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IMPACT OF DIFFERENT INSECTICIDES ON POLLINATOR VISITATION IN CASHEW UNDER FIELD CONDITIONS

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ABSTRACT

The present field investigation evaluated the impact of commonly used insecticides, a bio-pesticide and botanicals on pollinator visitation to cashew panicles. Pollinator activity recorded one day before spraying showed no significant difference among treatments. However, at 1, 3, and 5 days after spraying, unsprayed panicles consistently received the highest number of pollinator visits, reflecting normal foraging behavior. In contrast, panicles treated with chlorpyriphos 20 EC, profenofos 50 EC, lambda-cyhalothrin 5 EC, thiamethoxam 25 WG and acetamiprid 20 SP exhibited substatially reduced visitation. Meanwhile, *Beauveria bassiana,* neem oil 1500 ppm and pongamia soap exhibited relatively higher pollinator visitation, ranking next to the unsprayed control panicles, indicating partial avoidance by pollinators. Overall, the findings demonstrate that all the treatments viz: chemical insecticides, the bio-pesticide and botanicals were negatively influenced pollinator activity in cashew ecosystems, underscoring the importance of adopting pollinator-safe pest management strategies.
***Keywords* :** Cashew, Pollinators, Pollinator activity, Field evaluation, Insecticides, botanicals and bio-pesticide.

Introduction

Pollination is a vital process of nature and plays an important role in the reproduction and fruit set of flowering plant communities (Ricketts *et al.*, 2008 and Balina *et al.*, 2012). Cashew, *A. occidentale* is a cross pollinated commercial tree nut crop which bears male / staminate and bisexual / hermaphrodite flowers on the same panicle (Thimmaraju *et al.*, 1980). Cashew is andromonoecious having sticky pollen and even longer stamen of the hermaphrodite flower is shorter than style, thus making self-pollination difficult and hence favouring insect-mediated cross-pollination (Sundararaju, 2011). Despite early suggestions that cashew was wind pollinated, later studies through bagging of panicles (to exclude insects and wind as pollinating agent) and caging / bagging with nylon mosquito nets (allow access to wind but exclude insects) have proven that wind does not has any role and insects play a key role in pollination of cashew (Reddi, 1993). Cashew flowers also generate large quantities of nectar that lures more pollinators. Globally, Flies, moths, ants and bees (Sundararaju, 2000; Bhattacharya, 2004 and Tuo *et al.*, 2022) were recorded as the major cashew pollinators worldwide.

Cashew is commonly attacked by several insect pests. To manage these pests, many insecticides are commonly used in cashew-growing ecosystems to prevent crop losses. However, excessive reliance on chemical insecticides leads to contamination of the agroecosystem and causes severe harm to honey bees and other pollinators (Deepika *et al.*, 2022). Loss of honey bees will directly affect honey production and indirectly affect crop production due to insufficient pollination. When insecticides are utilized reasonably, their adverse effects on the pollinators are comparable with those on target organisms (Naik and Hugar, 2015). Non target impact of insecticides on honey bees excessively causes sublethal effects, direct mortality and also cause the toxicity residues on floral parts and nectar of crops (Desneux *et al.,* 2007). Honey bee behaviour such as communication dances, return flights, orientation and foraging efficacy during floral visits are getting affected when it gets direct contact with insecticide-treated floral parts during insecticide application (Vandame *et al.,* 1995). Hence, a properly planned pollination programme coupled with use of insecticides which are safer to pollinators in cashew can significantly contribute to increase in its productivity and meet the global demand.

Material and Methods

Study area and location

The experiment was carried out to evaluate the impact of various insecticides on cashew visiting pollinators under field conditions during 2022-2023 (*rabi* - Jan to May) and 2023-2024 (*rabi* - Jan to May) in the cashew orchard at the Instructional Farm of Dr. YSRHU-Krishi Vigyan Kendra (KVK), Venkataramannagudem, West Godavari district of Andhra Pradesh which is located between 16.8779° Northern Latitude and 81.4703° Eastern Longitude.

Details of insecticidal treatments and its application

The experiment was laid out in Randomized Block Design (RBD) with five replications and nine treatments *viz.,* chlorpyrifos 20 EC, profenofos 50 EC, lambda cyhalothrin 5 EC, thiamethoxam 25 WG, acetamiprid 20 SP, *Beauveria bassiana*, neem oil, pongamia soap and untreated control. The treatments were selected based on the recommendations outlined in the package of practices of Dr. Y.S.R. Horticultural University, Venkataramannagudem, as well as on the insecticides commonly used by cashew farmers for pest management. Each treatment was applied to five panicles per tree on five randomly selected trees during the optimum flowering period of cashew. The details and dosages of each treatment was presented in Table 1.

Observations on insect visitors

In order to assess the effect of insecticides on visiting pollinators in cashew, the number of pollinators visiting each panicle were recorded for duration of 5 minutes at 1030 h using an electronic stopwatch. This timing was chosen because the peak anthesis in cashew occurs between 0900 h and 1100 h, with anther dehiscence commences at 1000 h. Such observations were recorded a day before spraying (DBS) and subsequently at 1, 3 and 5 days after spraying (DAS) with insecticides.

The recorded observations were subjected to Analysis of Variance (ANOVA), and the treatment means were compared using Duncan's Multiple Range Test (DMRT) with the help of SPSS software to determine their statistical significance and facilitate meaningful interpretation of the results.

Results and Discussion

Impact of different insecticides on pollinator visitation in cashew under field conditions during 2023 and 2024

The data pertaining to the impact of different insecticides on cashew visiting pollinators such as *Apis cerana indica, A. mellifera, A. florea, A. dorsata, Tetragonula irridipennis, Ceratina binghami, Braunsapis picitarsis, Antepipona ceylonica, Eristalinus* sp and *Chrysomya* sp etc under field conditions during 2023, 2024, along with the pooled data for both years, are tabulated (Tables 2 to 4.) and presented below.

A day before spray: Number of insect pollinators visiting/ panicle/ 5 min were almost similar without any significant difference between the treatments. It varied from 0.2 to 3.4 pollinators/ panicle/ 5 min.

A day after spray: Number of insect pollinators/ panicle/ 5 min was statistically highest in untreated control panicles with 2.2, 2.8 and 2.5 pollinators /panicle / 5 min during 2023, 2024 and in the pooled data (2023 and 2024) respectively. During 2023, least number of insect pollinators were observed in both chlorpyriphos 20 EC and acetamiprid 20 SP treatments with no pollinators/ panicle/ 5 min and were statistically on par with rest of the treatments, except profenofos 50 EC (0.6 pollinators/ panicle/ 5 min). During 2024, least number of insect pollinators (0.4 pollinators /panicle / 5 min) were observed in chlorpyriphos 20 EC, profenofos 50 EC, thiamethoxam 25 WG and neem oil 1500 PPM treatments and were on par statistically with lambda cyhalothrin 5 EC, acetamiprid 20 SP and pongamia soap treatments (0.6 pollinators /panicle / 5 min). In Pooled data (2023 and 2024), *B. bassiana* treated panicles recorded (0.6 pollinators /panicle/5 min), while the lowest number of insect pollinators (0.2 pollinators /panicle / 5 min) were observed in chlorpyriphos 20 EC treated panicles and both are statistically on par with profenofos 50 EC, lambda cyhalothrin 5 EC, thiamethoxam 25 WG, acetamiprid 20 SP, neem oil 1500 PPM and pongamia soap treatments with 0.5, 0.4, 0.4, 0.3, 0.3, and 0.5 pollinators /panicle / 5 min, respectively.

Three days after spray: Insect pollinator visitation was highest in untreated control panicles with 2.6 pollinators/ panicle/ 5 min during 2023 and 2024 and in the pooled data (2023 & 2024).This was followed by *B.bassiana* which recorded 1.4 pollinators/ panicle/ 5 min in 2023, and was statistically par with neem oil (1 pollinator /panicle / 5 min). In 2024 *B.bassiana* recorded 1.6 pollinators /panicle / 5 min, which was statistically on par with neem oil, thiamethoxam, profenofos and pongamia Soap (1.4,1.4,1.2 and 1.2 pollinators /panicle / 5 min) respectively. In the pooled analysis *B.bassiana* recorded 1.5 pollinators /panicle / 5 min and was statistically on par with neem oil (1.2 pollinators /panicle / 5 min) and significantly differing from all other treatments. On the other hand during 2023, insect pollinator visitation was lowest in the panicles sprayed with thiamethoxam 25 WG with no pollinators/ panicle/ 5 min and it was statistically on par with the panicles sprayed with chlorpyriphos 20 EC (0.2 pollinators/ panicle/ 5 min), profenofos 50 EC (0.2 pollinators/ panicle/ 5 min), lambda cyhalothrin 5 EC (0.4 pollinators/ panicle/ 5 min) and acetamiprid 20 SP (0.4 pollinators/ panicle/ 5 min). During 2024 least number of insect pollinators were observed in chlorpyriphos 20 EC with 0.2 pollinators /panicle / 5 min and it was statistically on par with acetamiprid 20 SP with 0.6 pollinators /panicle / 5 min. In pooled analysis (2023 and 2024) similar trend was observed that least number of insect pollinators were observed in treatment with chlorpyriphos 20 EC (0.2 pollinators /panicle / 5 min) and it was statistically on par with acetamiprid 20 SP with 0.5 pollinators /panicle / 5 min.

Five days after spray: Statistically highest number of insect pollinators were found to visit untreated control panicles with 2.8 pollinators/ panicle/ 5 min during 2023 and 2024 and pooled data (2023 &2024). During 2023, least number of insect pollinators were observed in both lambda cyhalothrin 5 EC and thiamethoxam 25 WG (0.2 pollinators/ panicle/ 5 min) treatments and were statistically on par with chlorpyriphos 20 EC (0.4 pollinators/ panicle/ 5 min), profenofos 50 EC (0.6 pollinators/ panicle/ 5 min) and acetamiprid 20 SP (0.6 pollinators/ panicle/ 5 min) treatments. However, *B.bassiana* and neem oil recorded significantly more number of pollinators with 1.8 and 1.4 pollinators/ panicle/ 5 min and both are statistically on par with pongamia soap with 1.2 pollinators/ panicle/ 5 min. During 2024, lower number of insect pollinators were found in chlorpyriphos 20 EC with 1.2 pollinators /panicle / 5 min which did not differ statistically with profenofos 50 EC, lambda cyhalothrin 5 EC, thiamethoxam 25 WG, neem oil 1500 PPM (1.6 pollinators /panicle / 5 min) and pongamia soap treatments (1.4 pollinators /panicle / 5 min). While *B.bassiana* and acetamiprid 20 SP recorded comparatively more number of pollinators with 2.2 and 2.0 pollinators/ panicle/ 5 min and both the treatments were statistically on par with each other. In Pooled analysis of 2023 and 2024, lower number of insect pollinators were observed in chlorpyriphos 20 EC treated panicles (0.8 pollinators /panicle / 5 min) and it did not differ statistically with profenofos 50 EC, lambda cyhalothrin 5 EC, thiamethoxam 25 WG treated panicles with 1.1, 0.9 and 0.9 pollinators /panicle / 5 min respectively. In contrast, *B.bassiana* treated panicles showed a large number of pollinators with 2.0 pollinators /panicle / 5 min and significantly differ from all other treatments.

These results are in confirmation of the repellent action of insecticides (monocrotophos 0.04 and carbaryl 0.2 per cent) on bees as reported by Rajak *et al.* (2006) and Sharma and Abrol (2005) who stated that profenofos has strong repellent action on bees and the number of bees visiting sprayed plants were still significantly less than the normal even three days after spraying. Studies conducted by Karise *et al.* (2007), Pandey (2010), Kumar *et al.* (2010) and Umrao *et al.* (2012) who observed reduction in the frequency of visits of both honey bees and other pollinators following the spraying of neem oil also support the present findings of the study. The findings of Abrol and Kumar (2009) who reported reduction in the bee visits on strawberry blossoms after spraying chlorpyriphos and neem oil also support the present findings.

The above findings were also supported with the findings of Mommaerts *et al.* (2010), Laurino *et al.* (2011), Schneider *et al.* (2012), Matre *et al.* (2018), Bajiya and Abrol (2019), Saleem *et al.* (2023) and Franceschinelli *et al.* (2024) who stated that use of neonicotinoids like imidacloprid, clothianidin, and thiamethoxam had a negative impact on the visitation of pollinators like bees and butterflies.

The present findings of the study were on par with the results of Thompson and Wilkins (2003), Havstad *et al.,* 2019, Mali *et al.* (2023) and Franceschinelli *et al.* (2023) who reported that lambda-cyhalothrin had significant repellent effect on the pollinators and also reduced the visitation rate of pollinators.

This study was also supported with the reports of Gour and Pareek (2005), Reddy and Reddy (2006), Aupinel *et al.* (2007), Mohapatra and Patnaik (2009), Bhatnagar and Karnatak (2009) and Mohapatra *et al.* (2010) that insecticides had repellent action on pollinators.

Conclusion

The findings of the present investigation clearly indicate that insecticide applications in cashew significantly influence pollinator activity. Under field conditions, indiscriminate or poorly timed use of insecticides in cashew plantations can adversely affect pollinators, ultimately reducing pollination efficiency and yield. Although pollinator visitation did not differ among treatments prior to spraying, a pronounced decline was observed on panicles treated with chemical insecticides, including organophosphates (chlorpyriphos 20 EC and profenofos 50 EC), neonicotinoids (Thiamethoxam 25 WG and acetamiprid 20 SP) and the pyrethroid insecticide (Lambda-cyhalothrin 5 EC). In contrast, panicles treated with *Beauveria bassiana*, neem oil, and pongamia soap recorded comparatively higher pollinator visitation following application. Unsprayed panicles consistently attracted the highest number of pollinators, reflecting normal foraging behaviour. The reduced visitation to treated panicles suggests that these products negatively influence pollinator presence and activity in cashew ecosystems. Overall, the study underscores the importance of judicious selection and timing of pest management practices to protect pollinators and ensure sustainable cashew production.

Table 1: Details and dosages of different insecticidal treatments on pollinators under field conditions

S. No.	Treatment	Insecticide	Dose (ml or g/L)
1.	T1	Chlorpyrifos 20 EC	2.5 ml/L
2.	T2	Profenofos 50 EC	1 ml/L
3.	T3	Lambda cyhalothrin 5 EC	1 ml/L
4.	T4	Thiamethoxam 25 WG	0.3 g/L
5.	T5	Acetamiprid 20 SP	0.2 g/L
6.	T6	*Beauveria bassiana* (Balsamo – crivelli) vuillemin	5 g/L
7.	T7	Neem oil 1500 ppm	5 ml/L
8.	T8	Pongamia soap	7.5 g/L
9.	T9	Untreated (Control)	-

Table 2 : Impact of different insecticides on pollinators under field conditions during 2023

Treatments	Dose (ml or g/L)	Number of pollinators/ panicle/ 5 min at 1030 h			
		1 DBS	1 DAS	3 DAS	5 DAS
Chlorpyriphos 20 EC	2.5 ml/L	1.00 (1.19)	0.00 (0.71)^{c}	0.20 (0.82)^{de}	0.40 (0.94)^{d}
Profenofos 50 EC	1 ml/L	1.60 (1.41)	0.60 (1.04)^{b}	0.20 (0.82)^{de}	0.60 (1.04)^{cd}
Lambda cyhalothrin 5 EC	1 ml/L	0.60 (0.99)	0.20 (0.82)^{bc}	0.40 (0.94)^{cde}	0.20 (0.82)^{d}
Thiamethoxam 25 WG	0.3 g/L	1.20 (1.30)	0.40 (0.94)^{bc}	0.00 (0.71)^{e}	0.20 (0.82)^{d}
Acetamiprid 20 SP	0.2 g/L	0.80 (1.09)	0.00 (0.71)^{c}	0.40 (0.94)^{cde}	0.60 (1.03)^{cd}
Beauveria bassiana	5 g/L	0.20 (0.81)	0.20 (0.81)^{bc}	1.40 (1.37)^{b}	1.80 (1.51)^{b}
Neem oil 1500 ppm	5 ml/L	1.00 (1.16)	0.20 (0.81)^{bc}	1.00 (1.16)^{bc}	1.40 (1.37)^{b}
Pongamia soap	7.5 g/L	0.80 (1.09)	0.40 (0.91)^{bc}	0.60 (1.03)^{cd}	1.20 (1.28)^{bc}
Untreated (Control)	-	1.40 (1.37)	2.20 (1.64)^{a}	2.60 (1.75)^{a}	2.80 (1.81)^{a}
S.Em (±)		0.14	0.08	0.09	0.09
CD (0.05)		NS	0.23	0.26	0.25
CV(%)		--	18.97	18.87	16.70

Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same letter in a column do not differ significantly by DMRT (p= 0.05)
DBS – Day before spraying, DAS - Day after spraying

Table 3 : Impact of different insecticides on pollinators under field conditions during 2024

Treatments	Dose (ml or g/L)	Number of pollinators/ panicle/ 5 min at 1030 h			
		1 DBS	1 DAS	3 DAS	5 DAS
Chlorpyriphos 20 EC	2.5 ml/L	2.00 (1.57)	0.40 (0.94)[c]	0.20 (0.82)[e]	1.20 (1.30)[d]
Profenofos 50 EC	1 ml/L	2.60 (1.75)	0.40 (0.94)[c]	1.20 (1.30)[bcd]	1.60 (1.44)[bcd]
Lambda cyhalothrin 5 EC	1 ml/L	1.80 (1.38)	0.60 (1.03)[bc]	0.80 (1.13)[cd]	1.60 (1.44)[bcd]
Thiamethoxam 25 WG	0.3 g/L	2.00 (1.58)	0.40 (0.94)[c]	1.40 (1.37)[bc]	1.60 (1.44)[bcd]
Acetamiprid 20 SP	0.2 g/L	3.00 (1.84)	0.60 (1.04)[bc]	0.60 (1.02)[de]	2.00 (1.58)[abc]
Beauveria bassiana	5 g/L	2.00 (1.52)	1.00 (1.21)[b]	1.60 (1.44)[b]	2.20 (1.64)[ab]
Neem oil 1500 ppm	5 ml/L	2.40 (1.65)	0.40 (0.93)[c]	1.40 (1.37)[bc]	1.60 (1.44)[bcd]
Pongamia soap	7.5 g/L	3.40 (1.96)	0.60 (1.04)[bc]	1.20 (1.30)[bcd]	1.40 (1.37)[cd]
Untreated (Control)	-	1.80 (1.51)	2.80 (1.81)[a]	2.60 (1.75)[a]	2.80 (1.81)[a]
S.Em (±)		0.16	0.08	0.09	0.08
CD (0.05)		NS	0.22	0.26	0.23
CV(%)		--	15.59	15.99	11.83

Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same letter in a column do not differ significantly by DMRT (p= 0.05)
DBS- Day before spraying, DAS - Day after spraying

Table 4 : Impact of different insecticides on pollinators under field conditions during 2023 and 2024 (Pooled data)

Treatments	Dose (ml or g/L)	Number of pollinators/ panicle/ 5 min at 1030 h			
		1 DBS	1 DAS	3 DAS	5 DAS
Chlorpyriphos 20 EC	2.5 ml/L	1.50 (1.41)	0.20 (0.83)[c]	0.20 (0.83)[e]	0.80 (1.14)[d]
Profenofos 50 EC	1 ml/L	2.10 (1.60)	0.50 (1.00)[bc]	0.70 (1.09)[cd]	1.10 (1.26)[cd]
Lambda cyhalothrin 5 EC	1 ml/L	1.20 (1.26)	0.40 (0.95)[bc]	0.60 (1.04)[d]	0.90 (1.18)[d]
Thiamethoxam 25 WG	0.3 g/L	1.60 (1.45)	0.40 (0.95)[bc]	0.70 (1.09)[cd]	0.90 (1.18)[d]
Acetamiprid 20 SP	0.2 g/L	1.90 (1.54)	0.30 (0.89)[bc]	0.50 (0.99)[de]	1.30 (1.34)[c]
Beauveria bassiana	5 g/L	1.10 (1.26)	0.60 (1.04)[b]	1.50 (1.41)[b]	2.00 (1.58)[b]
Neem oil 1500 ppm	5 ml/L	1.70 (1.45)	0.30 (0.87)[bc]	1.20 (1.28)[bc]	1.50 (1.41)[c]
Pongamia soap	7.5 g/L	2.10 (1.61)	0.50 (0.99)[bc]	0.90 (1.18)[cd]	1.30 (1.34)[c]
Untreated (Control)	-	1.60 (1.44)	2.50 (1.73)[a]	2.60 (1.76)[a]	2.80 (1.81)[a]
S.Em (±)		0.1	0.05	0.07	0.05
CD (0.05)		NS	0.15	0.20	0.14
CV(%)			11.51	13.29	8.20

Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same letter in a column do not differ significantly by DMRT (p= 0.05)
DBS- Day before spraying, DAS - Day after spraying

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