sprayings are presented in table 1. After 5 days of all the three sprayings, the descending order of efficacy of treatments in reducing the nymphal population of thrips were, Imidacloprid 17.8 SL (78.94%), Spiromesifen 22.9 SC (76.30%), Neem oil 2% (65.75%), Neem seed extract 5% (60.93%), *Verticilium lecanii* 1 x 10^8 CFU/ ml (57.18%), Tobacco leaf extract 10% (56.83%), *Beauveria bassiana* 1 x 10^8 CFU/ml (52.53%), *Metarhizium anisopliae* 1 x 10^8 CFU/ml (49.12%) respectively. However, significantly lower percent reduction in nymphal population of aphid (12.78) was recorded in

control. The order of efficacy among treatments remained the same after 10 days of spraying. Imidacloprid 17.8 SL recorded maximum per cent reduction (77.88%) and was at par with Spiromesifen 22.9 SC (74.20%). Amongst the botanicals and microbials, Neem oil 2% recorded 63.80 per cent nymphal reduction followed by Neem seed extract 5% (59.39%), Tobacco leaf extract 10% (55.06%), V*erticilium lecanii* 1 x 10^8 CFU/ml (52.06%), *Beauveria bassiana* 1 x 10^8 CFU/ml (48.92%), *Metarhizium anisopliae* 1 x 10^8 CFU/ml (45.85%) respectively as compared with 12.92 per cent in control.

Similar finding with Imidacloprid in accordance with present study was reported by. Saini and Rohilla (2003) [27], Choudhari *et al*. (2005) [6], Khattak *et al*. (2006) [16], Mamoon-ur-Rashid *et al*. (2012) [19] reported the efficacies of Neem oil at 2% and Neem seed water extract at 3% against cotton thrips. Halagatti (2007) [12] and Kulkarni and Adsule (2008) [17] reported the efficacy of *Verticillium lecanii* and *B. bassiana* against thrips of rose and jarbera respectively.

Conclusion

Sucking pests in cotton are emerging as a major problem in India. During the present study Imidacloprid and Spiromesifen was found effective against all the major sucking pests of cotton and can be included as a chemical control measure in different IPM modules. Amongst the botanicals, neem oil was found more effective than NSKE and tobacco leaf extract. Microbial pesticide *Verticillium lecanii* was found effective against all the sucking pests except jassids. Whereas, *Metarhizium anisoplaie* was found effective against jassids.

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