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Impact of insecticides on stingless bee pollinating in okra under field condition

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Abstract
An experiment was carried out at Central Experimental Station, Wakawali, Dr. BSKKV, Dapoli during Summer, 2023 with eight treatments and three replications. Results revealed that the treatment T_8- Untreated control was recorded maximum bees visits (2.76 bees/plant/5 min) and was found at par with the treatment T_5- Neem oil 0.5% EC @ 5 ml (2.47 bees/plant/5 min). It was significantly superior over the treatments T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml (2.45 bees/plant/5 min), T_3- Spinetoram 11.7 SC @ 0.9 ml (2.23 bees/plant/5 min), T_2- Emamectin benzoate 5 SG @ 0.4 g (1.91 bees/plant/5 min), T_6- Lambda cyhalothrin 5 EC @ 0.6 ml (1.88 bees/plant/5 min) and T_7- Imidacloprid 17.8 SL @ 0.3 ml (1.78 bees/plant/5 min). The lowest stingless bees visits were observed in T_4- Spinosad 45 SC @ 0.3 ml (1.64 bees/plant/5 min). The data revealed that the maximum yield of okra was recorded in T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml (13.70 t/ha). Stingless bee pollination can enhance the fruit yield of okra.

Keywords: Fruit yield, impact, insecticides, okra, pollination, stingless bee

Introduction
Stingless bees are important not only in honey production but also in specialized practice like pollination of crops. Konkan region of Maharashtra have occupied major cultivation of coconut, mango, cashew nuts, spice crops and vegetable crops like okra. Bees are essential pollinator in these crops. Currently, India is largest producer of okra with over 60% of the global production. India produces approximately 6 million tonnes of okra. Okra plays important role in human nutrition provides fat, protein, carbohydrates, minerals and vitamins (Benchasri, 2012) [3]. Okra pollination by insects increased the number of matured seeds and decreased fruits malformation (Azoo *et al*. 2011) [2]. In okra, there is a positive correlation between the number of seeds in a pod and its weight, and insect pollination increases the number of seeds present in a pod (Angbanyere and Baidoo, 2014) [1]. Size and weight of pod, the number of seeds, and the percentage of fruit set of okra were enhanced by pollination of three stingless bee species *Heterotrigona itama*, *Tetragonula laeviceps* and *T. clypearis* (Kartika *et al*. 2022) [6]. No. of pesticidal sprays are taken on the okra crop against different pests. Pesticides are primarily used to kill pest insects, they also can harm non-target species such as pollinators. Its contamination poses considerable risks to non-target organisms. Among non-intentional organisms, the honey bee is significant agro environmental, economic and scientific insect. During the pollination activity, stingless bees can also be exposed directly or indirectly to the insecticidal products. Hence the bees population is decreasing day by day. In the Konkan region, number of stingless bee colonies have been found in electric pole, plumbing pipe, crevices in wall, door, window, live and dead trees and other concealed places (Wankhede *et al.* 2022) [15] and playing major role in okra for pollination. Considering importance of stingless bees in pollination of okra and impact of different insecticides on bees, the present research work was conducted with objective to study the impact of insecticides on stingless bees under field condition.

Materials and Methods
An experiment was carried out at Central Experimental Station, Wakawali, Dr. BSKKV, Dapoli during Summer, 2023. The experiment was laid out in a randomised block design with three replications and eight treatments *viz*., T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml, T_2- Emamectin benzoate 5 SG @ 0.4 g, T_3- Spinetoram 11.7 SC @ 0.9 ml, T_4- Spinosad 45 SC @ 0.3 ml, T_5- Neem oil 0.5% EC @ 5 ml, T_6- Lambda cyhalothrin 5 EC @ 0.6 ml, T_7-

Imidacloprid 17.8 SL @ 0.3 ml and T_8- Untreated control. In each treatment plot, total 5 plants in a 4x3 m^2 area were tagged randomly for recording the visits of bees. At 50% flowering, two stingless bee colonies were installed with equal distance in a okra plot. Two sprays were undertaken at 50 percent flowering and second spray was taken after the 15 days of first spray. Pre-count observations were undertaken at one day prior to spraying and post treatments observations were recorded @ 1^{st}, 3^{rd}, 5^{th}, 7^{th}, 10^{th} and 14^{th} days after application of treatments about visiting bees per plant per five minutes during its peak period (11.00 hr-1.00 hr) on okra flowers. Recommended agronomical package of practices were followed for raising good seed production plot. Okra fruit yield was recorded separately for each treatment. Each plot was harvested and weigh separately and yield per plot was later convert into yield per hectare. The generated data was subjected in statistical analysis.

Results and Discussion

Mean number of bees visiting towards different treatments for pollination in okra

The pooled mean of the first spray, second spray and pooled data of stingless bees under field condition are presented in table 1 and graphically depicted in figure 1. The mean data of first spray revealed that the maximum stingless bees visits were recorded in T_8- Untreated control (2.73 bees/plant/5 min) and was found on par with the treatments, T_5- Neem oil 0.5% EC @ 5 ml (2.53 bees/plant/5 min) and T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml (2.42 bees/plant/5 min). The results are in close conformity with those of Gokulakrishnan *et al*. (2021) [5] reported that the chlorantraniliprole treated plot somewhat repellent to *Apis cerana indica* bees with 0.7 bees/plant. It was significantly superior over rest of the treatments T_3- Spinetoram 11.7 SC @ 0.9 ml (2.18 bees/plant/5 min), T_2- Emamectin benzoate 5 SG @ 0.4 g (1.94 bees/plant/5 min), T_6- Lambda cyhalothrin 5 EC @ 0.6 ml (1.94 bees/plant/5 min) and T_4- Spinosad 45 SC @ 0.3 ml (1.70 bees/plant/5 min). Minimum bees visits were observed in T_7- Imidacloprid 17.8 SL @ 0.3 ml (1.66 bees/plant/5 min). The observations recorded after second spray application showed that the lowest bees visits were observed in T_4- Spinosad 45 SC @ 0.3 ml (1.64 bees/plant/5 min). The present findings of spinosad are in conformity with of Scott *et al.* (2009) [10] reported that foliar applications of spinosad affected bees foraging. The treatment T_8- Untreated control was recorded the maximum bees visits (2.79 bees/plant/5 min). It was followed by T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml next best treatment (2.47 bees/plant/5 min) which found on par with the treatments, T_5- Neem oil 0.5% EC @ 5 ml (2.40 bees/plant/5 min) and T_3- Spinetoram 11.7 SC @ 0.9 ml (2.27 bees/plant/5 min). It was found significantly superior over rest of the treatments. The data on pooled mean of two sprays indicated that the treatment T_8- Untreated control was recorded maximum bees visits (2.76 bees/plant/5 min) and was found at par with the treatment T_5- Neem oil 0.5% EC @ 5 ml (2.47 bees/plant/5 min). The present finding that neem oil was least repellent to bees is in conformity with the findings of earlier worker Umrao *et al*. (2012) [14] and Kumar *et al*. (2012) [7]. It was significantly superior over the treatments T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml (2.45 bees/plant/5 min), T_3- Spinetoram 11.7 SC @ 0.9 ml (2.23 bees/plant/5 min), T_2- Emamectin benzoate 5 SG @ 0.4 g (1.91 bees/plant/5 min), T_6- Lambda cyhalothrin 5 EC @ 0.6 ml (1.88 bees/plant/5 min) and T_7- Imidacloprid 17.8 SL @ 0.3 ml (1.78 bees/plant/5 min). The lowest stingless bees visits were observed in T_4- Spinosad 45 SC @ 0.3 ml (1.64 bees/plant/5 min). The present study is in agreement with the earlier field studies Dinter *et al*. (2009) [4] revealed that chlorantraniliprole was safe insecticide to insect pollinators. Present results in respect of imidacloprid are in corroboration with those of Sharma and Abrol (2014) [12] who observed reduction in the number of honey bees visits after spraying over the toria (*Brassica campestris*) crop with imidacloprid. Similarly, Pashte and Patil (2016) [8] reported the reduction in the bees activity was observed for four days subsequent to application of imidacloprid. The bees visits in insecticide treated plots were reduced may be due to the odour of insecticides. It may be possible due to availability of abundance pollen resource (another okra plots, watermelon plots etc.) near the experimental plot.

Fruit yield/ha

The yield in various treatments had been greatly impacted by stingless bees visitation in okra. The data revealed that the maximum yield of okra was recorded in the treatment of T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml (13.70 t/ha). The next best treatments were T_2- Emamectin benzoate 5 SG @ 0.4 g (13.65 t/ha), T_4- Spinosad 45 SC @ 0.3 ml (13.20 t/ha), T_3- Spinetoram 11.7 SC @ 0.9 ml (12.80 t/ha), T_6- Lambda cyhalothrin 5 EC @ 0.6 ml (12.04 t/ha), T_7- Imidacloprid 17.8 SL @ 0.3 ml (11.90 t/ha) and T_5- Neem oil 0.5% EC @ 5 ml (10.30 t/ha). The lowest fruit yield was found in T_8- Untreated control (8.80 t/ha). Visitation of entomofauna on okra flowers increased the fruit set by 1.4–3% and 5.5–6.1% compared to self-pollination (Azoo *et al*., 2011) [2]. Honey bee, *Apis mellifera* which dominantly pollinated okra increased 0.03% of yield and 1.26% of seed number (Angbanyere and Baidoo, 2014) [1]. Similarly, pollination using two species of stingless bees *T. iridipennis* and *Lithurgus attratus* in Sri Lanka also enhanced about 50% of the number of seeds and seed germination, 17% of pod diameter, and 4% of pod length (Perera and Karunaratne, 2019) [9]. The results corroborate with those of Tej *et al*. (2017) [13] who also reported that stingless bees are essential to the pollination of greenhouse cucumber crops. Besides that, it was noted that the improvement in the qualitative and quantitative yield parameters of the cucumber crop had increased the yield and selling value of the crop. The present results are in conformity with those of Shaikh *et al*. (2023) [11] who observed maximum visitation of stingless bee towards flowers of radish and they recorded high percent of pod setting and seed yield.

Table 1: Impact of different insecticidal treatments on stingless bees in okra field

Tr. No.	Treatment	Formulation	Dose per litre	Stingless bees visits/plant/5 min		
				1st spray	2nd spray	Pooled mean
T_1	Chlorantraniliprole	18.5 SC	0.25 ml	2.42 (1.85)*	2.47 (1.86)	2.45 (1.86)
T_2	Emamectin benzoate	5 SG	0.4 g	1.94 (1.71)	1.88 (1.69)	1.91 (1.70)
T_3	Spinetoram	11.7 SC	0.9 ml	2.18 (1.78)	2.27 (1.80)	2.23 (1.79)
T_4	Spinosad	45 SC	0.3 ml	1.70 (1.63)	1.64 (1.62)	1.67 (1.63)
T_5	Neem oil	0.5% EC	5 ml	2.53 (1.88)	2.40 (1.84)	2.47 (1.86)
T_6	Lambda cyhalothrin	5 EC	0.6 ml	1.94 (1.71)	1.81 (1.67)	1.88 (1.69)
T_7	Imidacloprid	17.8 SL	0.3 ml	1.66 (1.62)	1.89 (1.69)	1.78 (1.66)
T_8	Untreated control			2.73 (1.92)	2.79 (1.95)	2.76 (1.94)
SE±				0.03	0.02	0.02
C.D @ 5%				0.08	0.07	0.07

*(Figures in parenthesis are square root (X+1) transformed values)

Table 2: Impact of different treatments on yield performance of okra by honey bees pollination

Tr. No.	Treatment	Formulation	Dose per litre	Fruit Yield (t/ha)
T_1	Chlorantraniliprole	18.5 SC	0.25 ml	13.70
T_2	Emamectin benzoate	5 SG	0.4 g	13.65
T_3	Spinetoram	11.7 SC	0.9 ml	12.80
T_4	Spinosad	45 SC	0.3 ml	13.20
T_5	Neem oil	0.5% EC	5 ml	10.30
T_6	Lambda cyhalothrin	5 EC	0.6 ml	12.04
T_7	Imidacloprid	17.8 SL	0.3 ml	11.90
T_8	Untreated control			8.80

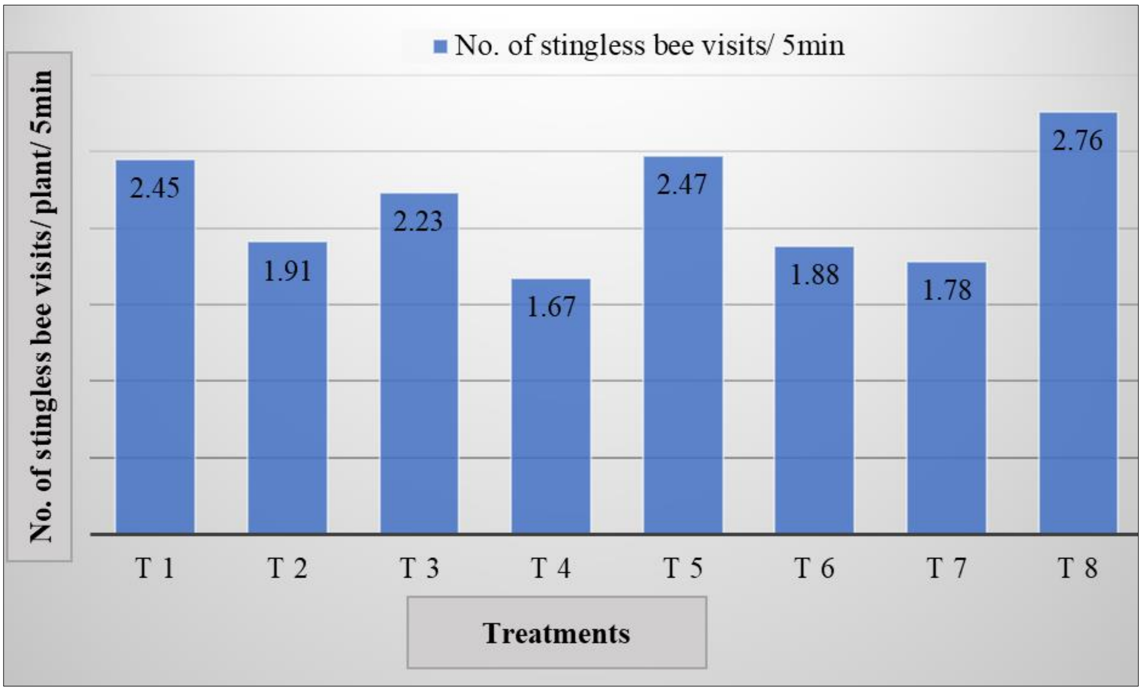

Fig 1: No. of stingless bee visits on okra flower

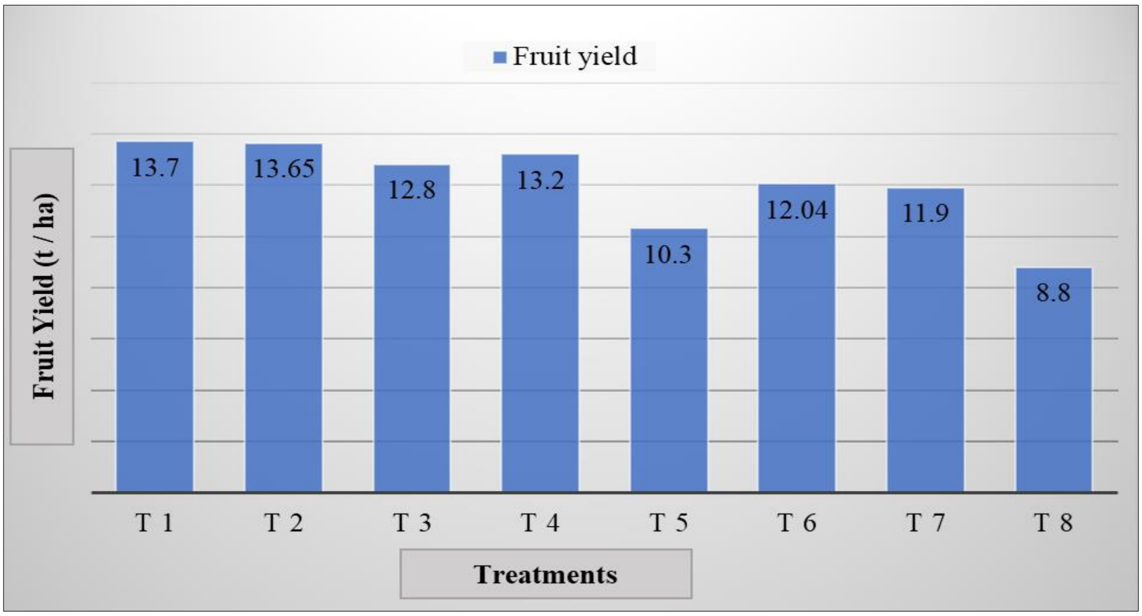

Fig 2: Impact of different treatments on yield performance of okra pollinating by stingless bees

Plate 1: General view of experimental plot

Plate 2: Establishment of Stingless bee colonies in okra plot

Plate 3: Stingless bee visiting okra flower

Conclusion

In the present investigation it is observed that the maximum bee visits were observed in T_5- Neem oil 0.5% EC @ 5 ml and T_1- Chlorantraniliprole 18.5 SC @ 0.25 ml. To enhance the yield of pollinating crop by stingless bees can be used as an alternative pollinator.

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