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Ghanendra Pal Patel
Department of Entomology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Anoorag R Tayde
Department of Entomology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Sobita Simon
Department of Entomology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Correspondence
Anoorag R Tayde
Department of Entomology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Evaluation of Bio-Rational and chemical insecticides against leafhopper, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius) on okra

Ghanendra Pal Patel, Anoorag R Tayde and Sobita Simon

Abstract
The present investigation was conducted during July to December 2016 at the Central Research Field, SHUATS, Naini, Allahabad. Application of seven insecticides *viz* Azadirachtin 5% EC, *Verticillium lecanii, Metarhizium anisopliae, Beauveria bassiana,* Imidacloprid 17.8% SL, Fipronil 5% SC, Acetamiprid 20% SP were evaluated against leafhopper, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius). The lowest population of leafhopper, whitefly and high B:C ratio was recorded in Imidacloprid 17.8% SL with (1.04, 0.85 and 1:9.54) followed by Acetamiprid 20% SP (1.69, 1.21 and 1:7.70), Fipronil 5% SC (1.89, 1.54 and 1:7.31) and Azadirachtin (2.84, 2.48 and 1:5.81) respectively.

Keywords: *Amrasca biguttula biguttula, Bemesia tabaci*, Benefit Cost Ratio, Bio-rational and chemical, Evaluation

Introduction
In India okra *Abelmoschus esculentus* (L.) Moench (Malvaceae) is a commonly grown green vegetable cultivated throughout the year and it is ravaged by as many as 44 insect pests. Among the various insect pests, sucking pests like leafhopper, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius) pose a major threat, affecting the okra production. Anand *et al*., 2013 [1].

The major pests are sucking pests. The important pests are aphids *Aphis gossypii,* jassids *Amrasca biguttula biguttula* (Ishida) and whitefly *Bemisia tabaci* (Gennadius). Heavy infestation of sucking pests in young stage results in stunted growth and gradual death of the plants.

About 40 to 56% losses in okra due to leafhopper, is reported. Among the wide array of insect pests infesting okra crop, the sucking pests which are, aphid, leafhopper and whitefly, were reported to be quite serious during all stages of the crop growth. Both nymphs and adults suck the cell sap usually from the ventral surface of the leaves and while feeding inject toxic saliva into plant tissues, affected leaves turn yellowish and curl.

Leafhoppers are important pests in the early stage of the crop which desap the plants, make them weak and reduce the yield. Failure to control the pests in the initial stages was reported to cause a yield loss upto 54.04 per cent Chaudhary and Dadeech 1989 [4]. Whitefly besides causing direct damage, acts as a vector of yellow vein mosaic virus (YVMV), which is a major constraint for okra cultivation Neeraja *et al*., 2004 [5].

Whitefly (*B. tabaci*) the milky white minute flies; nymphs and adults suck the cell sap from the leaves. The affected leaves are curled and dried. The affected plants show a stunted growth. Whiteflies are also responsible for transmitting yellow vein mosaic virus Singh *et al*., 2013 [10]. In recent years, various types of insecticides belonging to different chemical group were used as spray to manage the pest complex. Therefore, the present experiment was conducted to evaluate some bio-pesticides along with chemical insecticides for an effective integrated management of leafhopper and whitefly in okra.

Materials and methods
The field experiments were conducted on Centre Field Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, (U.P.), India, during *kharif* season 2016.

The research farm is situated at 20^0 and 15^0 North, 60^0 East longitude city and is about 129.2 cm above sea level.

The experiments were configured with eight treatments which were three replicated. Okra variety BND 777 was sown in a plot size of 2x1 sq.m. With a spacing of 45x30 cm. The crop was raised following all standard agronomical practices. The treatments were imposed as and when sucking pests crossed ETL viz, 2-5 nymphs of leafhopper, or 4-5 nymphs/adults of whitefly /leaf. Observations on the number of leafhopper and whiteflies were recorded on five randomly selected plants per plot. Numbers of insects were recorded from three leaves of each randomly selected plants, one upper, one middle and one bottom canopy of the plant. The population of sucking pests before spraying as pre-count and on 3rd, 7th and 14th days after each spray was recorded in the early morning hours. Spray schedule of insecticides commenced on 35th days (1st spray) and 55th days (2nd spray) after sowing. The weight of healthy fruits during each picking was recorded from each net plot. The treatment-wise total yield was calculated by summation of the yield obtained from each picking. The data recorded in the different treatments were subjected to statistical analysis after suitable transformation by following standard procedures of RBD experiment. And the yield was expressed as quintal/ha. Begum *et al*., 2016 [1].

Results and discussion

The mean populations of leafhopper and whitefly of first spray were calculated and the result represented in the table reveals that all the treatments were significantly superior over control. Among all the treatments Imidacloprid (1.17 leafhopper and 1.28 whitefly /3leaves) recorded lowest population of leafhopper and was statistically significant to remaining treatment. Acetamiprid (1.95 leafhopper and 1.73 whitefly /3leaves) and fipronil (2.08 leafhopper and 2.15 whitefly /3leaves) were statistically at par with each other, followed by Azadirachtin (3.22 leafhopper and 3.26 whitefly /3leaves), *Verticillium lecanii* (3.98 leafhopper and 4.17 whitefly /3leaves), *Metarhizium anisopliae* (4.77 leafhopper and 5.53 whitefly /3leaves) and *Beauveria bassiana* (5.13 leafhopper and 4.91 whitefly /3leaves) showed least effect among all the treatments.

The mean populations of leafhopper and whitefly of second spray were calculated and the result represented in the table reveals that all the treatments were significantly superior over control. Among all the treatments Imidacloprid (0.91 leafhopper and 0.42 whitefly /3leaves) recorded lowest population of leafhopper and was statistically significant to remaining treatment, followed by Acetamaprid (1.42 leafhopper and 0.68 whitefly /3leaves), fipronil (1.70 leafhopper and 0.93 whitefly /3leaves), Azadirachtin (2.48 leafhopper and 1.17 whitefly /3leaves) and *Verticillium lecanii* (3.80 leafhopper and 3.04 whitefly /3leaves). *Metarhizium anisopliae* (4.17 leafhopper and 4.75 whitefly /3leaves) and *Beauveria bassiana* (4.35 leafhopper and 3.68 whitefly /3leaves) were statistically at par with each other and showed least effect among all the treatments.

The overall mean populations of leafhopper and whitefly of two sprays were calculated and the result represented in the table reveals that all the treatments were significantly superior over control. Among all the treatments Imidacloprid (1.04 leafhopper and 0.86 whitefly /3leaves) recorded lowest population of leafhopper and was statistically significant to remaining treatment, followed by Acetamaprid (1.68 leafhopper and 1.21 whitefly /3leaves), fipronil (1.89 leafhopper and 1.54 whitefly /3leaves), Azadirachtin (2.85 leafhopper and 2.48 whitefly /3leaves), *Verticillium lecanii* (3.88 leafhopper and 3.61 whitefly /3leaves), *Metarhizium anisopliae* (4.47 leafhopper and 5.14 whitefly /3leaves) and *Beauveria bassiana* (4.74 leafhopper and 4.30 whitefly /3leaves)is least effective among all the treatments and showed least effect among all the treatments.

The results obtained are in close agreement with Preeth *et al*. 2009 [8] who reported that imidacloprid 17.8 SL @ 20 g a.i./ha was effective against jassids (0.96 Number/3 leaves). Similarly, Begum *et al*. (2016) [3] reported that imidacloprid 17.8 SL @ 40 g a.i./ha was the most effective treatment indicating lowest population of leafhoppers (2.47 Number/3 leaves), Rohini *et al*. 2011 [9] who reported that, fipronil 5 SC @ 2ml/L and imidacloprid 17.8 SL @ 0.4ml/L were found to be promising. Similarly Anitha *et al*. 2009 [2] and also reported the efficiency Imidacloprid.

Table 1: Effect of bio-rational and chemical insecticides against leafhopper, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemesia tabaci* (Gennadius) on okra (first and second spray pooled mean).

Treatments		Concentrations/ Doses	Number of leafhoppers / 3leaves			Number of whitefly / 3leaves		
			I-Spray	II-Spray	Overall Mean	I-Spray	II-Spray	Overall Mean
T_1	Azadirachtin 5% EC	6ml/lit	3.22 (1.79)	2.48 (1.57)	2.85 (1.69)	3.27 (1.82)	1.71 (1.30)	2.49 (1.57)
T_2	*Verticillium lecanii*	2g/lit	3.97 (1.99)	3.80 (1.94)	3.89 (1.97)	4.18 (2.04)	3.04 (1.74)	3.61 (1.92)
T_3	*Metarhizium anisopliae*	2g/lit	4.78 (2.18)	4.17 (2.04)	4.48 (2.26)	5.53 (2.35)	4.75 (2.18)	5.14 (2.27)
T_4	*Beauveria bassiana*	2.5g/lit	5.13 (2.26)	4.35 (2.08)	4.74 (2.17)	4.91 (2.23)	3.69 (1.98)	4.30 (2.07)
T_5	Imidacloprid 17.8% SL	0.4 ml/lit	1.17 (1.08)	0.91 (0.95)	1.04 (1.02)	1.29 (1.13)	0.42 (0.64)	0.85 (0.93)
T_6	Fipronil 5% SC	0.7g/lit	2.08 (1.49)	1.70 (1.30)	1.89 (1.37)	2.15 (1.46)	0.93 (0.97)	1.54 (1.27)
T_7	Acetamiprid 20% SP	0.15g/lit	1.95 (1.39)	1.42 (1.19)	1.69 (1.29)	1.74 (1.32)	0.69 (0.83)	1.21 (1.15)
T_8	Control	-	8.51 (2.92)	11.28 (3.35)	9.90 (3.14)	8.31 (2.89)	11.11 (3.34)	9.71 (3.12)
F- test		-	S	S	S	S	S	S
S. Ed. (±)		-	0.07	0.08	0.05	0.08	0.06	0.06
C. D. (P = 0.05)		-	0.02	0.23	0.16	0.25	0.19	0.18

*Figures in parenthesis are Square root transformed values.

Table 2: Economics of Cultivation

Tr. No.	Treatment	Yield of q/ha	Total cost of yield (₹)	Common cost (₹)	Treatment cost (₹)	Total cost (₹)	C:B ratio
T_1	Azadirachtin 5% EC	80.30	160600	25728	1900	27628	1:5.81
T_2	*Verticilium lecanii*	69.50	139000	25728	1650	27378	1:5.07
T_3	*Metarhizium anisopliae*	64.43	128860	25728	1650	27378	1:4.70
T_4	*Beauveria bassiana*	58.35	116700	25728	2025	27753	1:4.20
T_5	Imidacloprid 17.8% SL	128.71	257420	25728	1248	26976	1:9.54
T_6	Fipronil 5% SC	98.81	197620	25728	1300	27028	1:7.31
T_7	Acetamiprid 20% SP	104.62	209240	25728	1170	26898	1:7.70
T_0	Control	31.81	63620	25728	-	25728	1:2.47

Cost of yield ₹/q: 2000

The yields among the treatment were significant. The highest yield was recorded in Imidacloprid (128.71 q/ha), followed by Acetamiprid (104.6 q/ha), Fipronil (98.81 q/ha), Azadirachtin (80.30q/ha), *Verticilium lecanii* (69.50 q/ha), *Metarhizium anisopliae* (64.43 q/ha), *Beauveria bassiana* (58.35 q/ha) as compared to the Control (31.81 q/h). When the cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and most economical treatment was Imidacloprid (1:9.14), followed by T_7 (1:7.70), T_6 (1:7.31), T_1 (1:5.81), T_2 (1:5.07), T_3 (1:4.70), T_4 (1:4.20) as compared to control T_0 (1:2.47).

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