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Efficacy of botanicals against red pumpkin beetle and their impact on pollinator diversity in pumpkin (*Cucurbita pepo L.*) cultivation

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ABSTRACT

The study aimed to assess insect pollinator diversity in pumpkin (*Cucurbita pepo* L.) and evaluate the bio-efficacy of botanicals for pest management while considering their impact on pollinators. Seven pollinator species were identified, with Hymenopterans, particularly honey bees, dominating. *Apis dorsata* (67.40%) was the most common pollinator followed by *Apis florea* (14.28%). Other pollinators include species from Halictidae, Sphecidae, Syrphidae and Pieridae families. Among the botanicals tested, neem seed kernel extract (5%) and leaf extract (10%) effectively managed the red pumpkin beetle (*Raphidopalpa foveicollis*) with minimal harm to pollinators. Post-application, pollinator activity slightly increased after three to five days. The study highlights the effectiveness of neem-based botanicals in reducing pest populations while conserving pollinators, emphasizing the value of eco-friendly pest control in promoting sustainable pumpkin farming, improving both yield and crop quality.

Key words: Variability, hymenoptera, neem, *Raphidopalpa foveicollis*, yield.

INTRODUCTION

Pumpkin (*Cucurbita pepo* L.), a key crop within the Cucurbitaceae family, is extensively cultivated during the *kharif* and summer seasons across India. With a cultivation area of approximately 78,000 hectares and an annual production of 17.14 lakh metric tonnes, India stands as the second-largest global producer of pumpkin, followed by China. Beyond its value as a vegetable, pumpkin is recognized for its medicinal properties, attributed to its rich content of phyto-constituents such as alkaloids, flavonoids and linoleic acids. However, pumpkin cultivation faces significant challenges due to pests like pumpkin beetle (*Aulacophora foveicollis*), caterpillar (*Diaphania indica*), aphid (*Aphis gossypii*), and fruit fly (*Bactrocera cucurbitae*), which negatively impact production. The use of pesticides, while effective against pests, can also reduce the population of beneficial pollinators, exacerbating the problem. Neem (*Azadirachta indica*), a widely studied botanical, has shown mixed effects on both pollinators and pests. For example, Singh *et al*. (17) observed a significant reduction in pollinator numbers in neem-treated plots in coriander, while Khan *et al*. (9) and Neupane and Shrestha (12) found neem extracts effective against various pests in chilli crop.

On the other hand, a critical aspect of successful pumpkin cultivation is the role of pollinators in enhancing fruit quality and uniformity through cross-pollination. Approximately 85% of pumpkin flowers rely on cross-pollination, with bees contributing nearly 80% of this activity, significantly boosting crop yields (Rout *et al*., 15). Pollination is not only essential for increasing yields but also plays a vital role in maintaining biodiversity. Numerous studies have highlighted the importance of insect pollinators across various crops. For instance, Nidagundi and Sattagi (13) identified *Apis florea* as the dominant pollinator in bitter gourd, while few other researchers observed that natural pollinators like bumblebees and carpenter bees are sufficient for fruit set in pumpkin, eliminating the need for additional honey bee colonies. Studies by Ali *et al*. (2) further emphasized the significance of native bees and other insect pollinators in pumpkin and cucumber crops. Additional research by Gautam and Kumar (7) highlighted the diversity of pollinators in cucumber and ridge gourd ecosystems. Furthermore, Chethan *et al*. (4) recorded a wide range of insect species visiting crops like muskmelon, coriander and cucumber, underscoring the critical role of pollinators in agricultural systems.

Considering the vital importance of pollinators as well as insect pests in crop production, it is essential to develop eco-friendly pest management strategies that safeguard these beneficial insects while eliminating the

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harmful once such as insect pests. Therefore, this study aims to assess the diversity of pollinators in pumpkin crop and evaluate the bio-efficacy of botanicals in pest management, with a focus on their impact on pollinators.

MATERIALS AND METHODS

The present study was conducted during the *kharif* season of 2019 at the Instructional Horticulture Farm and the Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. The research focused on the crop pumpkin, specifically the variety MAHY 1 (MPH-1). Udaipur is located at 24º35' N latitude and 73º42' E longitude, with an elevation of 582.17 m above mean sea level, within the Sub-Humid Southern Plain and Aravalli Hills of Agro-Climatic Zone IVa of Rajasthan. The pumpkin seeds were procured from a reliable agricultural seed supplier to ensure the quality and uniformity required for the study. The experimental field was prepared in mid-June 2023 with ploughing, cross-harrowing and planking. Manual weeding and hoeing were carried out at 20 and 30 days after sowing. The crop received recommended doses of N: P: K (70:25:25 kg/ha), with half of the nitrogen, full phosphorus, and potassium applied as a basal dose along with farmyard manure. The remaining nitrogen was split into two equal doses, applied at planting and full bloom. Although rainfed, the crop was irrigated during dry spells.

Observations on the diversity of insect pollinators visiting pumpkin flowers were taken at 10 AM, 12 PM and 4 PM for five minutes per square meter during peak flowering. Data were collected from five selected observation spots and then averaged by time and insect group to identify the pollinator fauna and determine the dominance of specific groups. The following mathematical analysis was then conducted (Fleischer *et al.*, 6):

To prepare neem seed kernel extract (NSKE), mature neem kernels dried in the shade, crushed with a brass mortar and pestle, and the powder was sieved through a 60-mesh sieve. The powder was mixed with lukewarm distilled water in a 1:1 ratio to create a 100% concentration, which was then diluted with distilled water to obtain a 5% concentration (Agbo *et al.*, 1). To prepare neem leaf extract (NLE), 600 g of fresh, tender neem leaves were placed in a glass container with 3 liters of lukewarm water and soaked for 12 hours. After soaking, the leaves were macerated using a mixer-grinder, and the mixture was filtered through muslin cloth into a glass jar. This yielded a 20% concentrated extract, which was then diluted to achieve the desired 10% concentration for spraying. The preparation of Dashparni involves combining 10 liters of cow urine, 2 kg each of bael leaves, marigold leaves, cow dung, neem leaves, karanj leaves, custard apple leaves, datura leaves, basil leaves, papaya leaves and nerium leaves. Additionally, 500 g each of tobacco leaves, garlic, turmeric, and green chili, along with 200 g of ginger, are included. The mixture is then diluted with 200 liters of water to complete the composition (Biswas and Pakhira, 3).

Aforementioned botanicals were evaluated for their bio-efficacy against the pests and their side effect on the insect pollinators. The experiment on pumpkin (variety MAHY 1, also known as MPH-1) was conducted using a Randomized Block Design (RBD) with 4 replications and 6 treatments, resulting in a total of 24 plots. Each plot measured 4.0 m × 2.0 m, with plant spacing maintained at 90 cm × 90 cm. The treatments details were as follows: T_1 – neem seed kernel extract (NSKE) at 5% concentration, T_2 – neem leaf extract (NLE) at 10% concentration, T_3 – neem oil at 1% concentration, T_4 - Dashparni (DP) at 10% concentration, T_5 - Teekha sat (TS) at 3% concentration and T_6 - control. The treatments were applied once during the study.

Pollinator counts were taken one day before treatment and again at 1, 3 and 5 days after treatment to monitor changes in insect populations. The reduction in insect numbers for one day post-application was calculated through the Henderson and Tilton (8) method, with percentage changes in pollinator abundance assessed at 3 and 5 days after treatment in relation to the control.

RESULTS AND DISCUSSION

Pumpkin pollinators consist of seven species, with Hymenopterans being the dominant group, particularly honey bees. Among different honey bees, *Apis dorsata* was the most prevalent (67.40%), followed by an *A. florea* (14.28%) (Table 1). Other Hymenopteran pollinators included Halictidae (7.93%) and Sphecidae (3.17%). Additionally, Diptera and Lepidoptera, mainly Syrphidae and Pieridae butterflies, contributed to about 6.87% of the pollination. The list of insect pollinators and their relative abundance is given in Table 1, while general bee pollinators (Fig. 1). The current results align with Ali *et al*. (2), who found that bees are the primary pollinators of pumpkins. Agbo *et al*. (1) identified 24 insect species visiting cucumbers, with Hymenoptera being the most prevalent. Subhakar *et al*. (18) reported Hymenoptera as the dominant pollinators (88.51%), followed by Diptera (5.81%) and Lepidoptera (4.68%). Gautam and Kumar (7) recorded 8 insect species visiting ridge gourd flowers, with Hymenoptera again being prominent. These findings confirm the dominance of Hymenoptera, especially honey bees, as key pollinators.

The study on the side-effects of botanicals on pumpkin pollinators showed a decrease in pollinator

Table 1. Pollinator fauna of pumpkin.

Sl. No.	Pollinator	Systemic position	% Relative abundance
1.	*Apis dorsata* F.	Hymenoptera: Apidae	67.40
2.	*Apis florea* F.	Hymenoptera: Apidae	14.28
3.	*Halictus* sp.	Hymenoptera: Halictidae	4.76
4.	*Lasioglosum* sp.	Hymenoptera: Halictidae	3.17
5.	Sphecid wasp	Hymenoptera: Sphecidae	3.17
6.	Syrphid fly	Diptera: Syrphidae	5.55
7.	*Pieris brassicae*	Lepidoptera: Pieridae	1.32

numbers across all treatments at one day after spraying. However, three days post-treatment, pollinator numbers increased in most treatments, except Teekha sat (3%), but remained lower than pre-treatment levels, except for neem seed kernel extract (5%) and leaf extract (10%). By the fifth day, pollinator numbers increased further in the neem seed kernel and leaf extract treatments but declined in those treated with neem oil (1%), Dashparni (10%), and Teekha sat (3%) (Table 2).

Fig. 1. Pollinators of pumpkin.

After spraying botanicals on pumpkins to control the red pumpkin beetle, pollinator populations decreased, with reductions ranging from 7.95% to 20.45% one day after treatment. Neem seed kernel extract (5%) had the least impact, while neem oil (1%) caused the greatest reduction. By the third day, pollinator numbers increased in plots which were treated with neem seed kernel extract (5%) and leaf extract (10%), but continued to decline in those treated with neem oil (1%), Dashparni (10%), and Teekha sat (3%). By the fifth day, neem seed kernel extract (5%) showed the highest increase in pollinators (13.41%), while neem oil (1%) had the greatest reduction (-17.07%) (Table 3). The results align with Naumann *et al*. (11), who found no significant differences in bee numbers between neem-treated, solvent-treated, and untreated plots. Singh *et al*. (17) reported a maximum pollinator reduction of 25.06% in plots treated with neem seed oil (1%), with pollinator numbers increasing after 3 days in the plots treated with NSKE (5%) and neem leaf extract (10%). Dutta *et al*. (5) also found that neem 1EC was safest for coccinellid beetles (7.50/5 plants) and foraging honey bees (9.64/plot/5 min). Swaminathan (19) explored the side effects of neem

Table 2. Effect of botanicals on the intensity of the insect pollinators of pumpkin (No./m^2/5 min).

Treatment	Pre-treatment	Mean insect-pollinator intensity post-treatment		
		I day	III day	V day
Neem seed kernel extracts (5%)	22	20.3	22	23.25
Neem leaf extracts (10%)	20.25	18.8	20.5	21.75
Neem oil (1%)	21.75	17.5	18.25	17
Dashparni (10%)	20	18.3	18.75	18.25
Teekha sat (3%)	21.5	20	19.5	21
Control	20.75	22	20	20.5

Table 3. Effect of botanicals on the mean insect pollinators intensity over control.

Treatment	Pollinator intensity (%)		
	I day	III day	V day
Neem seed kernel extracts (5%)	(-)7.95 *(21.12)	(+)9.09 (17.55)	(+)13.41 (21.48)
Neem leaf extract (10%)	(-)14.77 (20.58)	(+)2.43 (8.97)	(+)6.09 (14.29)
Neem oil (1%)	(-)20.45 (29.41)	(-)8.75 (17.21)	(-)17.07 (24.4)
Dashparni (10%)	(-)17.04 (20.94)	(-)6.25 (14.48)	(-)10.97 (19.34)
Teekha sat (3%)	(-)9.09 (18.57)	(-)2.5 (9.1)	(+)2.43 (8.97)
SEm ±	1.43	1.02	1.29
CD 0.05	4.35	3.27	3.42

*Figures in parenthesis are arc sine values, (+) indicates per cent increase in pollinator intensity and (-) indicates per cent decrease in pollinator intensity.

seed kernal botanicals on the coccinellid recorded the highest mortality (73.33%) due to NSKE (10%) followed by (65.0% mortality) for neem oil (5.0%); and the post treatment effect (one day after) evinced maximum reduction in feeding (72.0%) for NSKE (10%) followed by that recorded as 68 per cent for neem oil (5%).

The study on the bio-efficacy of botanicals against the red pumpkin beetle revealed that neem seed kernel extract (5%) was the most effective treatment, resulting in the lowest beetle count (1.31 beetles/m²), showing a significant difference with other treatments even after 3 or 5 days (Fig. 2). This effectiveness could be attributed to the high concentration of active compounds in the neem seed kernel extract, which likely provided a more prolonged residual effect, leading to sustained pest control and a continued reduction in beetle numbers over time, followed by neem leaf extract (10%) (1.57 beetles/m²). Control plots had the highest beetle count (2.28 beetles/m²). Among the treatments, Dashparni (10%), Teekha sat (3%), and neem oil (1%) showed higher beetle counts, with 1.91, 1.86, and 1.78 beetles/m², respectively.

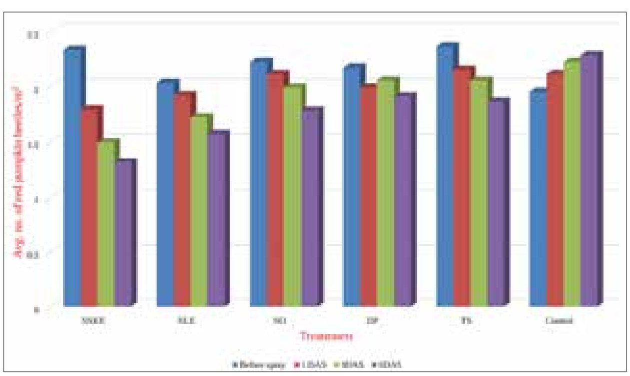

Fig. 2. Effect of various botanicals on the average number of red pumpkin beetles.

Note: NSKE: Neem seed kernel extract; NLE: Neem leaf extract; NO: Neem oil; DP: Dashparni; TS: Teekha sat. DAS: Days after spraying.

These findings are consistent with previous research. Kraiss and Cullen (10) found that both azadirachtin and neem seed oil significantly increased aphid nymphal mortality (80 and 77%, respectively) while significantly increasing development time of those surviving to adulthood. Khan *et al.* (9) reported that a 5% ethanolic extract of *Azadirachta indica* repelled 76.7% of *Aulocophora foveicollis* adults under lab conditions. Neupane and Shrestha (12) found that using 5 ml of multineem per liter of water led to a 100% reduction in red pumpkin beetles. Similarly, Rashid *et al*. (14) observed the lowest beetle population and leaf infestation in neem-treated plots, while Sathua *et al*. (16) noted that a 5% NSKE caused the highest mortality (64.50%) among the botanicals tested.

In conclusion, this study underscores the importance of pollinators, especially honey bees like *Apis dorsata*, in pumpkin cultivation. It highlights the effectiveness of neem seed kernel extract (5%) and neem leaf extract (10%) in controlling red pumpkin beetles while minimally affecting pollinators. These botanicals showed an increase in pollinator numbers three to five days after application, making them viable eco-friendly options for integrated pest management. The findings align with prior research, confirming that careful botanical use can balance pest control with pollinator conservation, promoting sustainable farming and better pumpkin yields.

AUTHORS' CONTRIBUTION

Investigation and writing- original draft (USR), writing, review and editing (BSN, VCK, CKKB, VS, GR), supervision (AKV).

DECLARATION

The authors declare that there are no conflicts of interest regarding this article.

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