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Lakshana R
M. Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Dt.), Maharashtra, India

Dr. VS Desai
Professor (CAS) Regional Fruit Research Station, Vengurla, Sindhudurg (Dt.), Maharashtra, India

Dr. SD Desai
Assistant Professor, Agricultural Technology Information Centre, Dapoli.), Maharashtra, India

Dr. YR Parulekar
Assistant Professor, Department of Horticulture, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Dt.), Maharashtra, India

Dr. VN Jalgaonkar
Head, Department of Agricultural Entomology, College of Agriculture, Dapoli.), Maharashtra, India

Dr. (Mrs.) KV Naik
Professor (CAS), Department of Agricultural Entomology, College of Agriculture, Dapoli.), Maharashtra, India

Venkata Srinivasa Chari M
M. Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Dt.), Maharashtra, India

Dalvi NS
M. Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Dt.), Maharashtra, India

Corresponding Author:
Lakshana R
M. Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Dt.), Maharashtra, India

Battling beetle pests: A comprehensive guide for effective management of okra flea beetle using chemicals

Lakshana R, Dr. VS Desai, Dr. SD Desai, Dr. YR Parulekar, Dr. VN Jalgaonkar, Dr. (Mrs.) KV Naik, Venkata Srinivasa Chari M and Dalvi NS

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Abstract
A randomized block field experiment was conducted to study the management of flea beetle, *Podagrica bowringi* (Baly.) infesting okra, using several insecticides. This experiment was conducted in Vegetable science farm, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The okra variety, Mahyco Hybrid 10 was sown in the field during *kharif* 2022. A randomized block design (RBD) was constructed with eight treatments and three replications. The treatments used were thiamethoxam 25 WG @ 0.5 g/l, deltamethrin 2.8 EC @ 0.9 ml/l, cypermethrin 25EC @ 0.5 ml/l, emamectin benzoate 5% SG @ 0.4 g/l, imidacloprid 17.8 SL @ 0.2 ml/l, lambda cyhalothrin 5 EC @ 0.6 ml/l and quinalphos 25EC @ 1 ml/l. The treatments were sprayed twice with an interval of 15 days in between. Data on the mean number of shot holes were taken at 1, 3, 5, 7, 10 and 14 days after spraying. Results obtained at the end of both sprays, revealed that imidacloprid 17.8 SL @ 0.2 ml/l performed well than all other treatments followed by thiamethoxam 25 WG @ 0.5 g/l and lambda cyhalothrin 5EC @ 0.6 ml/l. The least effective treatment among them was cypermethrin 25EC @ 0.5 ml/l which recorded least number of shots just above the untreated plots.

Keywords: Chemical insecticides, flea beetle, okra and shot holes

Introduction
Okra, also known as "*bhendi*" or "lady's finger," is a popular vegetable crop produced extensively in tropical and subtropical regions for its tender green pods. Common names for it include "Gumbo," "Okra" in the United States, "Lady's Finger" in England, and "Bhendi" or "Bhinda" in India. It is a native crop of Africa, South East Asia and North Australia to the Pacific (Boswell and Reed, 1962) [3]. It is the only significant vegetable crop in the Malvaceae family. Minerals, carbohydrates, fibres, protein, fat, and phenols are abundant in the plant (Huang *et al.*, 2007) [8]. Due to its high calcium and iodine content as well as the mucilaginous qualities of its fruit, it is an essential component of the diet. Vitamins A, B, and C are all abundant in okra. Their value is important especially in underdeveloped and developing countries like India, where malnutrition abounds (Randhawa, 1974) [16].

Heavy infestations brought on by a number of insect pests, which not only cause quantitative losses to the crop but also qualitative losses, are one of the main obstacles to okra production. On okra, up to 72 different insect species have been identified (Srinivasa and Rajendran, 2003) [14]. Up to 20 insect and non-insect pests attack okra in the country, which results in output losses ranging from 8% to 76% (Butani and Verma, 1981) [4].

Among them, the okra flea beetle, *Podagrica bowringi* Baly, has been seen during the *kharif* season on okra, seriously harming the crop. Flea beetle having different species is one of the important pests attacking cruciferous, solanaceous and malvaceous plants. It is a polyphagous pest, having wide host range (Youdeowei, 2002) [15]. *Podagrica uniformis* Jacoby and *Nisotra sjostedti* Jacoby are the most destructive flea beetle insect species at Nsukka, Nigeria (Egwuatu, 1982) [7].

Flea beetles are mainly leaf eaters and have biting and chewing type of mouth parts. They are observed to commence their infestation on okra plants from the stage of germination throughout all stages of its growth (Ahmed *et al.*, 2007; Pitan and Adewole, 2011) [1, 11].

The adult beetles attack the okra's vulnerable leaves by puncturing them with numerous holes, which later dramatically widen during the crop's advanced growth stage. The grubs are found in the soil and feed on the crop's root system, inflicting only minor damage. Flea beetle infestation has been linked to decreased crop vigour, functional leaf area loss, and poor crop output. During the pest's peak activity, as many as 4 to 12 adults have been discovered on a single plant. Defoliation caused by infestations has been estimated to reach up to 80%, and the degree of damage varies depending on the location (Egwuata, 1982; Clementine *et al.*, 2009) [7, 6].

Management of any insect pest is an important factor for getting more yields. Chemical control, though poses various environmental problems, it proved as a best alternative tool for quick management of the pest. If this important tool is used cleverly, it will manage the pests efficiently, gives better yields as well as it will not lead many problems. Fla beetle population pose a serious threat to okra cultivation throughout the world; therefore, they should be brought to a manageable level.

Materials and Methods

The field experiment with Randomized Block Design (RBD) was conducted from June 14th, 2022 to September 23rd, 2022 at Vegetable Science Farm, College of Horticulture, Dapoli, Taluka-Dapoli, Dist-Ratnagiri, situated at 17° 19' N latitude and 73° 1' E longitude, having an altitude of 280 metres above mean sea level. According to the climatology, this location is subtropical, with a mean annual precipitation of 3500mm which typically occurs between June and September in a period of 95 to 100 days in most of the years. The experimental plot was finely tilled, ploughed twice and clod crushed, and the harrowed. The experimental plot was set up with a gross plot size of 2.25m x 2.4 m for each treatment. Each allotment had flat beds ready to be planted with okra. Then mulch is laid over it to restrict weed growth, and drip lines are laid to facilitate irrigation. The seeds were then sown in the experimental plot by adopting the spacing of 45x60 cm. To overcome seedling death and germination failure, four seeds are placed per spot by dibbling at a 2cm gap. After the germination and successful establishment of the seedlings, two healthy seedlings were retained, and the remaining ones were roughed up. The healthy seeds of okra variety 'Mahyco Hybrid 10' was obtained from Krushi Seva Kendra, Dapoli, Dist. Ratnagiri (M.S.). The recommended seed rate of 10 Kg / ha was used. Before the final harrowing, organic manure was incorporated into the soil in the form of F.Y.M. @ 10 tonnes per hectare. Urea (46 per cent N) and Suphala (15:15:15 per cent NPK) were used to apply the necessary fertilizer dosage of 100 kg N_2O, 50 kg P_2O_5, and 50 kg K_2O per hectare to each plot. Phosphorus and potassium were applied as a base dose, whereas nitrogen was applied in three split doses: half at the time of sowing and half at 30 and 60 days after sowing. These fertilizers were applied by gently disturbing the upper layer of the soil and covered with soil so as to prevent their dissolving. Care was taken to make sure that the fertilizers are not in direct contact with the shoot of the plant. The pesticides were sprayed using knapsack sprayer and since it was a rainy season, a sticker is used to prevent the washing away of chemicals.

A statistically designed field experiment using Randomized Block Design having three replications and eight treatments was laid out at Vegetable Science farm, Department of Vegetable Science, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, College of Horticulture, Dapoli, Dist. Ratnagiri (Maharashtra) to study the management of okra flea beetle. The treatment details were given as follow.

Table 1: Treatment details

Tr. No.	Treatments	Dose
T_1	Thiamethoxam 25 WG	0.5 g/l
T_2	Deltamethrin 2.8 EC	0.9 ml/l
T_3	Cypermethrin 25 EC	0.5 ml/l
T_4	Emamectin benzoate 5% SG	0.4 g/l
T_5	Imidacloprid 17.8 SL	0.2 ml/l
T_6	Lambda cyhalothrin 5 EC	0.6 ml/l
T_7	Quinalphos 25 EC	1 ml/l
T_8	Control	-

The application of different pesticides was done as and when the incidence of the pest is noticed. Spraying of the insecticides was done at the interval of fifteen days. Two sprays of insecticides were given in the course of study. Five plants were selected randomly to record the observations on the incidence of okra flea beetle. The shot holes made by flea beetle were counted from top, middle and bottom leaf of the plant. The observations were recorded at a day before spraying, 1, 3, 5, 7, 10 and 14 days after each spray. The average infestation of each day was calculated. The square root transformed values were obtained for all these average values. By comparing the mean infestation of pest from each treatment, the best treatment among them was found out. The mean, standard error (S.E.) and critical difference (C.D.) at 5 per cent probability was worked out for comparison between treatments. The yield from each treatment plot was also measured and the superior treatment with the high yield could be predicted.

Results and Discussions

Effect of different insecticidal sprays on okra flea beetle, *Podagrica bowringi* (Baly.) after first spray

Data on number of shot holes made by okra flea beetle per three leaves per five plants at 1, 3, 5, 7, 10 and 14 days after spraying of insecticides for the first spray are presented in Table II and depicted in Fig. I. The number of shot holes by okra flea beetle per three leaves per five plants prior to the first insecticidal spray were recorded. The value ranged from 17.33 to 24.80. The difference among the treatments was non-significant, indicating uniform damage.

The observations recorded at first day after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 11.48 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at first day after spraying. The next effective treatment was deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 14.42 per three leaves per five plants and was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 15.44 per three leaves per five plants. The next effective treatment was cypermethrin 25 EC (0.5 ml/l) (T_3) with mean number of shot holes of 17.53 per three leaves per five plants and was at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 17.79 per three leaves per five plants and also with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 18.04 per three leaves per five plants. The least effective treatment was quinalphos 25 EC (1 ml/l) (T_7) with the highest mean number of shot holes of 20.68 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 25.65 per three leaves per five plants than all other treatments.

The data recorded at three days after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 11.29 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at three days after spraying. The next effective treatment was deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 14.18 per three leaves per five plants and was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 15.13 per three leaves per five plants. The next effective treatment was cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 17.23 per three leaves per five plants and was at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 17.52 per three leaves per five plants and also with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 17.81 per three leaves per five plants. The least effective treatment was quinalphos 25 EC (1 ml/l) (T_7) with the highest mean number of shot holes of 20.45 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 30.41 per three leaves per five plants than all other treatments.

Table 2: Effect of different insecticidal sprays on okra flea beetle after first spray

Treatment	Pre count	Average no. of shot holes per three leaves						
		1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Cumulative Mean
Thiamethoxam 25 WG @ 0.5 g/l	19.27 (4.50) *	15.44 (4.05)	15.13 (4.02)	14.27 (3.90)	13.29 (3.76)	7.93 (2.95)	2.02 (1.72)	11.35 (3.40)
Deltamethrin 2.8 EC @ 0.9 ml/l	17.51 (4.29)	14.42 (3.92)	14.18 (3.89)	19.53 (4.53)	17.93 (4.35)	11.93 (3.59)	2.75 (1.91)	13.46 (3.70)
Cypermethrin 25 EC @ 0.5 ml/l	18.29 (4.38)	17.53 (4.30)	17.23 (4.27)	19.81 (4.56)	18.18 (4.37)	12.60 (3.68)	2.77 (1.93)	14.69 (3.85)
Emamectin benzoate 5% SG @ 0.4 g/l	20.02 (4.58)	18.04 (4.36)	17.81 (4.33)	17.73 (4.31)	14.16 (3.89)	8.64 (3.07)	2.39 (1.83)	13.13 (3.63)
Imidacloprid 17.8 SL @ 0.2 ml/l	17.64 (4.28)	11.48 (3.53)	11.29 (3.50)	11.04 (3.46)	9.18 (3.18)	4.80 (2.38)	1.70 (1.64)	8.25 (2.95)
Lambda cyhalothrin 5 EC @ 0.6 ml/l	17.33 (4.26)	17.79 (4.33)	17.52 (4.30)	15.24 (4.02)	13.47 (3.80)	8.07 (2.99)	2.28 (1.79)	12.40 (3.54)
Quinalphos 25 EC @ 1 ml/l	17.62 (4.29)	20.68 (4.66)	20.45 (4.63)	18.69 (4.43)	14.62 (3.93)	8.91 (3.15)	2.66 (1.90)	14.34 (3.78)
Control	24.80 (5.07)	25.65 (5.12)	30.41 (5.60)	30.58 (5.62)	32.91 (5.83)	33.09 (5.84)	34.42 (5.94)	31.18 (5.66)
SE (m±)	0.26	0.12	0.09	0.18	0.20	0.24	0.16	0.17
CD at 5%	NS	0.35	0.28	0.55	0.60	0.72	0.48	0.50

* Figures in parentheses are $\sqrt{n}+0.5$ transformed values

At five days after spraying data indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 11.04 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at five days after spraying. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 14.27 per three leaves per five plants. The next effective treatment was lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 15.24 per three leaves per five plants and was at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 17.73 per three leaves per five plants and was also at par with quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 18.69 per three leaves per five plants and also at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 19.53 per three leaves per five plants and also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 19.81 per three leaves per five plants. The least effective treatment at 5 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 19.81 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 30.58 per three leaves per five plants than all other treatments.

The data recorded at seven days after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 9.18 per three leaves per five plants. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 13.29 per three leaves per five plants. The next effective treatment was lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 13.47 per three leaves per five plants and was at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 14.16 per three leaves per five plants and was also at par with quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 14.62 per three leaves per five plants and also at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 17.93 per three leaves per five plants and also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 18.18 per three leaves per five plants. The least effective treatment at 7 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 18.18 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 32.91 per three leaves per five plants than all other treatments.

At ten days after spraying result indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 4.80 per three leaves per five plants. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 7.93 per three leaves per five plants and also at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 8.07 per three leaves per five plants and also at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 8.64 per three leaves per five plants. The next effective treatment was quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 8.91 per three leaves per five plants and was at par with deltamethrin 2.8

EC (0.9 ml/l) (T_2) with mean number of shot holes of 11.93 per three leaves per five plants and was also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 12.60 per three leaves per five plants. The least effective treatment at 10 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 12.60 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 33.09 per three leaves per five plants than all other treatments.

The observations recorded at fourteen days after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 1.70 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at fourteen days after spraying. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 2.02 per three leaves per five plants and also at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 2.28 per three leaves per five plants and also at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 2.39 per three leaves per five plants and was also at par with quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 2.66 per three leaves per five plants and was also at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 2.77 per three leaves per five plants and was also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 2.77 per three leaves per five plants. The least effective treatment at 14 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 12.60 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 33.09 per three leaves per five plants than all other treatments.

The data recorded on cumulative mean after first spray indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T5) was found to be effective treatment which recorded least mean number of shot holes of 8.25 per three leaves per five plants and significantly superior over the rest of treatments. The next best treatment thiamethoxam 25 WG (0.5 g/l) (T_1) recorded mean number of shot holes of 11.35 per three leaves per five plants and at par with all remaining treatments except untreated control (T_8) *i.e.* lambda cyhalothrin 5 EC (0.6 ml/l) (T_6), emamectin benzoate 5% SG (0.4 g/l) (T_4), deltamethrin 2.8 EC (0.9 ml/l) (T_2), quinalphos 25 EC (1 ml/l) (T_7) and cypermethrin 25EC (0.5 ml/l) (T_3) which was recorded mean number of shot holes of 12.40, 13.13, 13.46, 14.34 and 14.69 per three leaves per five plants, respectively.

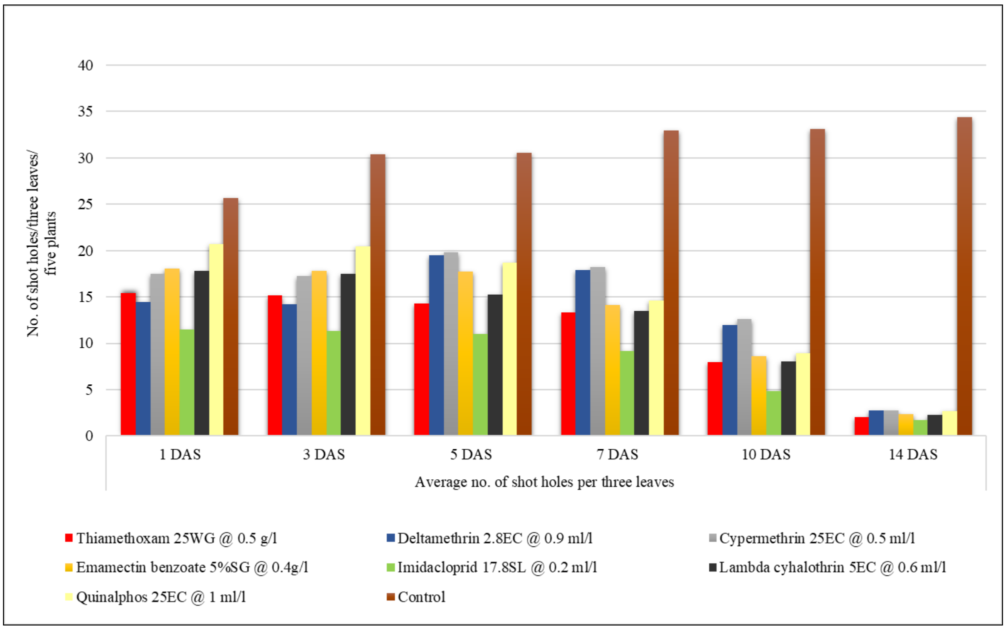

Fig 1: Effect of insecticides on okra flea beetle after first spray

Effect of different insecticidal sprays on okra flea beetle, *Podagrica bowringi* (Baly.) after second spray

Data on number of shot holes made by okra flea beetle per three leaves per five plants at 1, 3, 5, 7, 10 and 14 days after spraying of insecticides for the second time were presented in Table III and depicted in Fig. II. The observations recorded at first day after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 1.27 per three leaves per five plants. The next effective treatment was deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 3.35 per three leaves per five plants and was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 3.45 per three leaves per five plants. The next effective treatment was cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 6.06 per three leaves per five plants and was at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 6.15 per three leaves per five plants and also with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 6.77 per three leaves per five plants. The least effective treatment was quinalphos 25 EC (1 ml/l) (T_7) with the highest mean number of shot holes of 8.75 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 32.09 per three leaves per five plants than all other treatments.

The data recorded at three days after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 0.86 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at three days after spraying. The next effective treatment was deltamethrin 2.8

EC (0.9 ml/l) (T_2) with mean number of shot holes of 2.98 per three leaves per five plants and was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 3.08 per three leaves per five plants. The next effective treatment was cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 5.39 per three leaves per five plants and was at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 5.68 per three leaves per five plants and also with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 5.99 per three leaves per five plants. The least effective treatment was quinalphos 25 EC (1 ml/l) (T_7) with the highest mean number of shot holes of 7.75 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 27.09 per three leaves per five plants than all other treatments.

Table 3: Effect of different insecticidal sprays on okra flea beetle after second spray

Treatment	Average no. of shot holes per three leaves						
	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Cumulative Mean
Thiamethoxam 25WG @ 0.5 g/l	3.45 (2.10)*	3.08 (2.02)	1.48 (1.57)	0.82 (1.34)	0.35 (1.16)	0.03 (1.02)	1.59 (1.54)
Deltamethrin 2.8EC @ 0.9 ml/l	3.35 (2.08)	2.98 (1.99)	4.08 (2.24)	3.08 (2.02)	1.08 (1.44)	0.43 (1.19)	2.50 (1.87)
Cypermethrin 25EC @ 0.5 ml/l	6.06 (2.66)	5.39 (2.52)	5.16 (2.47)	3.16 (2.03)	1.82 (1.65)	1.13 (1.42)	3.79 (2.19)
Emamectin benzoate 5%SG @ 0.4 g/l	6.77 (2.78)	5.99 (2.64)	3.65 (2.15)	2.65 (1.89)	0.65 (1.28)	0.18 (1.08)	3.32 (1.97)
Imidacloprid 17.8SL @ 0.2 ml/l	1.27 (1.50)	0.86 (1.36)	0.56 (1.25)	0.13 (1.06)	0.03 (1.02)	0.00 (1.00)	0.48 (1.20)
Lambda cyhalothrin 5EC @ 0.6 ml/l	6.15 (2.67)	5.68 (2.58)	3.08 (2.01)	2.08 (1.75)	0.45 (1.19)	0.13 (1.06)	2.93 (1.88)
Quinalphos 25EC @ 1 ml/l	8.75 (3.11)	7.75 (2.95)	4.06 (2.22)	2.73 (1.91)	1.06 (1.41)	0.35 (1.16)	4.12 (2.26)
Control	32.09 (5.75)	27.09 (5.29)	25.76 (5.16)	24.42 (5.04)	21.42 (4.73)	14.14 (3.86)	24.15 (4.97)
SE (m±)	0.14	0.14	0.16	0.14	0.12	0.14	0.14
CD at 5%	0.43	0.41	0.48	0.42	0.36	0.43	0.42

* Figures in parentheses are $\sqrt{n} + 0.5$ transformed values

At five days after spraying results indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 0.56 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at five days after spraying. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 1.48 per three leaves per five plants. The next effective treatment was lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 3.08 per three leaves per five plants and was at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 3.65 per three leaves per five plants and was also at par with quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 4.06 per three leaves per five plants and also at par with Deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 4.08 per three leaves per five plants and also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 5.16 per three leaves per five plants. The least effective treatment at 5 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 5.16 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 30.58 per three leaves per five plants than all other treatments.

The observations recorded at seven days after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 0.13 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at seven days after spraying. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 0.82 per three leaves per five plants. The next effective treatment was lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 2.08 per three leaves per five plants and was at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 2.65 per three leaves per five plants and was also at par with quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 2.73 per three leaves per five plants and also at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 3.08 per three leaves per five plants and also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 3.16 per three leaves per five plants. The least effective treatment at 7 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 3.16 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 24.42 per three leaves per five plants than all other treatments.

At ten days after spraying data indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 0.03 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at ten days after spraying. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 0.35 per three leaves per five plants and also at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 0.45 per three leaves per five plants and also at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 0.65 per three leaves per five plants. The next effective treatment was quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 1.06 per three leaves per five plants and was at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 1.08 per three leaves per five plants and was also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 1.82 per three leaves per five plants. The least effective treatment at 10 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 1.82 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 21.42 per three leaves per five plants than all other treatments.

The observations recorded at fourteen days after spraying indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T_5) was found to be effective treatment which recorded least mean number of shot holes of 0.00 per three leaves per five plants. Therefore, imidacloprid is the significantly superior treatment at fourteen days after spraying. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) (T_1) with mean number of shot holes of 0.03 per three leaves per five plants and also at par with lambda cyhalothrin 5 EC (0.6 ml/l) (T_6) with mean number of shot holes of 0.13 per three leaves per five plants and also at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) with mean number of shot holes of 0.18 per three leaves per five plants and was also at par with quinalphos 25 EC (1 ml/l) (T_7) with mean number of shot holes of 0.35 per three leaves per five plants and was also at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) with mean number of shot holes of 0.43 per three leaves per five plants and was also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with mean number of shot holes of 1.13 per three leaves per five plants. The least effective treatment at 14 days after spraying was cypermethrin 25EC (0.5 ml/l) (T_3) with the highest mean number of shot holes of 1.13 per three leaves per five plants among the treatments. The untreated control (T_8) recorded the highest mean number of shot holes of 14.14 per three leaves per five plants than all other treatments.

The data recorded on cumulative mean after second spray indicated that the treatment imidacloprid 17.8 SL (0.2 ml/l) (T5) was found to be effective treatment which recorded least mean number of shot holes of 0.48 per three leaves per five plants and at par with the treatment thiamethoxam 25 WG (0.5 g/l) (T_1) recorded (1.59) mean number of shot holes. The next best treatment was found to be deltamethrin 2.8 EC (0.9 ml/l) (T_2) recorded mean number of shot holes of 2.50 per three leaves per five plants and at par with all remaining treatments except untreated control (T_8) *i.e.* lambda cyhalothrin 5 EC (0.6 ml/l) (T_6), emamectin benzoate 5% SG (0.4 g/l) (T_4), quinalphos 25 EC (1 ml/l) (T_7) and cypermethrin 25EC (0.5 ml/l) (T_3) which was recorded mean number of shot holes of 2.93, 3.32, 3.79 and 4.12 per three leaves per five plants, respectively.

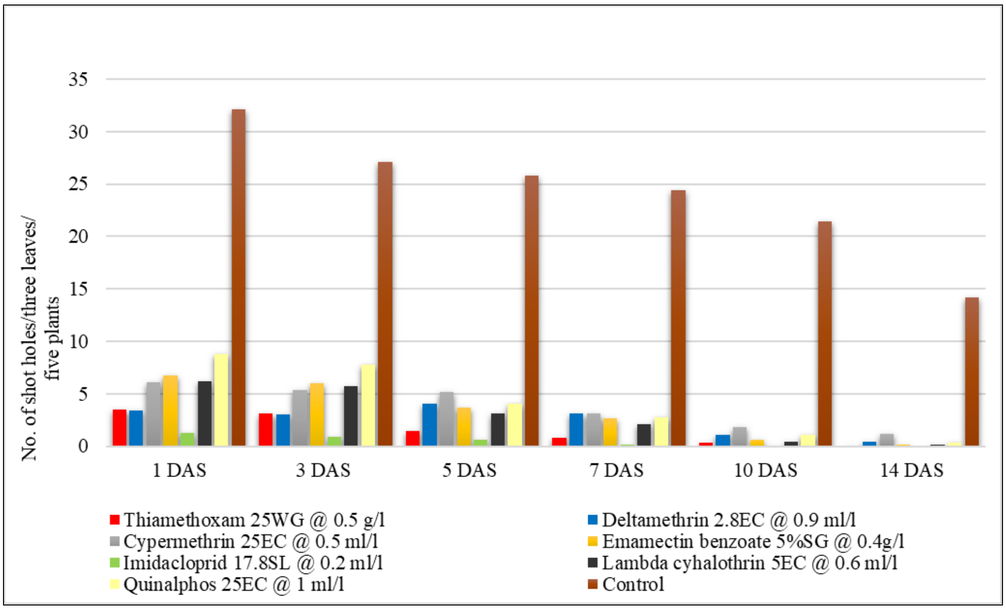

Fig 2: Effect of insecticides on okra flea beetle after second spray

Yield obtained from different treatment plots

Table IV shows the overall yield of marketable fruits produced for each treatment. Data showed that compared to the untreated control, all pesticide treatments produced a significantly increased yield of marketable fruits.

The treatment with imidacloprid 17.8 SL applied at the concentration of 0.2 ml/l produced maximum yield of marketable fruits (12.25 t/ha) which was significantly higher than rest of the treatments. This treatment of imidacloprid was at par with thiamethoxam 25 WG (0.5 g/l) which recorded a yield of 11.25 t/ha and also at par with lambda cyhalothrin 5 EC (0.6 ml/l) which recorded a yield of 11.01 t/ha and also at par with emamectin benzoate 5% SG (0.4 g/l) (T_4) which recorded a yield of 10.11 t/ha. The next effective treatment was quinalphos 25 EC applied at the concentration of (1 ml/l). The yield obtained from quinalphos treated plots was 9.71 t/ha. This treatment of quinalphos was at par with deltamethrin 2.8 EC (0.9 ml/l) (T_2) which obtained a yield of 8.58 t/ha and was also at par with cypermethrin 25EC (0.5 ml/l) (T_3) with a yield of 7.38 t/ha. The least effective treatment was cypermethrin 25EC (0.5 ml/l) (T_3) with very low quantity of marketable fruits among the treatments. The untreated control (T_8) recorded the lowest yield of 5.04 t/ha. Therefore, cypermethrin 25EC (0.5 ml/l) was found as the least promising compared with six other pesticides tried.

Data recorded on increased yield of okra over untreated control indicated that the treatment with imidacloprid 17.8 SL (0.2 ml/l) was found most promising with increased yield of 7.21 t/ha over untreated control followed by treatments with thiamethoxam 25 WG (0.5 g/l) and lambda cyhalothrin 5 EC (0.6 ml/l) which resulted in additional yield of 6.21 t/ha and 5.97 t/ha, respectively over untreated control. The treatment cypermethrin 25EC (0.5 ml/l) was found relatively least effective in producing additional yield (2.34 t/ha) of okra over untreated control.

Table 4: Effect of various pesticides on yield of okra

Treatment	Yield (t ha^{-1})	Increased yield over control (t ha^{-1})
Thiamethoxam 25WG @ 0.5 g/l	11.25	6.21
Deltamethrin 2.8EC @ 0.9 ml/l	8.58	3.54
Cypermethrin 25EC @ 0.5 ml/l	7.38	2.34
Emamectin benzoate 5% SG @ 0.4 g/l	10.11	5.07
Imidacloprid 17.8SL @ 0.2 ml/l	12.25	7.21
Lambda cyhalothrin 5EC @ 0.6 ml/l	11.01	5.97
Quinalphos 25EC @ 1 ml/l	9.71	4.67
Control	5.04	-
SE (m±)	0.78	
CD at 5%	2.38	

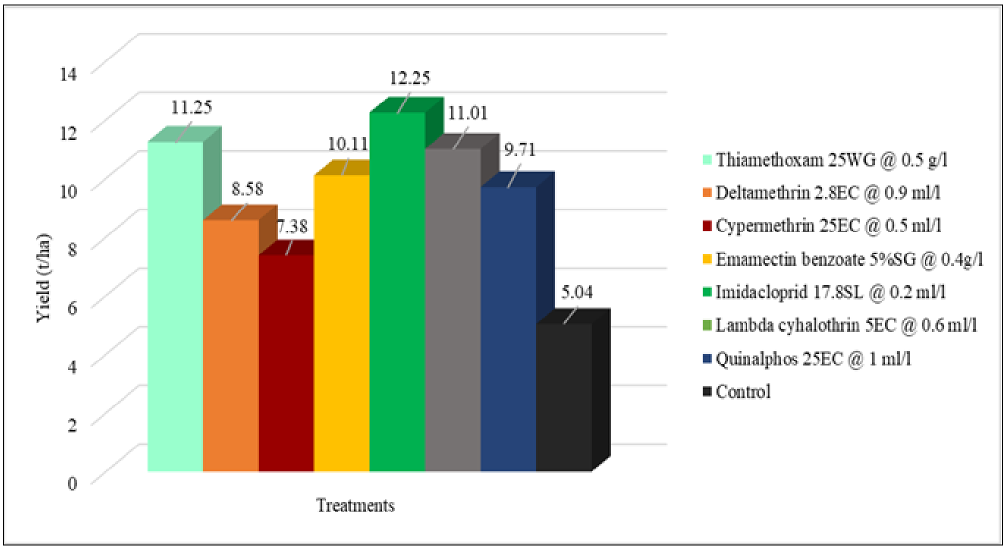

Fig 3: Yield obtained from different insecticide treatment plots

Application of imidacloprid is the first best treatment from our study. The present finding is supported by Kulkarni and Adsule (2006) [10] who confirmed that imidacloprid 200 SL @3 ml/10 litre is the best treatment for the control of population of flea beetles, thrips and jassids. Belekar (2008) [2] got best results from the treatments of lambda- cyhalothrin 5 EC @40.0 g a.i./ha and deltamethrin 2.8 EC @12.5 g a.i./ha for the control of okra flea beetle, even though imidacloprid which was the superior treatment in our experiment was also present there, whereas in case of yield, imidacloprid and deltamethrin recorded the highest yield, which is similar to our finding. Chaudhari *et al.* (2003) [5] reported that imidacloprid at 150 ml/ha provided highest protection against aphid in okra and recorded the highest yield. Satyanarayana and Arunakumara (2021) [13] on evaluating the efficacy of insecticides against grape vine flea beetle found that after tolfenpyrad, imidacloprid harboured less number of flea beetles. Kuhar and Taylor (2002) [9] found that seed treatments with imidacloprid reduced flea beetle injury in Sprint corn.

Conclusion

Based on over all observations recorded on mean number of shot holes made by flea beetle, recorded at 1,3,5,7,10 and 14 days after Ist and IInd spray of pesticides and the yield of marketable fruits of okra produced in each treatment, it is indicated that the significantly lowest damage was noticed in the treatment with imidacloprid 17.8 SL (0.2 ml/l) than rest of the treatments. It was followed by the treatments with thiamethoxam 25 WG (0.5 g/l) and lambda cyhalothrin 5 EC (0.6 ml/l), which ranked second and third best treatments, respectively. The treatment with cypermethrin 25EC (0.5 ml/l) was found relatively least effective in checking the incidence of flea beetle.

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