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ECOFRIENDLY INSECTICIDES: IMPACT ON ABUNDANCE AND FORAGING ACTIVITY OF BEE POLLINATORS IN SUNFLOWER

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ABSTRACT

Field study was conducted with ecofriendly insecticides on their effects on the foraging activity and time spent of bee pollinators in sunflower during 2016-17 and 2017-18 at the University of Agricultural Sciences, Bengaluru. Significantly less number of bees were observed with mahua oil one day after spray- 2.15 (*Apis dorsata*), 1.33 (*A. cerana*), 1.72 (*A. florea*) and 1.24 (*Tetragonula iridipennis*). BIPM (biointensive integrated pest management) and spinosad treatments led to maximum number of bees at 4 and 7 days after spray. The least mean time spent was observed with mahua oil treatment, whereas, BIPM and spinosad led to maximum mean time spent for all the bee pollinators. It is concluded that mahua oil has repellent activity on the bee pollinators.

Key words: *Apis* spp., *Tetragonula iridipennis*, sunflower, BIPM, spinosad, mahua oil, foraging activity, time spent

Sunflower (*Helianthus annuus* L.) is an important oilseed crop, and it is a cross pollinated, entomophilic, necessitating pollinator's effect for great quality fertilization. In India sunflower is grown in an area of 0.47 million ha, and is primarily confined to southern states viz., Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu. Karnataka occupies prime position with an area of 0.35 million ha with an annual production of 0.17 mt (Anonymous, 2016). As sunflower produces sticky pollen, the involvement of wind in transferring pollen is negligible (Low and Pistillo, 1986), and needs animal pollinators to achieve high quality pollination (Free, 1993). Sunflower inflorescence is a foraging source for bees, giving both nectar and pollen (Muller et al., 2006). The time taken by the bee on a flower is crucial as it indicates its pollinating potential (Fell, 1986). With widespread and indiscriminate use of pesticides in sunflower, pollinators have declined. However, botanical pesticides offer antibacterial, insecticidal, repelling and or ovicidal effects (Schmutterer, 1995; Adoyo et al., 1997; Peter, 2011; Koche et al., 2012). The present study explores some biointensive ecofriendly alternatives and their effect on abundance, foraging activity and time spent by honey bees belonging to *Apis* spp., and *Tetragonula iridipennis* in sunflower ecosystem.

MATERIALS AND METHODS

The field trial was conducted to know the impact of some ecofriendly insecticides and BIPM module on honey bee pollinators in sunflower ecosystem at AICRP (Sunflower), ZARS, GKVK, Bengaluru during the consecutive kharif seasons of 2016-17 and 2017-18. The experiment consisted of eight treatments: 1. Spinosad 45SC (Tracer(R)); 2. NSKE (Neem Seed Kernel Extract) @5%; PSKE (Pongamia Seed Kernel Extract) @5%; 4. Neem oil @ 1ml/ l; 5. Pongamia oil @ 1ml/ l; 6. Mahua oil @ 1ml/ l. 7. BIPM module (Seed treatment with imidacloprid 70WS (5g/ kg) + metalaxyl 35SD (5g/ kg)+ handpicking and destruction of gregarious early instar larvae of defoliators (*Spodoptera litura* and *Spilarctia obliqua* + two sprays with spinosad 45SC @0.0045%, first spray during star bud stage and second spray during full bloom stage; and 8. Untreated control. There were three replications, in randomized complete block design (RCBD). The observations with respect to bee activity was taken after second spray which coincides with the full bloom stage. Pretreatment observations were made on 10 randomly selected heads in each treatment while, the post treatment observations on bee foraging, number of foragers/ 10 heads for 5 min/ hr between 0600 to 1900 hr and time spent for foraging by each bee, was taken at 1, 4 and 7 days after spray, respectively (Basavaraj et al., 2016). The sunflower hybrid KBSH-53 was used adopting the recommended package of practices except plant protection- UAS, Bengaluru (Anon., 2012). Ten flowers were selected in each treatment and time spent (in sec) on each flower head starting from arrival on flower till its departure, were recorded by using a digital stop watch. The flowers were observed at one hr interval starting from 0600 to 1900 hr and the mean calculated. The time spent on each genotype was expressed in sec. The data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Abundance: During kharif 2016-17 and 2017-18, significant differences were observed between the treatments with respect to number of bees/ 10 heads at one day before spraying, and their counts varied from 72.82 (BIPM module) to 69.05 (mahua oil), and 67.56 (PSKE) compared to 72.21 in untreated control for *A. dorsata;* almost similar trend was noticed with *A. cerana*; no significant difference was observed with *A. florea*; and with *T. iridipennis* it varied from 8.33 (BIPM), 8.48 (spinosad, NSKE), 9.36 (mahua oil), as compared to 8.97 (untreated control) (Table 1). Similar observations had been made by Basavaraj et al. (2016) in that pollinators were more before imposition of treatments. One day after treatment (1 DAS), a drastic reduction in abundance of bees was observed in all the treatments, except untreated control. For *A. dorsata* maximum counts were 11.10 (NSKE), 9.14 (spinosad), 9.41 (BIPM) as against 71.59 in untreated control. For *A. cerana* these were 7.81 (NSKE), 8 (BIPM) and 25.40 in untreated control; similar trendwas observed with *A. florea* and for *T. iridipennis*. Significantly least number of pollinators was observed with mahua oil spray. These observations corroborate with those of Anitha (2008), wherein the bees were significantly reduced in sunflower, one day after spray of insecticides/ biopesticides.

At 4 DAS, significantly more *A. dorsata* was found in untreated control (69.23), followed by spinosad (67.48) and BIPM (66.51); with *A. cerana*, spinosad (21.86) and BIPM (21.71) revealed more; *A. florea* and *T. iridipennis* were maximum with BIPM and spinosad. Significantly, least number of bees were observed in mahua oil. These results agree with those of Miles (2003) and Morandin et al. (2005) on spinosad. After 7 DAS, bee activity resumed with significantly maximum counts of *A. dorsata* in spinosad (60.97) and BIPM (60.53); with *A. cerana* also similar trend was noticed; with *A. florea* significantly, again more bees were in spinosad and BIPM; and in case of *T. iridipennis,* it was with BIPM followed by spinosad. Significantly, least number of bees were observed with mahua oil. Similar results were obtained by Basavaraj et al. (2016). Thus, among the biorationals the botanicals were relatively safe to *A. cerana indica* and *A. dorsata.*

Time spent: The bee pollinators viz*., A. dorsata, A. cerana, A. florea* and *T. iridipennis* spent mean time of 19.02, 23.90, 32.95 and 32.70 sec respectively before imposition of the treatments (prespray counts). One DAS there were significant reduction in the foraging time spent by all the four species (spinosad was 2.44, 3.02, 3.74, and 4.28 sec for *A. dorsata, A. cerana, A. florea* and *T. iridipennis* respectively for neem oil, 2.28, 2.20, 3.22 and 3.52 sec. The same trend was seen in case of pongamia oil. Maximum reduction of time spent was observed in the mahua oil treatmen. A similar trend was observed in case of NSKE. Significant reduction in bee foraging time was observed at 1 DAS viz*.,* 2.54, 2.71, 3.63 and 4.20 sec for *A. dorsata, A. cerana, A. florea* and *T. iridipennis* respectively. BIPM module treatment was similar to that of spinosad w.r.t. forager activity (Figs. 1-4). Similar results were obtained by Anitha (2008) in which less time was spent one day after spraying and reduction of foraging activity was observed in sunflower hybrids. The present study also reveals similar findings in which sudden decline of foraging activity by bees immediately one day after spray, which is due to presence of toxic residues and odour of botanical pesticides on flower heads which repel the bees.

All the four species of bees appeared to resume back their normal foraging activity as the day progressed by spending more time viz., 16.75, 21.59, 31.27, and 29.78 sec. at four days after spraying (4 DAS) and 15.34, 20.53, 30.29 and 29.67 sec. at seven days after spraying (7 DAS) for *A. dorsata, A. cerana, A. florea* and *T. iridipennis* respectively for spinosad treatment. In neem oil, the activity of bees was resumed back at 4 DAS and 7 DAS with mean time spent of 16.75, 21.59, 31.27 and 29.78 sec at 4 DAS and 15.34, 20.53, 30.29 and 29.67 sec at 7 DAS for *A. dorsata, A. cerana, A. florea* and *T. iridipennis,* respectively. However, at 4 DAS and 7 DAS *A. dorsata, A. cerana, A. florea* and *T. iridipennis* appeared to resume back their normal activity by recording greater number of foragers for pongamia oil. In case of mahua oil, at four and seven days after treatment imposition also bees spent less time as compared to other treatments viz., 13.55,

Table 1. Effect of ecofriendly insecticides on abundance of *Apis* spp. *and T. iridipennis* in sunflower as pollinators (kharif 2016-17, 2017-18)

Treatments	No. of bees/ 10 heads/ 5 min (2016-17)								No. of bees/ 10 heads/ 5 min (2017-18)							
	A. dorsata				*A. cerana*				*A. florea*				*T. iridipennis*			
	Pre-spray	1 DAS	4 DAS	7 DAS	Pre-spray	1 DAS	4 DAS	7 DAS	Pre-spray	1 DAS	4 DAS	7 DAS	Pre-spray	1 DAS	4 DAS	7 DAS
Spinosad 45 SC	72.76	9.15	67.48	60.97	27.71	4.40	21.86	17.56	17.05	2.79	13.43	12.09	8.48	2.71	7.56	6.17
(0.0045%)	(8.56)^{c}	(3.11)^{e}	(8.25)^{f}	(7.84)^{f}	(5.31)^{c}	(2.21)^{d}	(4.73)^{e}	(4.25)^{c}	(4.19)	(1.81)^{bc}	(3.73)^{bc}	(3.55)^{d}	(3.00)^{ab}	(1.79)^{cd}	(2.84)^{de}	(2.58)^{c}
Neem oil (1ml/ lit)	72.36	4.69	58.76	54.61	26.28	3.43	19.16	16.36	17.43	2.70	12.59	10.97	8.97	2.12	6.97	5.43
	(8.54)^{c}	(2.28)^{c}	(7.70)^{d}	(7.42)^{d}	(5.17)^{b}	(1.98)^{c}	(4.43)^{d}	(4.11)^{b}	(4.23)	(1.79)^{b}	(3.62)^{bc}	(3.39)^{c}	(3.08)^{ab}	(1.62)^{c}	(2.73)^{de}	(2.43)^{b}
Pongamia oil (1ml/ lit)	69.79	3.56	57.49	51.86	25.36	2.40	16.82	16.25	16.51	2.48	12.56	10.49	8.63	1.71	6.63	5.02
	(8.38)^{b}	(2.01)^{b}	(7.61)^{c}	(7.24)^{c}	(5.09)^{a}	(1.70)^{b}	(4.16)^{c}	(4.09)^{b}	(4.12)	(1.73)^{b}	(3.61)^{b}	(3.31)^{b}	(3.02)^{a}	(1.49)^{b}	(2.67)^{bcd}	(2.35)^{a}
Mahua oil (1ml/ lit)	69.05	2.15	29.53	29.28	25.56	1.33	11.90	14.74	16.97	1.72	8.36	9.13	9.36	1.24	3.36	4.82
	(8.34)^{b}	(1.63)^{a}	(5.48)^{a}	(5.46)^{a}	(5.10)^{a}	(1.35)^{a}	(3.52)^{a}	(3.90)^{a}	(4.18)	(1.49)^{a}	(2.97)^{a}	(3.10)^{a}	(3.14)^{c}	(1.32)^{a}	(1.96)^{a}	(2.31)^{a}
NSKE (Neem Seed	72.38	11.10	66.94	58.48	25.25	7.81	27.28	17.63	16.74	7.40	12.40	11.02	8.48	3.63	6.33	5.86
Kernel Extract) (5%)	(8.54)^{c}	(3.40)^{f}	(8.21)^{e}	(7.68)^{e}	(5.07)^{a}	(2.88)^{e}	(5.27)^{g}	(4.26)^{c}	(4.15)	(2.81)^{e}	(3.59)^{b}	(3.39)^{e}	(3.00)^{ab}	(2.03)^{e}	(2.61)^{b}	(2.52)^{bc}
PSKE (Pongamia Seed	67.56	5.46	53.25	43.30	24.94	4.82	15.56	16.85	17.59	3.51	12.13	10.13	9.05	2.77	5.90	5.05
Kernel Extract) (5%)	(8.25)^{a}	(2.44)^{d}	(7.33)^{b}	(6.62)^{b}	(5.04)^{a}	(2.30)^{d}	(4.01)^{b}	(4.16)^{b}	(4.25)	(2.00)^{d}	(3.55)^{b}	(3.26)	(3.09)^{abc}	(1.81)^{d}	(2.53)^{b}	(2.35)^{ab}
BIPM module	72.82	9.41	66.51	60.53	27.36	4.48	21.71	18.48	16.97	3.17	13.71	12.09	8.33	2.48	7.86	6.63
	(8.56)^{c}	(3.15)^{e}	(8.19)^{e}	(7.81)^{f}	(5.28)^{c}	(2.23)^{d}	(4.71)^{e}	(4.36)^{d}	(4.18)	(1.91)^{cd}	(3.77)^{c}	(3.55)^{d}	(2.97)^{a}	(1.72)^{c}	(2.89)^{de}	(2.67)^{d}
Untreated control	72.21	71.59	69.49	68.23	26.90	25.40	24.43	22.74	17.33	17.60	16.74	15.43	8.97	8.90	8.43	7.54
	(8.53)^{c}	(8.49)^{g}	(8.37)^{g}	(8.29)^{g}	(5.23)^{c}	(5.09)^{f}	(4.99)^{f}	(4.82)^{e}	(4.22)	(4.25)^{f}	(4.15)^{d}	(3.99)^{f}	(3.08)^{ab}	(3.06)^{f}	(2.99)^{f}	(2.83)^{e}
F-test	**	**	**	**	**	**	**	**	NS	**	**	**	*	**	**	**
SEm±	0.02	0.04	0.01	0.01	0.02	0.04	0.03	0.02	0.03	0.04	0.03	0.02	0.02	0.03	0.03	0.03
CD at p=0.05	0.06	0.13	0.05	0.05	0.08	0.13	0.10	0.07	0.11	0.12	0.09	0.07	0.08	0.11	0.11	0.10
CV %	0.40	2.33	0.40	0.39	0.97	2.99	1.33	1.11	1.62	3.23	1.50	1.28	1.66	3.53	2.40	2.47

DAS: Days after spraying; *Significant at p=0.05; ** Significant at p=0.01; Figures in parentheses √X+0.5 transformed values

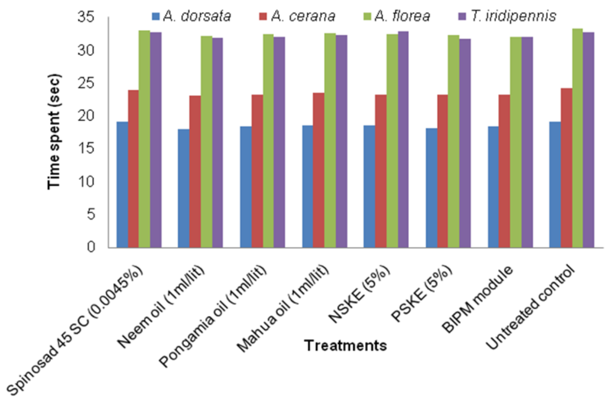

Fig. 1. Mean time spent by bee pollinators during pre-spray

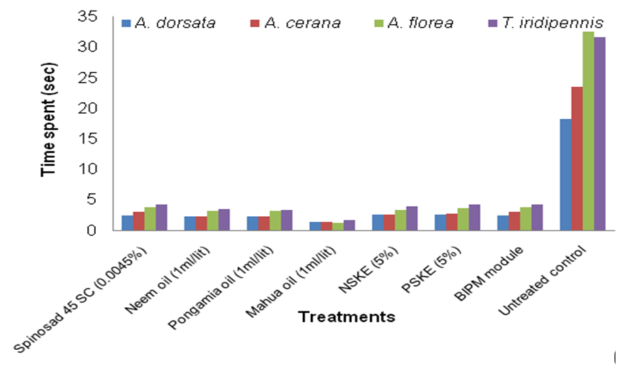

Fig. 2. Mean time spent by bee pollinators one day after spray (1 DAS)

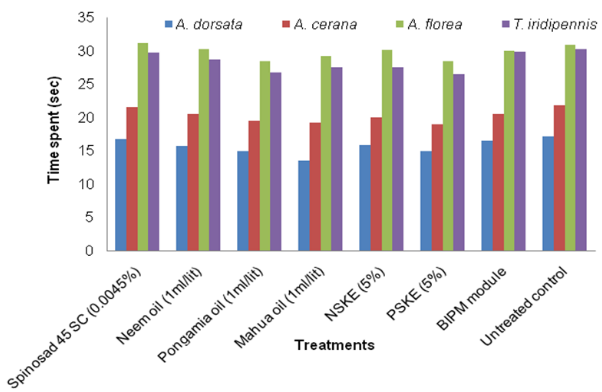

Fig. 3. Mean time spent by bee pollinators four day after spray (4 DAS)

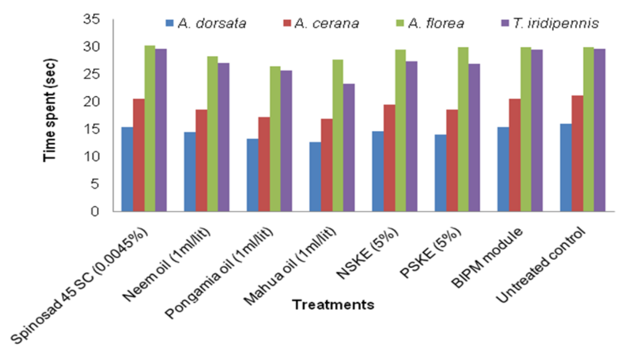

Fig. 4. Mean time spent by bee pollinators seven day after spray (7 DAS)

19.22, 29.32, and 27.56 sec (4 DAS) and 14.60, 19.83, 27.68 and 26.23 sec (7 DAS) for *A. dorsata, A. cerana, A. florea* and *T. iridipennis,* respectively. Mahua oil showed highest repellent activity to all the bee foragers. Whereas in NSKE and PSKE treatments the activity of bees commenced back to normal levels as the days progressed i.e., 4 DAS and 7 DAS (Figs. 3, 4). There were no significant differences in mean time spent by bees in untreated control at pre-spray, 1 DAS, 4 DAS and 7 DAS w.r.t. all the four species of pollinators.

Similar findings were obtained by Anitha (2008), with maximum time being spent before treatments, and less time spent at one DAS, and foraging activity resumed back to normal as the day progressed. Basavaraj et al. (2016) and Jagadish et al, (2016) revealed that, BIPM module, spinosad and NSKE treatments have less effect on foraging activity. In BIPM, spinosad, and other botanicals except mahua oil by the 7th DAS, all the four bee pollinators resume their normal activity in sunflower. Thus, mahua oil showed significantly more repellent activity, with reduced foraging time and lowest number of bees. BIPM module and spinosad treatments were observed to be the best and safe to the bee pollinators.

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