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Bio-Efficacy of Newer Insecticide Against Whiteflies *Bemisia tabaci* on Okra Crop *Abelmoschus esculentus* (L.) Moench

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Abstract During *kharif* cropping season, the treatment of Imidacloprid 17.8% SL @ 40 g a.i./ha has been found most effective insecticide against the population of *Bemisia tabaci* on okra followed by Imidacloprid 17.8% SL @ 30 g ai/ha. Maximum fruit yield (14.97 T/ha) was also recorded with Imidacloprid 17.8% SL @ 40 g a.i./ha treated plots. However, Imidacloprid 17.8% SL @ 10 and 20 g a.i./ha and Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.23 whiteflies/3 leaf) (all at par with each other). However, the whitefly population in all the treatments was significantly less than untreated control (7.85 whiteflies/ 3 leaf). appeared to be the safest treatment to non target organism.

Keywords Newer insecticide, Bio-efficacy, *Bemisia tabaci* on okra crop.

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Introduction

India has emerged out as the second largest producer of vegetables in the world. Vegetables constitute a substantial part of human diet supplying vitamins and minerals, in which other food materials are deficient. India ranks first in okra production and area in the world and occupies prime position among the vegetables excluding potato and tomato. In India the production was about 6350.27 thousand metric tones from 530.79 thousand hectares of area during 2012–2013 (72.9% of the total world production) of ladyfinger/ okra [1]. In India major leading state in okra production is West Bengal, Andhra Pradesh, Odisha, Gujarat and Bihar with a production of 74.60, 74.25, 67.04, 65.66 and 59.24 thousand metric tones, respectively [1]. Whitefly besides causing direct damage, acts as a vector of yellow vein mosaic virus (YVMV), which is a major constraint for okra cultivation, whitefly, *Bemisia tabaci* is most destructive sucking pest [2]. Ahmad et al. [3], an intensive research have been carried out experiments on comparative efficacy of new insecticides for evaluating new insecticides with novel mode of action against whitefly and cause mini-

Table 1. Bio-efficacy of newer insecticide against the population of whitefly *Bemisia tabaci* Gennadius on okra after first insecticidal application during *kharif*, 2014. PTC–Pre treatment count; DAT–Days after treatments, ROC–Reduction over control, *Mean of three replications. Values in parentheses are √ x + 0.5 transformed value.

Treatments	Dose (g ai ha^{-1})	PTC	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	Mean	% ROC
			Population of whitefly per 3 leaf (Nos)						
Imidacloprid 17.8% SL	10	7.60	2.04 (1.59)	1.98 (1.57)	1.95 (1.57)	2.18 (1.64)	2.73 (1.80)	2.18	72.89
Imidacloprid 17.8% SL	20	7.14	1.26 (1.33)	1.22 (1.31)	1.19 (1.30)	1.31 (1.34)	1.65 (1.47)	1.33	83.45
Imidacloprid 17.8% SL	30	7.26	0.95 (1.20)	0.92 (1.19)	0.88 (1.17)	0.97 (1.21)	1.15 (1.28)	0.97	87.94
Imidacloprid 17.8% SL	40	7.21	0.71 (1.10)	0.66 (1.08)	0.52 (1.01)	0.67 (1.08)	1.02 (1.23)	0.72	91.04
Imidacloprid 17.8% SL (HOT SHOT)	20	6.95	1.22 (1.31)	1.19 (1.30)	1.15 (1.29)	1.30 (1.34)	1.66 (1.47)	1.30	83.83
Quinalphos 25% EC (FLASH)	250	7.74	2.23 (1.65)	2.16 (1.63)	2.11 (1.62)	2.75 (1.80)	3.26 (1.94)	2.50	68.91
Untreated control	–	7.45	7.85 (2.89)	7.86 (2.89)	7.89 (2.90)	8.12 (2.94)	8.50 (2.99)	8.04	–
SEm±	–	0.022	0.100	0.098	0.101	0.086	0.064	–	–
CD at 0.05%	–	NS	0.308	0.302	0.312	0.266	0.196	–	–

mum health hazards to mammals and safer for natural enemies. The neonicotinoids are a new class of insecticides, which includes the commercial products imidacloprid, acetamiprid, thiacloprid and thiamethoxam. These insecticides are important to agriculture because of their activity against sucking insects [4, 5]. At the same time the shifting ecological imbalances of pests and other species led to level of infestation, which varied, widely from year to year in space and time. Hence, a continuous monitoring of all important pests under field condition is essential for timely prevention of sudden outbreaks of epidemics and for devising the suitable pest management strategies.

The indiscriminate use of insecticides by the farmers to control the various pests have resulted hazardous effects to the environment. Unforeseen side effects such as toxicity to non-target organisms, development of resistance in pests to the pesticides and environmental contamination greatly affect the entire food chain. Moreover, conventional insecticides provide poor control of insect pests and generally lead to pest resurgence Ishaaya et al. [6], Incerti et al. [7] has been reported high volume spray of imidacloprid is harmful to the beneficial insects like, green lacewing, European honey bee, bumble bees. Therefore, to overcome these problems the use of new generation chemical neonicotinoids is the ultimate alternative for effective pests management.

Materials and Methods

Field experiments on okra during *kharif*, 2014 at Vegetable Research Center (VRC), Haldi, of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand were conducted to study the biodiversity and their natural enemies under present investigation, commonly grown okra variety Parbhani Kranti' was raised in field with a plot size of 5 × 3. Row to row and plant to plant distance were kept 60 × 45 cm. This experiment was laid under RBD design with three replication. Each replication was divided into seven treatment.

Chemical treatments used in okra crop during *kharif*, 2014.

Sl. No.	Treatment/insecticide	Dose/ha (ai/g)	Dose/ha (ml)
1.	Imidacloprid 17.8% SL	10	50
2.	Imidacloprid 17.8% SL	20	100
3.	Imidacloprid 17.8% SL	30	150

Table 2. Bio-efficacy of newer insecticide against the population of whitefly *Bemisia tabaci* Gennadius on okra after second insecticidal application during *kharif*, 2014. PTC–Pre treatment count; DAT–Days after treatments, ROC–Reduction over control, *Mean of three replications. Values in parentheses are √ x + 0.5 transformed values.

Treatments	Dose (g ai ha^{-1})	PTC	Population of whitefly per 3 leaf (Nos) 1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	Mean	% ROC
Imidacloprid 17.8% SL	10	5.50	2.41 (1.71)	2.36 (1.69)	2.29 (1.67)	2.44 (1.71)	2.65 (1.77)	2.43	78.72
Imidacloprid 17.8% SL	20	5.27	1.56 (1.44)	1.45 (1.40)	1.33 (1.35)	1.39 (1.38)	1.43 (1.39)	1.43	87.48
Imidacloprid 17.8% SL	30	5.05	1.05 (1.24)	1.00 (1.22)	0.89 (1.18)	0.94 (1.20)	1.06 (1.25)	0.99	91.33
Imidacloprid 17.8% SL	40	4.27	0.5 (1.01)	0.45 (0.97)	0.39 (0.94)	0.45 (0.97)	0.83 (1.15)	0.53	95.36
Imidacloprid 17.8% SL (HOT SHOT)	20	5.31	1.58 (1.44)	1.47 (1.40)	1.31 (1.35)	1.41 (1.38)	1.49 (1.41)	1.45	87.30
Quinalphos 25% EC (FLASH)	250	5.64	2.42 (1.71)	2.36 (1.69)	2.32 (1.68)	2.45 (1.72)	2.74 (1.78)	2.46	78.46
Untreated control	–	10.42	10.40 (3.31)	10.88 (3.37)	11.03 (3.40)	12.23 (3.57)	12.52 (3.61)	11.42	–
SEm±	–	0.011	0.085	0.089	0.102	0.101	0.087	–	–
CD at 0.05%	–	NS	0.262	0.273	0.313	0.310	0.267	–	–

Sl. No.	Teratment/insecticide	Dose/ha (ai/g)	Dose/ha (ml)
4.	Imidacloprid 17.8% SL	40	200
5.	Imidacloprid 17.8% SL (HOT SHOT)	20	100
6.	Quinalphos 25% EC (FLASH)	250	1000
7.	Untreated control	–	–

Insecticidal application

Two sprays of each insecticidal treatment were given. First spray was done at 50% flowering and second spray were done after 20 days of interval using spray solution @ 500 l/ha with knapsack sprayer by high volume fitted with hollow cone nozzle.

Observation

The efficacy of different doses of the test insecticide was compared with those of market sample (Imidacloprid 17.8% SL) and Quinalphos 25% EC. The population of whiteflies was recorded before the treatment of insecticide and after 1, 3, 5, 7 and 10 days of spray. These observations were taken on three leaves per plant, one each from top, middle and bottom region from ten plants per plot selected at random leaving border rows.

Statistical analysis

The data thus obtained was transformed to square root values and subjected to analysis of variance. After determination of significance of difference between the treatment means at 0.05% probability, critical difference was calculated in order to compare the treatment means.

Results and Discussion

Bio-efficacy of newer insecticide against white fly, *Bemisia tabaci* Gennadius on okra during *kharif*, 2014

The data on population of white fly, *Bemisia tabaci* on okra in various treatments recorded one day before and 1st, 3rd, 5th, 7th and 10th days after each application during the cropping season 2014 are summarized in Table 1.

It was revealed that before first spray the mean population of *Bemisia tabaci* varied from 6.95 to 7.74

(adults and nymph) which was non-significant. At 1st day after 1st spray the whiteflies population was minimum (0.71 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (0.95 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.22 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.26 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (2.04 whiteflies/3 leaf) and Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.23 whiteflies/3 leaf) (all at par with each other). However, the whitefly population in all the treatments was significantly less than untreated control (7.85 whiteflies/3 leaf).

At 3rd day after 1st spray, the whiteflies population was recorded minimum (0.66 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (0.92 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.19 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.22 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (1.98 whiteflies/3 leaf), Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.16 whiteflies/3 leaf) (all at par with each other) indicating the decreasing trend of their efficacy as evident by the increasing trend of whiteflies population irrespective to these treatments. However, the leaf hopper population in all the treatments was significantly less than untreated control (7.86 whiteflies/3 leaf). At 5th day after 1st spray, the whiteflies population was again recorded minimum (0.52 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (0.88 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.15 whiteflies/3 leaf) (all at par with each other), Imidacloprid 17.8% SL @ 20 g ai/ha (1.19 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (1.95 whiteflies/3 leaf), Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.11 whiteflies/3 leaf) (all at par with each other) indicating the decreasing trend of their efficacy as evident by the increasing trend of whiteflies population irrespective to these treatments. However, the leaf hopper population in all the treatments was significantly less than untreated control (7.89 whiteflies/3 leaf).

At 7th day after 1st spray, the whiteflies population was once again recorded minimum (0.67 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (0.97 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.30 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.31 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (2.18 whiteflies/3 leaf) (all at par with each other), Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.75 whiteflies/3 leaf) exhibiting the decreasing order of their efficacy. However, the whitefly population in all the treatments was significantly less than untreated control (8.35 whiteflies/3 leaf).

At 10th day after 1st spray, the whiteflies population was again recorded minimum (1.02 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (1.15 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.65 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.66 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (2.73 whiteflies/3 leaf) (all at par with each other) and treatment in decreasing order of efficacy was Quinalphos 25% EC (FLASH) @ 250 g ai/ha (3.26 whiteflies/3 leaf). Nevertheless, the whiteflies population (8.50 whiteflies/3 leaf) in untreated control was found significant as compared to all the treatments.

Thus, on the basis of overall mean population of whitefly, the decreasing order of efficacy of different treatments in the present study was: Imidacloprid 17.8% SL @ 40 g ai/ha > Imidacloprid 17.8% SL @ 30 g ai/ha > Imidacloprid 17.8% SL @ 20 g ai/ha (HOT SHOT) > Imidacloprid 17.8% SL @ 20 g ai/ha > Imidacloprid 17.8% SL @ 10 g ai/ha > Quinalphos 25% EC (FLASH) > untreated check (Fig. 1). A perusal of data collected one day before 2nd spray, revealed that the population of *Bemisia tabaci* varied from 4.27 to 10.42 (adults and nymph) per/3 leaf (Table 2) but, at 1st day after 2nd spray, whiteflies population was 0.50, 1.05, 1.56 and 1.58 whiteflies/3 leaf with Imidacloprid 17.8% SL @ 40, 30, 20 and 20 (HOT SHOT) g ai/ha, respectively all being at par with each other. These treatment were followed by Imidacloprid 17.8% SL @ 10 g ai/ha (2.41 whiteflies/3 leaf) and Quinalphos 25% EC (FLAH) @ 250 g ai/ha (2.42 whiteflies/3 leaf) (both at par with each other) where the whiteflies population was significantly less than untreated control (10.40 whiteflies/3 leaf).

At 3rd day after 2nd spray, the whiteflies popula-

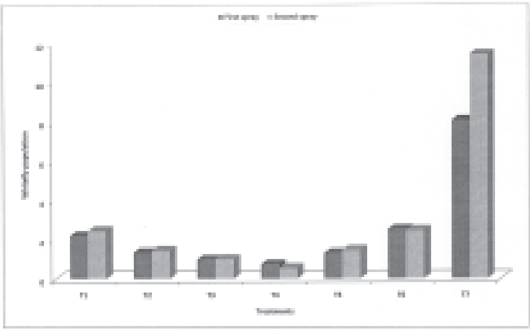

Fig. 1. Bio-efficacy of imidacloprid 17.8% SL against the population of whitefly, *B. tabaci* on okra during *kharif*, 2014. T_1– Imidacloprid 17.8% SL @ 10 g ai/ha; T_2–Imidacloprid 17.8% SL @ 20 g ai/ha; T_3–Imidacloprid 17.8% SL @ 30 g ai/ha; T_4–Imidacloprid 17.8% SL @ 40 g ai/ha; T_5–Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha; T_6–Quinalphos 25% EC (FLASH) @ 250 g ai/ha; T_7–Untreated control.

tion was recorded minimum (0.45 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (1.00 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.45 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.47 whiteflies/3 leaf) (all at par with each other), Imidacloprid 17.8% SL @ 10 g ai/ha (2.36 whiteflies/3 leaf) and Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.36 whiteflies/3 leaf) (both at par with each other) indicating the decreasing trend of their efficacy as evident by the increasing trend of whiteflies population irrespective to these treatments. Nevertheless, the leaf hopper population in all the treatments was significantly less than untreated control (10.88 whiteflies/3 leaf).

At 5th day after 2nd spray, the whiteflies population was minimum (0.39 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (0.89 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.31 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.33 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (2.29 whiteflies/3 leaf). Among all the insecticidal treatments the maximum larval population was recorded with Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.32 whiteflies/3 leaf). This was in comparison to the untreated control where the whiteflies population was to the extent of 11.03 whiteflies/3 leaf, exhibiting a significant difference. However, the whitefly population in all the treatments was significantly less than untreated control (11.03 whiteflies/3 leaf).

At 7th day after 2nd spray, the whiteflies population was once again recorded minimum (0.45 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (0.94 whiteflies/3 leaf) which were at par with Imidacloprid 17.8% SL @ 20, 20 (HOT SHOT) g ai/ha (with 1.39, 1.41 whiteflies/3 leaf respectively). Next treatment in decreasing order of efficacy were Imidacloprid 17.8% SL @ 10 g ai/ha (2.44 whiteflies/3 leaf) and Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.45 whiteflies/3 leaf) where the whitefly population was significantly less than untreated control (12.23 whiteflies/3 leaf).

All the insecticidal treatment exhibited their effectiveness till 10th day after 2nd spray against the whiteflies population. The whiteflies population was recorded minimum (0.83 whiteflies/3 leaf) with Imidacloprid 17.8% SL @ 40 g ai/ha followed by Imidacloprid 17.8% SL @ 30 g ai/ha (1.06 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 20 g ai/ha (1.43 whiteflies/3 leaf), Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha (1.49 whiteflies/3 leaf), Imidacloprid 17.8% SL @ 10 g ai/ha (2.65whiteflies/3 leaf) and Quinalphos 25% EC (FLASH) @ 250 g ai/ha (2.74 whiteflies/3 leaf) where the whitefly population was significantly less than untreated control (12.52 whiteflies/3 leaf).

Thus, on the basis of overall mean population of whitefly, the order of efficacy in different treatments in the present study was: Imidacloprid 17.8% SL @ 40 g ai/ha > Imidacloprid 17.8% SL @ 30 g ai/ha > Imidacloprid 17.8% SL @ 20 g ai/ha > Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha > Imidacloprid 17.8% SL @ 10 g ai/ha > Quinalphos 25% EC (FLASH) > untreated check (Fig. 1). A comparison of data collected on the percent reduction of the pest over control during the cropping season *kharif* 2014, after the application of neonicotinoids (Imidacloprid) after two spray in different treatments revealed that the application of Imidacloprid 17.8% SL @ 40 g ai/ha and Imidacloprid 17.8% SL @ 30 g ai/ha were the promising treatments as they recorded minimum population after two spray, followed by Imidacloprid 17.8% SL (HOT SHOT) @ 20 g ai/ha, Imidacloprid 17.8% SL @ 20 g ai/ha, Imidacloprid 17.8% SL @ 10 g ai/ha and Quinalphos 25% EC (FLASH). The data revealed that maximum reduction of whitefly population took place with Imidacloprid 17.8% SL @ 40 g ai/ha. The present finding corroborates with [8] who found that mean percent reduction in whitefly population varied from 51.52 to 85.80 and 45.47 to 86.53 after first and second applications, respectively among the Imidacloprid 17.8% SL treatments. The present finding is also supported by Misra and Senapati [9] and Kastle and Palumbo [10]. Razat et al. [11] who observed imidacloprid to be most effective but next to acetamiprid and difenthuron in controlling *B. tabaci* in cotton. Singh et al. [12] reported that among the different insecticidal seed treatment the imidacloprid @ 3 g kg^{-1} was most effective, provided maximum reduction in population of sucking pests and maximum germination of seed. In recent Ghosal et al. [13] evaluated that imidacloprid @ 50 g ai/ha again proved most effective in keeping the lowest population of whitefly with a per cent reduction of 83.15% Lobna [14] reported that cotton seed treatment with imidacloprid @ 4.9 g ai kg^{-1} resulted in 65.3% reduction in population of thrips, *Thrips tabaci* Lindeman over control.

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