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Influence of Insecticide Application on Pollinators and Predatory Arthropods in Watermelon Agroecosystem

Archana, B. R. [a*], Kishor Pujar [b], Chethan, T. [b], Kavya, M. Hiremath [c], Godavari [d], Arpitha K.C. [b], Manjula [b] and Harish Varma, M. [b]

[a] Department of Entomology, University of Agricultural Sciences, Raichur-584104, India.
[b] Department of Entomology, University of Agricultural Sciences, Bangalore-560065, India.
[c] Department of Entomology, University of Agricultural Sciences, Dharwad-580005, India.
[d] Division of Entomology, Indian Agricultural Research Institute, New Delhi-110012, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors HVM and CT executed the field/ lab experiments and collected the data. Authors ABR, KP, KMH analyzed and interpreted the data. Author ABR, Godavari, AKC and Manjula prepared the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This study, conducted from January to April 2021 in Kandavara village, Karnataka, examined the effects of various insecticides on honeybees, spiders, and coccinellids in watermelon crops. Using a randomized complete block design, watermelon plants were treated with insecticides when pest populations reached economic thresholds. Honeybee foraging activity and populations of spiders

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*Corresponding author: Email: archanaento19@gmail.com;

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and coccinellids were monitored before treatment and at 3,7 and 10 days post-application. Results showed that untreated control plots consistently had the highest activity of all beneficial insects. Among the insecticides tested, Spinosad 45 SC was the least harmful, with relatively higher levels of honeybee and natural enemy activity. In contrast, Imidacloprid 17.8 SL and Acephate 75 SP were the most detrimental, resulting in significantly lower activity levels for honeybees, spiders, and coccinellids. These findings highlight the importance of selecting insecticides that minimize harm to beneficial insects, emphasizing the need for integrated pest management practices that balance effective pest control with the preservation of essential ecosystem services.

Keywords: Coccinellids; foraging; honeybees; pest management and spiders.

1. INTRODUCTION

The widespread use of insecticides in agriculture has become a cornerstone of pest management, significantly enhancing crop productivity by reducing damage caused by insect pests [1]. However, the non-selective nature of many insecticidal molecules means that their effects often extend beyond the targeted pests, impacting beneficial organisms within the ecosystem [2]. In watermelon (*Citrullus lanatus*) cultivation, this issue is particularly significant, as both pollinators and natural enemies play crucial roles in ensuring crop success. Honeybees, the primary pollinators in watermelon fields, are essential for pollination, directly influencing fruit set, quality, and yield [3]. Similarly, natural enemies like spiders and coccinellids are key biological control agents, preying on harmful pests and thereby reducing the need for chemical interventions [4].

During the watermelon cropping season, the application of insecticides aimed at controlling pests can inadvertently affect these beneficial species. The decline in pollinator activity, particularly among honeybees, can lead to insufficient pollination, resulting in poor fruit development and lower yields [5]. Moreover, the reduction in the population of natural enemies such as spiders and coccinellids can lead to a resurgence of pest populations, as the natural balance is disrupted [6]. This scenario not only compromises the ecological sustainability of watermelon production but also necessitates increased chemical inputs, creating a cycle of dependency on insecticides.

The interaction between insecticides and non-target organisms, such as honeybees, spiders, and coccinellids, is complex and influenced by various factors including the type of insecticide used, its application method, and the timing of application [7]. For instance, some insecticides may have sub-lethal effects on honeybees, affecting their foraging behavior and colony health, while others may directly reduce their numbers [8]. Similarly, the survival and effectiveness of natural enemies can be compromised by insecticides that either kill them directly or disrupt their ability to locate and prey on pests [9].

Understanding the impact of insecticides on these beneficial species is crucial for developing integrated pest management (IPM) strategies that are both effective and environmentally sustainable. By minimizing the negative effects on pollinators and natural enemies, growers can maintain the ecological balance within their fields, ensuring long-term productivity and reducing reliance on chemical controls. This study aims to assess the influence of different insecticidal molecules on the occurrence and activity of honeybees, spiders, and coccinellids during the watermelon cropping season. The findings will contribute to the ongoing efforts to optimize pest management practices, balancing the need for effective pest control with the preservation of essential ecosystem services provided by pollinators and natural enemies.

2. MATERIALS AND METHODS

The study was conducted from January to April 2021 in Kandavara village (13.41482º N, 77.71791º E), Chikkaballapur taluk, Karnataka, to assess the effects of various insecticide molecules on natural enemies and pollinators in watermelon crops. The experiment employed a randomized complete block design (RCBD) with watermelon plants arranged in a spacing of 1.5 m × 1 m. Standard agronomic practices were followed, excluding specific pest control measures. Insecticides were applied using a knapsack sprayer fitted with a hollow cone nozzle when pest populations reached the economic threshold level. The experimental field was divided into four equal-sized quadrants. Within each quadrant, five plants were randomly selected for observations. Details of different insecticide molecules used in watermelon cultivation given in Table 1.

Table 1. Details of different insecticide molecules used in watermelon cultivation

Treatments	Insecticides	Trade name	Dose (gm/ml/lit)
T1	Cyantraniliprole 10.26 OD	Benevia	1.5 ml/l
T2	Thiomethoxam 25 WG	Arrow	0.2 g/l
T3	Fipronil 5 SC	Regent	1.0 ml/l
T4	Acephate 75 SP	Luna	1.0 g/l
T5	Spinosad 45 SC	Tracer	0.3 ml/l
T6	Diafenthiuron 50 WP	Pegasus	1.0 g/l
T7	Imidachloprid 17.8 SL	Indomida	0.3ml/l
T8	Untreated control (Water spray)	-	-

The study focused on two main groups of beneficial organisms: natural enemies (coccinellids and spiders) and pollinators (honey bees). To evaluate the impact on natural enemies, the population of coccinellids and spiders was recorded on the day before spraying and subsequently on days 3, 7, and 10 post-spray. For coccinellids, data included the number of eggs, grubs, pupae, and adults per plant. Similarly, spider populations were monitored and recorded in the same intervals. Pollinator activity was primarily assessed through observations of honey bees, the major pollinator present during the cropping period. Honey bee activity was recorded by counting the number of bees per five plants in each treatment area during the morning hours. Pre-treatment counts were taken the day before spraying, with follow-up counts conducted on days 3, 7, and 10 post-spray. Data analysis involved square root transformation to stabilize variance before applying ANOVA for the RCBD design. This statistical approach ensured accurate interpretation of the effects of insecticides on both natural enemies and pollinators, providing insights into the ecological impact of different pest management practices in watermelon cultivation.

3. RESULTS AND DISCUSSION

3.1 Influence of Insecticidal Molecules on Foraging Activity of Honeybees

Before insecticide application, foraging activity of honeybees ranged from 5.80 to 7.10 bees per five plants, showing no significant difference. Three days after spraying, untreated control plots had the highest foraging activity with 5.73 bees, while Spinosad 45 SC and Cyantraniliprole 10.26 OD followed with 3.43 and 3.10 bees, respectively. Imidacloprid 17.8 SL showed the lowest activity with 2.40 bees. At seven days post-treatment, untreated control plots recorded an increase to 6.53 bees, with Spinosad 45 SC showing 3.81 bees, and Thiomethoxam 25 WG showing the lowest activity at 2.20 bees. Ten days after spraying, untreated control plots peaked at 6.68 bees, while Spinosad 45 SC recorded 4.21 bees. Thiomethoxam 25 WG again had the lowest activity at 2.71 bees, with overall foraging activity increasing across all treatments compared to earlier observations (Table 2).

3.2 Influence of Insecticidal Molecules on Natural Enemies (Spiders and Coccinellids)

A day before treatment, spider activity was uniformly distributed across the field, ranging from 2.40 to 3.40 spiders per five plants. Three days after spraying, spider activity varied significantly, with untreated control showing the highest activity at 3.04 spiders, and Spinosad 45 SC following with 2.64 spiders. Acephate 75 SP recorded the lowest activity with 1.62 spiders. At seven days post-treatment, untreated control plots maintained the highest activity at 2.99 spiders, with Spinosad 45 SC recording 2.67 spiders and Acephate 75 SP the lowest at 1.40 spiders. Ten days after treatment, the trend continued with untreated control showing 3.10 spiders, Spinosad 45 SC at 2.79 spiders, and Acephate 75 SP at 1.45 spiders. Coccinellid beetle activity, which ranged from 0.95 to 1.36 per five plants before treatment, followed a similar pattern. Three days after spraying, untreated control recorded the highest activity at 1.49 coccinellids, with Spinosad 45 SC following at 1.34 coccinellids, and Thiomethoxam 25 WG showing 1.06 coccinellids. Imidacloprid 17.8 SL consistently recorded the lowest activity across all observation periods (Tables 3 and 4).

Table 2. Influence of usage of insecticides against honeybees on watermelon during 2021

Sl.No	Treatment	Population of honeybees per five plants			
		Pre- treatment	**3 DAT**	**7 DAT**	**10 DAT**
1	Cyantraniliprole 10.26 OD	6.30 (2.61)	3.10^{bc} (1.90)	3.40^{b} (1.97)	3.53^{cd} (2.01)
2	Thiomethoxam 25 WG	6.37 (2.62)	2.20^{e} (1.64)	2.02^{c} (1.59)	2.71^{e} (1.79)
3	Fipronil 5 SC	6.57 (2.66)	3.05^{bc} (1.89)	3.30^{b} (1.95)	3.87^{bc} (2.09)
4	Acephate 75 SP	5.80 (2.51)	2.75^{cd} (1.80)	2.44^{c} (1.71)	3.12^{de} (1.90)
5	Spinosad 45 SC	6.57 (2.66)	3.43^{b} (1.98)	3.81^{b} (2.08)	4.21^{b} (2.17)
6	Diafenthiuron 50 WP	7.10 (2.76)	3.07^{bc} (1.89)	3.47^{b} (1.99)	3.67^{c} (2.04)
7	Imidachloprid 17.8 SL	6.80 (2.70)	2.40^{de} (1.70)	2.35^{c} (1.69)	2.88^{e} (1.84)
8	Untreated control	5.97 (2.54)	5.73^{a} (2.50)	6.53^{a} (2.65)	6.68^{a} (2.71)
F test		NS	*	*	*
SEm±		0.01	0.48	0.47	0.38
CD(p=0.05)		-	0.14	0.14	0.11
CV (%)		3.35	4.17	4.12	3.17

Table 3. Influence of usage of insecticides against spiders on watermelon during 2021

Sl.No	Treatment	Population of spiders per five plants			
		Pre- treatment	**3 DAT**	**7 DAT**	**10 DAT**
1	Cyantraniliprole 10.26 OD	3.40 (1.97)	2.08^{cd} (1.61)	2.15^{bc} (1.63)	2.22^{b} (1.64)
2	Thiomethoxam 25 WG	2.80 (1.81)	2.22^{c} (1.65)	2.18^{bc} (1.64)	2.26^{b} (1.65)
3	Fipronil 5 SC	2.40 (1.70)	2.03^{cd} (1.59)	1.85^{cd} (1.53)	1.80^{cd} (1.52)
4	Acephate 75 SP	3.10 (1.89)	1.62^{e} (1.45)	1.40^{d} (1.37)	1.45^{d} (1.40)
5	Spinosad 45 SC	3.23 (1.93)	2.64^{b} (1.77)	2.67^{ab} (1.78)	2.79^{a} (1.81)
6	Diafenthiuron 50 WP	2.50 (1.73)	1.86^{de} (1.54)	1.94^{c} (1.56)	2.04^{bc} (1.59)
7	Imidachloprid 17.8 SL	2.74 (1.78)	2.24^{c} (1.65)	2.31^{bc} (1.68)	2.34^{b} (1.68)
8	Untreated control	2.97 (1.86)	3.04^{a} (1.88)	2.99^{a} (1.87)	3.10^{a} (1.90)
F test		NS	*	*	*
SEm±		0.01	0.03	0.06	0.31
CD(p=0.05)		-	0.11	0.18	0.12
CV (%)		3.01	3.87	6.38	4.31

The study revealed that untreated control plots had the highest activity of honeybees, spiders, and coccinellids, while insecticidal treatments led to a significant reduction in these beneficial insects. Among the insecticides tested, Spinosad 45 SC was the least harmful, showing relatively higher levels of honeybee and natural enemy activity. In contrast, Imidacloprid 17.8 SL and Acephate 75 SP were the most detrimental, causing the lowest activity levels.

Table 4. Influence of usage of insecticides against coccinelids on watermelon during 2021

Sl.No	Treatment	Population of coccinelids per five plants			
		PT	3 DAT	7 DAT	10 DAT
1	Cyantraniliprole 10.26 OD	1.10 (1.26)	0.90^{bc} (1.20)	0.84^{cd} (1.16)	0.82^{cd} (1.15)
2	Thiomethoxam 25 WG	1.25 (1.32)	1.06^{abc} (1.25)	1.04^{bc} (1.24)	0.90^{cd} (1.18)
3	Fipronil 5 SC	1.10 (1.30)	1.20^{abc} (1.30)	1.11^{bc} (1.27)	1.05^{bc} (1.24)
4	Acephate 75 SP	1.10 (1.30)	0.97^{bc} (1.21)	0.94^{c} (1.20)	0.82^{cd} (1.15)
5	Spinosad 45 SC	1.10 (1.29)	1.34^{ab} (1.35)	1.24^{ab} (1.32)	1.14^{b} (1.28)
6	Diafenthiuron 50 WP	1.20 (1.30)	1.00^{bc} (1.21)	0.90^{c} (1.18)	0.94^{bcd} (1.20)
7	Imidachloprid 17.8 SL	0.95 (1.20)	0.86^{c} (1.17)	0.64^{d} (1.06)	0.72^{d} (1.10)
8	Untreated control	1.36 (1.33)	1.49^{a} (1.41)	1.44^{a} (1.39)	1.60^{a} (1.45)
F test		NS	*	*	*
SEm±		0.03	0.05	0.03	0.03
CD(p=0.05)		-	0.15	0.10	0.09
CV (%)		3.90	7.06	4.78	4.79

These findings underscore the need for careful insecticide selection to protect non-target species like honeybees, spiders, and coccinellids. The results are consistent with previous research. Ratnakar et al. [10] found high bee mortality with Thiamethoxam, clothianidin, and imidacloprid, while acetamiprid was moderately toxic, and Spinosad and chlorantraniliprole were safer. Pashte and Patil [11] also noted reduced bee visits with cypermethrin and imidacloprid. Similarly, Awasthi et al. [12] reported that Spinosad was the safest insecticide for predatory coccinellids, with acetamiprid and imidacloprid being more toxic. Overall, the study emphasizes the importance of selecting insecticides that minimize harm to beneficial insects.

4. CONCLUSION

The study highlights the broader implications of insecticide use in agriculture, particularly regarding its impact on beneficial insects like honeybees, spiders, and coccinellids. The findings emphasize that while insecticides are essential for pest control, their selection must be carefully considered to avoid detrimental effects on non-target species that contribute to pollination and natural pest regulation. The observed variations in the safety profiles of different insecticides, with some being far less harmful than others, underscore the need for integrated pest management strategies that prioritize the preservation of beneficial insect populations. Ultimately, the study advocates for informed and responsible insecticide use to ensure both effective pest control and the sustainability of agricultural ecosystems.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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