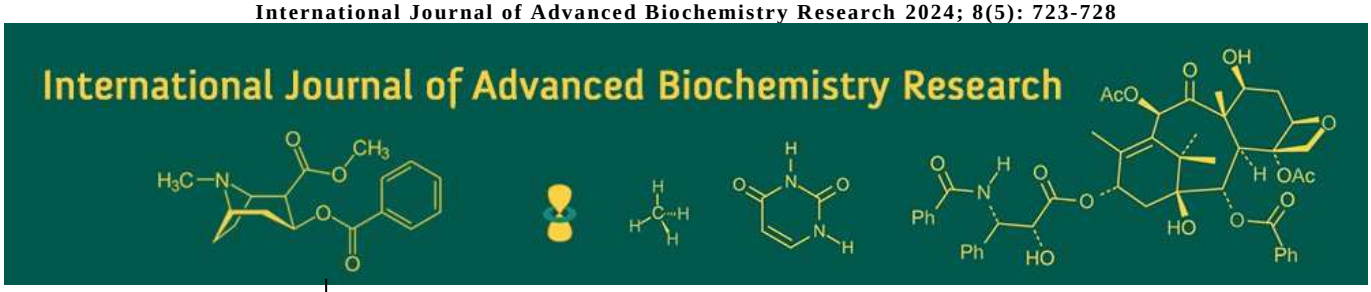

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Effect of some botanicals and neonicotinoids on activity of honey bee in sunflower

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Abstract
Experiment was conducted to find out the effect of some botanicals and neonicotinoids on activity of honey bee in sunflower. The research work was carried out on field of Division of Entomology RCSM College of Agriculture, Kolhapur during *Summer*, 2021.
The daily foraging activity of honey bee was initiate at 0800 hr and cessation at late evening 17.45 hr. The peak activity periods of honey bee during day time were recorded at 0900 hr, 1000 hr, 1100 hr, 1600 hr and 1700 hr. Relative abundance of different honey bee species at 10 percent flowering of sunflower revealed that the maximum number of *Apis cerana indica* was recorded this was (35.55%) followed by *A. dorsata* (21.41%), *A. florae* (19.72%), *A. mellifera* (13.56%). The maximum repellent activity was seen in the plots treated with imidacloprid 17.8% SL and clothianidin 50% WDG from the day of spraying to 9th day after spraying. Among the neonicotinoids acetamiprid 25% SP was less repellent activity recorded from the day of spraying to till the 9th day after spraying. The repellent activity of neonicotinoids to *Apis cerana indica* was in order to: imidacloprid > clothianidin > thiamethoxam > acetamiprid.
The normal bee's visits were recorded in the plots treated with botanicals *viz.* Tobacco and Nirgundi except Neem at initial hours after spraying of neem the visits were low after that it restore till the 9th day of spraying. After spraying of 5% sugar syrup attracted more bees, hence it can be used as attractant. The maximum bee activity was recorded in the plots treated with the one colony of *Apis cerana indica*.

Keywords: *Apis cerana indica*, botanicals, neonicotinoids, repellent

Introduction
Sunflower (*Helianthus annuus* L.) belongs to the family most commonly referred as annual sunflower. Sunflower is an important oil seed crop in India for both domestic and commercial uses. The area of sunflower in world was 26.36 mh with 54.57 mt production having 2090 kg/ha productivity. In India, total growing area of sunflower was 0.25 mh with 0.22 mt production with 886 kg/ha productivity. In Maharashtra total area of sunflower cultivation was 0.0251mh with 0.0119 mt production having 475kg/ha productivity (Annon, 2019) [1].
Bees are vital agent in crop production which imparts quantitative and qualitative improvements. Sunflower is a cross pollinated crop. Bee pollinators plays an important role in sunflower pollination. Even sunflower rewards bees with substantial quantity of nectar and pollen that fascinates huge number of pollinators. There were many studies reveled that honey bee pollination improves qualitative as well as quantitative yields of sunflower crop (Altayeb and Nagi, 2015) [2].
The study of pesticide effect on the honey bee is vital because of the need to control a wide variety of agricultural pest with insecticides without hurting bees that inadvertently come into contact with pesticides when foraging. The hazards of insecticide application on flowering crops include direct mortality of bees, sublethal effects, repellent effects and toxicity of the residues present on various floral parts and nectar (Doublet *et al*., 2015) [5]. Prolonged repellent effect may hamper pollination benefits while a short repellency will deter the insect pollinators from visiting the treated flowering crop for a brief period but there after allow them to restart foraging activities (with minimal residual hazards) without compromising the crop yield. The aim of this study was to examine the repellent effects formulation on foraging honey bees and other bee pollination practices. In India most of the

pollination research is concerned with crop production. However, there are very few studies regarding to the impact of combination of recommended pesticides on bee foraging in field condition along with honey bee pollination managements and simultaneous effect on crop yields.

Materials and Methods

The present experiment was carried out in *Summer* season of 2020-2021 at Division of Entomology RCSM College of Agriculture, Kolhapur. The sunflower variety Kaveri champ was sown with randomized block design with spacing 60 × 30 cm.

Treatment Details

Treatment no.	Treatment	dose/L
T_1	Neem (*Azadirachta indica*)	5 ml
T_2	Tobacco (*Nicotina tobacum*)	5 ml
T_3	Nirgundi (*Vitex negundo*)	5 ml
T_4	Imidacloprid 17.8% SL	0.25 ml
T_5	Clothianidin 50%WDG	0.1 gm
T_6	Thimethoxam 25% WG	0.14 gm
T_7	Acetamiprid 20% SP	0.2 gm
T_8	Sugar syrup 5%	50 g
T_9	*A.cerana indica*	One colony/plot
T_{10}	Pollination without insect	Nylon net
T_{11}	Open pollination	Water

Methodology

1. Rearing of Honey Bee

Colonies were brought by beekeepers of The Shree Mouni Maharaj Shetkari Utpadak Gat, Madgaon, Tah. – Bhudargad, Dist. – Kolhapur. Honey bees (*Apis cerana indica*) were reared in langstroth boxes of size 46.5 x 36.5 x 23.8 cm at the experimental farm. Healthy honey bee colonies were maintained with regular monitoring and necessary treatment.

2. Collection and Extraction of Botanicals

Leaves of *Vitex negundo*, *Nicotiana tobacum* and seeds of *Azadirachta indica* were collected from surrounding areas of RCSM College of Agriculture, Kolhapur and dried under room temperature (28 ± 2°c) and relative humidity (RH 75 ± 5%) at, Division of Agricultural Entomology RCSM College of Agriculture, Kolhapur. After complete drying, the plant materials were powdered using electric blender and sieved through kitchen strainer. 200g of powders were mixed in 1 litre of distilled water kept for 24 hrs after that solution were extracted by using the filter paper. For treatment 5 ml/L extract were used. (Birhanu *et al.*, 2019) [4].

3. To Study Impact of Different Insecticides on Activities of Honey Bee on Sunflower

The experiment was conducted on sunflower crop with the foliar treatment of insecticides. Sunflower crop (var. Kaveri Champ) was grown at spacing of 60 x 30 cm in the plot (6 x 4 m) by following recommended agronomic practices. The experiment was laid out in RBD with three replications. One meter distance was maintained between the replication. For the studies, the blooming (50% flowering) sunflower crop (var. Kaveri champ) was sprayed with the recommended dose of insecticides with three replications. The control plot was sprayed with water only. Nylon mosquito nets having 6 m^3 size (mesh 20 micron) was erected over the plots by using the bamboo sticks for treatment number T_9 and T_{10}. At the stage of 50% flowering, one bee colony with frames were kept inside the covered plots of T_9. The colonies were retained in the cages till the cessation of flowering. Sugar syrup was sprayed with 5% concentration was sprayed at 50% percent flowering. In the plots under pollination without insect treatments, pollinating insects were not allowed to enter inside the net.

Foraging activity of bees were observed on sunflower during peak activity period (0900 hr, 1000 hr, 110 hr, 1600 hr and 1800 hr) and expressed as mean number of bees visited per five flowers per 5 min. The observations were taken one DBS, DOS and 3, 6, and 9 days after spray of insecticides. The values after square root transformation were subjected to ANOVA (Analysis of Variance) (Panse and Sukhatme, 1954) [7]. (DBS- Day before spray, DOS- Day of spray, DAS – Day after spray).

Results and Discussion

1. Effect of Different Insecticides on Activities of Honey Bee in Sunflower on Day before Spraying

The population of *A. cerana indica* species visiting sunflower before spraying of botanicals and neonicotinoids are presented in Table 1 and fig. 1

At 1700 hr the highest visitation activity of Indian bees was recorded in one colony of *A. cerana indica* (16.67 bees/5 flowers/5 min). The remaining plot was open condition. The population of *A. cerana indica* was at par with each other and ranged from 14.33 to 16.67 bees/5 flower/5 minutes. At 0900 hr and 1700 hr the highest activity was seen in all treatments ranged from 12.67 to 16.67 bees/5 flower/5 minutes.

2. Effect of Different Insecticides on Activities of Honey Bee in Sunflower 3rd Day After Spraying

Effect of botanicals and neonicotinoids spraying on sunflower and the observed the bee's activity and narrated in Table 2. On 3rd DAS 0900 hr data revealed the lowest activity of *A. cerana indica* was seen in imidacloprid 17.8% SL (2.67 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (4.67 bees/5 flower/5 minutes) and among the neonicotinoids acetamiprid 20% SP (6.67 bees/5 flower/5 minutes) was seen less repellence to bees. Plot treated with botanicals and Open Pollination (Water) which was without any treatment showed the normal bees activity. The highest activity was seen in one colony of *A. cerana indica* (13.00 bees/5 flower/5 minutes).

At 1000 hr the activity of bees were slightly increased in all treatment but lowest activity of bees were seen in imidacloprid 17.8% SL (8.00 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (9.00 bees/5 flower/5 minutes) and acetamiprid 20% SP (9.33 bees/5 flower/5 minutes) was showed the less repellence to the bee activity among all neonicotinoids. Normal bees activity were seen in all botanicals and open pollinated plots. The highest activity seen in caged condition of one colony of *A. cerana indica* (12.33 bees/5 flower/5 minutes) its followed by sugar syrup 5% (10.33 bees/5 flower/5 minutes) and similar trends of visitations were seen at 1100 hr in all treatment.

Table 1: Effect of Different Insecticides on Activities of Honey Bee in Sunflower on Day Before Spraying

Tr. No.	Treatment	No. of bees/five flowers/5 min.				
		0900 hr	1000 hr	1100 hr	1600 hr	1700 hr
T_1	Neem (*Azadirachta indica)*	11.00 (3.39)	14.33 (3.85)	10.00 (3.24)	11.67 (3.48)	16.00 (4.06)
T_2	Tobacco (*Nicotina tabacum*)	12.00 (3.53)	13.67 (3.76)	9.00 (3.08)	12.33 (3.58)	15.67 (4.02)
T_3	Nirgundi (*Vitex negundo*)	11.33 (3.44)	13.33 (3.72)	10.33 (3.28)	12.00 (3.53)	16.67 (3.85)
T_4	Imidacloprid 17.80% SL	12.00 (3.53)	12.33 (3.58)	11.33 (3.44)	12.00 (3.39)	14.33 (3.85)
T_5	Clothianidin 50% WDG	11.33 (3.44)	14.33 (3.84)	8.33 (2.96)	11.00 (3.29)	14.67 (3.89)
T_6	Thimethoxam 25% WG	10.00 (3.24)	12.67 (3.62)	11.67 (3.48)	12.00 (3.53)	15.33 (3.98)
T_7	Acetamiprid 20% SP	9.67 (3.19)	15.33 (3.98)	10.33 (3.29)	11.67 (3.48)	16.00 (4.05)
T_8	Sugar syrup 5%	11.00 (3.39)	15.33 (3.98)	10.00 (3.24)	12.00 (3.53)	15.33 (3.98)
T_9	*A. cerana indica*	12.00 (3.53)	15.00 (3.98)	11.33 (3.44)	13.33 (3.72)	16.67 (3.14)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	11.00 (3.38)	13.67 (3.74)	10.33 (3.29)	12.33 (3.58)	16.67 (4.14)
	SE ±	0.1362	0.1385	0.1208	0.1018	0.13
	CD@ 5%	0.40	0.41	0.36	0.30	0.38
	CV	7.46	6.81	6.88	5.51	6.04

Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed values

At 1600 hr mean data revealed the highest repellence activity of bees were seen in imidacloprid 17.8% SL (6.67 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (6.67 bees/5 flower/5 minutes). The activity was seen in the plot treated with botanicals and control was normal. The highest activity was seen in the one colony of *A. cerana indica* (13.67 bees/5 flower/5 minutes) followed by sugar syrup 5% (10.00).

At 1700 hr, the lowest active ty of Indian bees was seen in the imidacloprid 17.8% SL (8.00 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (9.33 bees/5 flower/5 minutes), among the neonicotinoids the acetamiprid 20% SP (10.33 bees/5 flower/5 minutes) were showed the less repellency. All plots treated with botanicals and sugar syrup 5% bees activity were normal. The highest activity was seen in the T_9 one colony of *A. cerana indica* (16.00 bees/5 flower/5 minutes) followed by Open Pollination (Water) (14.33 bees/5 flower/5 minutes) which was without any treatment.

Table 2: Effect of Different Insecticides on Activities of Honey Bee in Sunflower 3rd Day After Spraying

Tr. No.	Treatment	No. of bees/five flowers/5 min.				
		0900 hr	1000 hr	1100 hr	1600 hr	1700 hr
T_1	Neem (*Azadirachta indica)*	10.00 (3.24)	12.00 (3.53)	10.33 (3.59)	9.00 (3.08)	14.33 (3.84)
T_2	Tobacco (*Nicotina tabacum*)	10.67 (3.33)	12.00 (3.52)	9.33 (3.13)	9.00 (3.06)	13.67 (3.75)
T_3	Nirgundi (*Vitex negundo*)	11.00 (3.78)	12.00 (3.53)	9.33 (3.13)	9.67 (3.18)	13.67 (3.74)
T_4	Imidacloprid 17.80% SL	2.67 (1.74)	8.00 (2.91)	6.00 (2.54)	6.67 (2.67)	8.00 (2.91)
T_5	Clothianidin 50% WDG	4.67 (2.26)	9.00 (3.08)	6.67 (2.67)	6.67 (2.67)	9.33 (3.13)
T_6	Thimethoxam 25% WG	3.00 (1.81)	9.00 (3.08)	7.33 (2.78)	6.00 (2.54)	9.67 (3.18)
T_7	Acetamiprid 20% SP	6.67 (2.65)	9.33 (3.12)	8.33 (2.97)	7.00 (2.72)	10.33 (3.29)
T_8	Sugar syrup 5%	9.33 (3.12)	12.00 (3.52)	10.33 (3.29)	10.00 (3.23)	12.67 (3.61)
T_9	*Apis cerana indica*	13.00 (3.67)	12.33 (3.57)	11.33 (3.44)	13.67 (3.76)	16.00 (4.06)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	10.33 (3.29)	11.67 (3.46)	9.33 (3.13)	9.67 (3.18)	14.33 (3.84)
	SE ±	0.2021	0.1599	0.1344	0.1482	0.1634
	CD@ 5%	0.61	0.47	0.40	0.44	0.48
	CV	13.19	8.94	8.24	9.16	8.63

Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed values

3. Effect of Different Insecticides on Activities of Honey Bee in Sunflower 6th day After Spraying

Effect of botanicals and neonicotinoids spraying on sunflower and observed activity of *A. cerana indica* and presented in table 3, at 0900 hr in morning hours the activity of honey bees were moderately less in all treatment out of that lowest number of bees were recorded in imidacloprid 17.8% SL (3.67 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (4.00 bees/5 flower/5 minutes) among the neonicotinoids acetamiprid 20% SP (4. bees/5 flower/5 minutes) was less repellent than other neonicotinoids to bees. The foraging activity of bees were seen in the plots treated with botanicals it was similar to the control plots which was without treatment. The maximum number of bees visits were seen in the plot treated with one colony of Indian honey bee (11.33 bees/5 flower/5 minutes) its followed by sugar syrup 5% (10.67 bees/5 flower/5 minutes). The similar trends of visitation recorded up to 1700 hr.

Table 3: Effect of Different Insecticides on Activities of Honey Bee in Sunflower 6th Day After Spraying

Tr. No.	Treatment	No. of bees/five flowers/5 min.				
		0900 hr	1000 hr	1100 hr	1600 hr	1700 hr
T_1	Neem (*Azadirachta indica)*	8.67 (3.02)	10.67 (3.33)	10.33 (3.26)	8.33 (2.97)	10.33 (3.28)
T_2	Tobacco (*Nicotina tabacum*)	8.33 (2.96)	11.33 (3.44)	11.00 (3.39)	`9.00 (3.08)	9.00 (3.08)
T_3	Nirgundi (*Vitex negundo*)	10.67 (3.33)	10.33 (3.29)	10.33 (3.29)	8.67 (3.03)	9.67 (3.18)
T_4	Imidacloprid 17.80% SL	3.67 (2.02)	8.00 (2.89)	8.33 (2.95)	4.67 (2.24)	6.67 (3.18)
T_5	Clothianidin 50% WDG	4.00 (2.11)	9.00 (3.06)	8.33 (2.96)	5.33 (2.41)	7.33 (2.79)
T_6	Thimethoxam 25% WG	4.33 (2.18)	9.33 (3.12)	8.67 (3.01)	5.33 (2.40)	6.33 (2.79)
T_7	Acetamiprid 20% SP	4.67 (2.26)	9.33 (3.12)	9.33 (3.13)	5.67 (2.47)	8.00 (2.91)
T_8	Sugar syrup 5%	10.67 (3.33)	10.00 (3.24)	10.67 (3.33)	8.33 (2.96)	9.33 (3.13)
T_9	*Apis cerana indica*	11.33 (3.43)	13.00 (3.66)	13.00 (3.67)	10.33 (3.29)	12.00 (3.53)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	10.00 (3.32)	10.33 (3.29)	10.33 (3.28)	9.00 (3.08)	11.33 (3.43)
	SE ±	0.1797	0.1615	0.1682	0.1471	0.1584
	CD@ 5%	0.53	0.48	0.50	0.43	0.47
	CV	12.07	9.28	9.71	9.78	9.53

Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed values

4. Effect of Different Insecticides on Activities of Honey Bee in Sunflower 9th day After Spraying

Effect of botanicals and neonicotinoids on activity of *A. cerana indica* on 9th day after spraying was recorded in table 4 and fig. 2 at 0900 hr the minimal number of bees were recorded in the imidacloprid 17.8% SL (7.00 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (7.67 bees/5 flower/5 minutes), among the neonicotinoids acetamiprid 20% SP (8.33 bees/5 flower/5 minutes) less repellence activity was seen. The plots treated with botanicals the bee activity was normal. The highest activity was seen in the colony of *A. cerana indica* (11.33 bees/5 flower/5 minutes) followed by T_8 sugar syrup 5% (11.00), T_{11} Open Pollination (Water) (11.00) which was without any treatment.

At 1700 hr data revealed the minimal bees activities of were recorded in imidacloprid 17.8% SL (9.00 bees/5 flower/5 minutes) at par with clothianidin 50% WDG (9.00 bees/5 flower/5 minutes), among the neonicotinoids thimethoxam 25% WG (9.33 bees/5 flower/5 minutes) highest activity was recorded. The number of bees recorded in botanicals was more or less similar. The highest activity was recorded in one colony of *A. cerana indica* (14.00 bees/5 flower/5 minutes) followed by Open Pollination (Water) (11.67 bees/5 flower/5 minutes) which was without any treatment.

Table 4: Effect of Different Insecticides on Activities of Honey Bee in Sunflower 9th Day After Spraying

Tr. No.	Treatments	No. of bees/five flowers/5 min.				
		0900 hr	1000 hr	1100 hr	1600 hr	1700 hr
T_1	Neem (*Azadirachta indica*)	10.67 (3.34)	10.67 (3.34)	10.00 (3.24)	10.33 (3.29)	11.00 (3.38)
T_2	Tobacco (*Nicotina tabacum*)	9.33 (3.13)	11.00 (3.38)	10.00 (3.23)	10.00 (3.24)	11.00 (3.42)
T_3	Nirgundi (*Vitex negundo*)	10.00 (3.22)	11.33 (3.44)	11.33 (3.44)	10.67 (3.34)	11.33 (3.43)
T_4	Imidacloprid 17.80 SL	7.00 (3.73)	9.33 (3.13)	9.67 (3.17)	7.00 (2.72)	9.00 (3.08)
T_5	Clothianidin 50% WDG	7.67 (2.85)	9.00 (3.08)	9.67 (3.14)	9.33 (3.13)	9.00 (3.06)
T_6	Thimethoxam 25% WG	7.67 (2.85)	9.33 (3.11)	10.00 (3.22)	9.67 (3.15)	9.33 (3.10)
T_7	Acetamiprid 20% SP	8.33 (2.96)	9.33 (3.10)	10.00 (3.24)	11.00 (3.38)	9.00 (3.08)
T_8	Sugar syrup 5%	11.00 (3.38)	11.00 (3.39)	12.00 (3.53)	10.00 (3.23)	11.00 (3.39)
T_9	*Apis cerana indica*	11.33 (3.43)	13.67 (3.76)	13.33 (3.70)	12.33 (3.58)	14.00 (3.81)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	11.00 (3.38)	13.67 (3.42)	12.00 (3.53)	10.33 (3.28)	11.67 (3.48)
	SE ±	0.1629	0.1747	0.1959	0.165	0.1627
	CD@ 5%	0.48	0.52	0.58	0.49	0.48
	CV	9.70	9.83	10.92	9.51	9.13

Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed values

The observations were made on the foraging activity of Indian bee on sunflower from the DBS to 9 DAS the results were recorded during the observation periods neonicotinoids group of insecticides was significantly repel the honey bees. Among the neonicotinoids plots treated with the imidacloprid 17.8% SL, clothianidin 50% WDG and thimethoxam 25% WG were recorded the highest repellent activity. The present finding that imidacloprid 17.8% SL, clothianidin 50% WDG and thimethoxam 25% WG were repellent to honey bees in is conformity with the findings earlier workers (Matre *et al.*, 2018) [6] and Bajiya and Abrol, 2019) [3]. The acetamiprid 20% SP was less repellent to foraging activity of Indian bees as evidenced in the present investigation is in corroboration with Stanley *et al.* (2015) [10].

The present findings that spraying of botanicals were not repellent to bees is in conformity with the findings of earlier workers (Pashte and Patil, 2017) [8] and (Pereira *et al*., 2020)

[9] according to whom azadirachtin did not deter the honey bees in the field.

The activity of honey bees were recorded after application of sugar solution 5% the bees activity is highest than normal activity. The present finding that Spraying of 5% sugar solution attracted more bees is in conformity with the findings of (Wankhede *et al*., 2019) [11].

The bees activity was higher in plots treated with one colony of *A. cerana indica* as evidenced in the present investigation is in corroboration with Matre *et al*. (2018) [6].

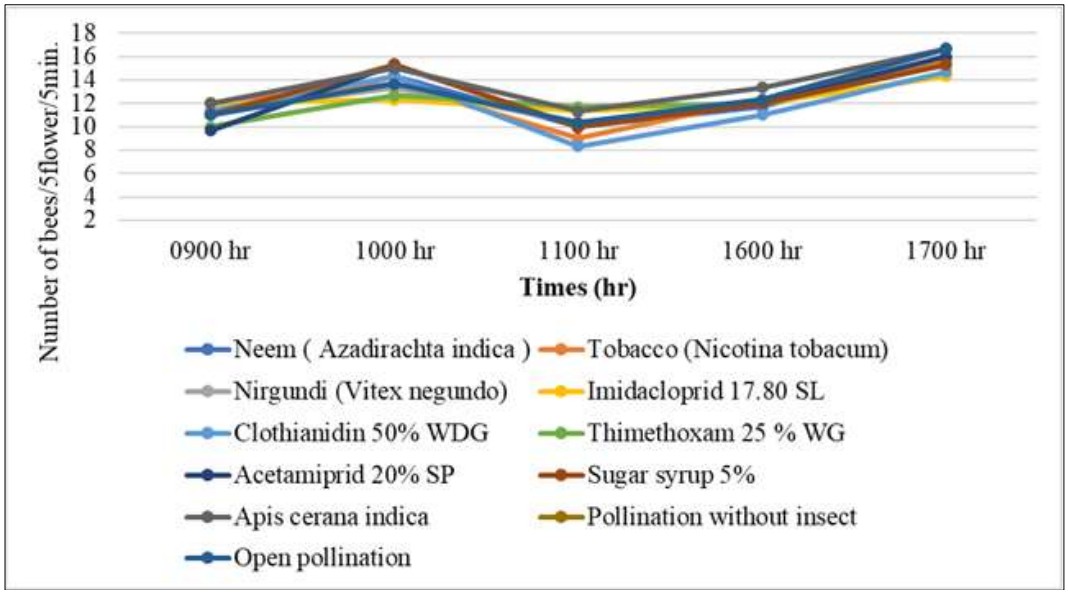

Fig 1: Effect of Different Insecticides on Activities of Honey Bee on Sunflower on Day Before Spraying

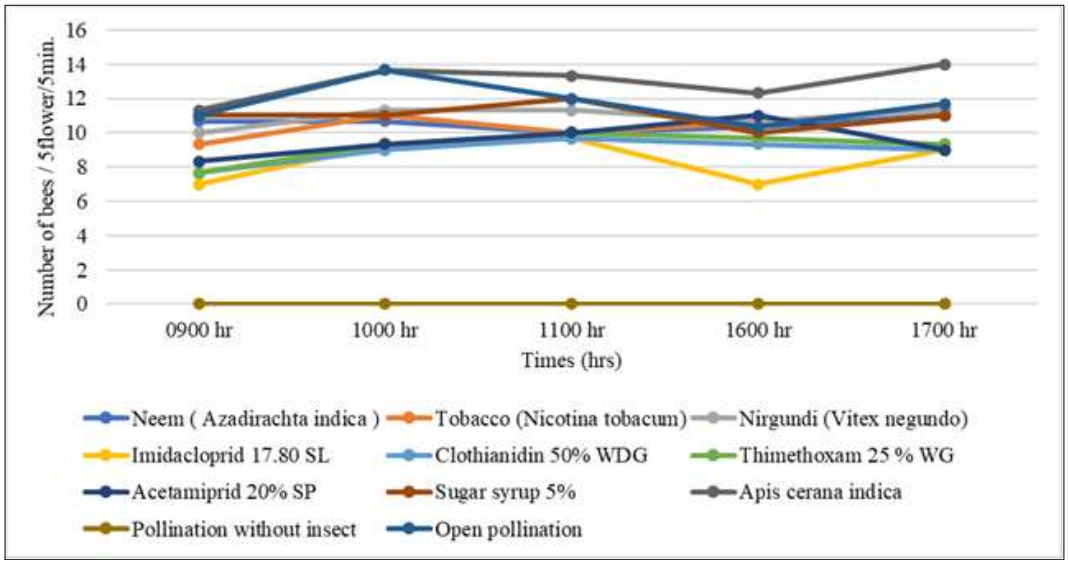

Fig 2: Effect of Different Insecticides on Activities of Honey Bee on Sunflower 9th day After Spraying

Conclusion

The spraying of botanicals on sunflower it was repellent to honey bees at initial hours after spraying after that restore normal till the 9th day after spraying and it concluded that the botanicals was safe for foraging activity of honey bees. Among neonicotinoids spraying of imidacloprid 17.8% SL and clothianidin 50% WDG were highest repellent activity from the day of spraying to till the 9th day after spraying. Acetamiprid 20% SP was recorded the lowest repellent activity among the neonicotinoids from the day of spraying to till the 9th day after spraying. However, comparison between imidacloprid and acetamiprid shows that acetamiprid was more foraging activity of honey bees as compared imidacloprid. However, the comparison of spraying of botanicals and neonicotinoids were presented and result revealed that botanicals were having lowest repellent properties to honey bees as compare to neonicotinoids.

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