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Utilization of Bumblebee in Crop Pollination

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Bumblebees play a vital role in pollination of plants due to their large size and hairiness hence are ideal for picking up and transferring pollen. They can vibrate ('buzz') flowers and have no communication system but can work efficiently in tunnels as they have a better sense of direction. They are 400 times more efficient than honeybees at any pollination chore and are capable of visiting 30 to 50 flowers per minute. They are non-swarming and less aggressive than honeybees. Bumblebee generally forages during the early morning (0530-0800h) and evening (1700-1900h) time. Bumblebees are better pollinators than honeybees in greenhouses and glass houses and they have a great potential to serve as supplemental pollinators in the cultivation of crops such as tomato, eggplant, cucumber, melon, strawberry, pumpkin, cherry, sweet pepper, etc. It improves the yield and quality parameters of the fruits. In India, efforts are being made at Solan to mass rear bumble bees and utilize them in pollination. A few private companies have attempted to introduce newer species of bumblebees in India. In the present era, the global population of bumblebees is declining due to injudicious use of pesticides, loss of natural colony and mechanization in agriculture and climatic effect.

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1. INTRODUCTION

"Bumblebees are social insects, belonging to order Hymenoptera, tribe Bombini and genus Bombus in the family Apidae. There are over 250 known species of bumblebees in the world, primarily existing in the Northern Hemisphere although they occur in South America also. They have been introduced to New Zealand and the Australian state of Tasmania". Chauhan et al., [1] Of the 400 species of bumblebees worldwide Heinrich, [2], the six species commonly found are *viz.,* Buff-tailed bumblebee, *Bombus terrestris;* White -tailed Bumblebee, *Bombus lucorum;* Garden Bumblebee, *Bombus hortorum;* Red-tailed Bumblebee, *Bombus lapidaries;* Early Bumblebee, *Bombus pratorumand* Common Carder Bee, *Bombus pascuorum*. In India, *Bombus haemorrhoidalis* is reported by Chauhan et al*.,* [1] at Solan.

"Bumblebees live in organized colonies in nests typically built in a small hole in the ground or under a clump of grass. The three castes of bumblebees are the queen, female workers and males. Bumblebees have an annual life cycle. Bumblebee colonies infested by pests and diseases like mite, moth, conopid flies, nematode and *Nosema* spp". Chauhan et al., [1]. They are robust, hairy and black with yellow bands and make a buzzing sound while flying. However, some species have orange or red bands on their bodies or may be entirely black. A rarity, the bumblebee is a warm-blooded insect, by "shivering" her massive flight muscles; she can create heat in her thorax. Then, by contracting her muscles, she circulates the warmth into her abdomen. Bumblebees require pollen as a protein source for feeding their larvae and nectar as a sugar (carbohydrate) source - a fuel for the adults' flight and to produce wax for nest building.

Bumblebees live in organized colonies in nests typically built in small holes in the ground or under clumps of grass. The size of queen cells is 16.56-20.57 mm in length and 12.55-15.20 mm width, the size of worker cells is 13.16-14.24 mm in length and 10.01-10.95 mm in width. Honey pots are 15.31-20.35 mm in length and 12.91-16.32 mm in width. The three castes of bumblebees are the queen, female workers and males. The body length of the queen is 20-25 mm, the worker is 18-25 mm and that of the male is 14 -16 mm. Bumblebees have an annual life cycle and pass through four stages (egg, larva, pupa and adult) during their life span. The queen lays eggs in batches of 5-20on the ball of pollen in the pots, seals it with wax, and incubates the eggs to keep them warm. Eggs hatched in 2.6 days after laying and the larval period is 17.2 days while the average pupal period was 8.6 days. The average total period from egg to adult is 28.4 days. Bumblebee colonies are infested by pests and diseases like mites, moths, conopid flies, nematodes and *Nosema* spp. Bumblebees forage on different kinds of flowers visiting about 8-12 flowers per minute. To collect pollen and nectar from a single flower it spends 4-8 seconds [3].

2. ROLE OF BUMBLEBEE AS A POLLINATOR

"Bumblebees act as an important pollinator of plants due to being large, very hairy and so are ideal for picking up and transferring pollen. Bumblebees are active at temperatures near 5°C as well as on cloudy, foggy and rainy days. It will fly in winds of up to 40 mph (70 km/hr). The bumblebees can vibrate ('buzz') flowers and have no communication system. Bumblebees are non-swarming and less aggressive than honeybees. Bumblebees work better in tunnels as they have a better sense of direction. They are 400 times more efficient than honeybees at any pollination chore, capable of visiting 30 to 50 flowers per minute. Bumblebee generally forages during early morning (0530-0800h) and evening (1700-1900h) time" [1]. Bumblebees are good pollinators in greenhouses and poly house and are of great economic importance in greenhouse cultivation of such as tomato, brinjal, strawberry, cucumber, melon, sweet pepper, cherry and pumpkin than honeybees.

3. BUMBLEBEE IN CROP POLLINATION

Abak et al*.* [4] observed that the bumblebee pollinated plants of eggplant and tomato recorded significantly higher fruit yield (23% in eggplant and 17% in tomato), number of fruits per m^2 and number of seeds per fruit. However, there was no significant differences observed in fruit quality parameters like total soluble solids content, pH of fruit juice, titratable acidity, fruit diameter and fruit length in both crops as compared to control. In case of pepper, Abak et al*.* [5] reported that "average yield, weight of fruit,

diameter of fruit and the numbers of seeds increased by 4.0%, 10.0%, 6.0% and 12.5%, respectively in the bumblebee pollination as compared to control in greenhouse".

"Tomato flowers pollinated by *B. vosnesenskii* produced larger fruit than manually pollinated flowers as evidenced by significant increases in fruit weight, height, diameter and seed count. Overall, bumblebee treatments (bumblebees and bumblebees plus manual) resulted in significantly greater fruit weight, seed count, fruit diameter and fruit height compared with non-bee treatments (manual and no-pollination). In contrast, fruit roundness did not differ between treatments" [6].

In cucumber and watermelon, the flowers visited by bumblebees had significantly lower abortion rates and higher seed sets than those visited by honeybees [7].

Eggplants pollinated by bumblebees yielded higher (25%) than those that had vibration treatment with bigger fruit sizes (14% in weight and 7% in length) and four times higher number of seeds per fruit [8]. Bumblebee pollinated plants of strawberries produced 30 per cent higher yield than control plants [9].

Significantly higher tomato yield (4.12 kg m^{-2}) in bumblebee pollinated plants with an increased yield of 89.9% and 60.9% over vibration treatment and growth regulator application respectively was observed. The quality of tomato like number of seeds per fruit, volume of fruits and number of carpels were also significantly higher [10]. Similarly, visits by bumblebees produced larger and heavier fruits and higher yields of sweet pepper as compared to self-pollination [11].

In strawberries, the pollination done by bumblebees had a significant impact on the number and weight of marketable fruits produced. The fruit yields were higher in comparison to the control group. In control group, 30% of the fruits produced were deformed due to insufficient pollination [12].

Chauhan, 2011 noted that in cucumbers pollination through bumblebee produced high quality fruits than without pollinators. Bumblebee supplementation led to higher pumpkin yields: 16.5 lbs/plant compared to 15.2 lbs/plant with honey bee supplementation and 13.1 lbs/plant in non-supplemented fields in New York [13].

The tomato plants pollinated by bumblebees produced fruits with greater number of seeds compared to those pollinated mechanically or not pollinated at all. "Maturation time was longer and sugar content, fresh weight and seed count were higher in bumblebee pollinated flowers than those pollinated manually or with no supplemental pollination; but did not differ with flowers pollinated mechanically" [14].

The positive impact of the bumblebees in bell pepper was found through the 3.77% increase in the number of fruits per plant and24.6% higher fruit weight as well as 13.51% and 21.52% increases in fruit length and fruit breadth respectively. An increase of 23.84% in the number of healthy fruits, 113.64% more seed number and 5.44% increase in 1000 seed weight and 89.42% higher fruit yields per m^2 over control plots [15]. According to Marques et al*.,* [16] fruit set was significantly higher in *B. terrestris* introduced field of almond as compared to control plots.

4. IMPACT OF PESTICIDES ON BUMBLEBEE POPULATION

"According to a study colonies treated with neonicotinoid (imidacloprid) suffered a significantly reduced growth rate and an 85% decline in production of new queens as compared to control colonies. It was suggested that the negative impact of these chemicals was considerable on wild bumblebee populations across the developed world" [17].

"Bumble bee, *Bombus terrestris* workers survived fewer days when exposed with syrup dosed at 98 μg thiamethoxam kg^{-1}, while production of brood (eggs and larvae) and consumption of syrup and pollen in microcolonies were significantly reduced by thiamethoxam only at the two highest concentrations (39, 98 μg kg^{-1}). In contrast, no detectable effect of thiamethoxam at levels typically found in the nectars of treated crops (between 1 and 11 μg kg^{-1}) and also brood production in worker bumble bees is more sensitive to imidacloprid than thiamethoxam" [18]. Baron et al*.,* 2017 reported that "exposure of thiamethoxam cause 26% reduction in the proportion of queens that laid eggs, and advanced the timing of colony initiation" [19,20].

5. CONCLUSION

Pollination is one of the most important ecological processes on the planet. Among

pollinators, bumblebees have gained importance as an efficient pollinator due to their large size and very hairy makes them more ideal for picking up and transferring pollen of many commercial crops grown under greenhouse, glasshouse, poly houses and open field. Bumblebees are better pollinators than honeybees in greenhouses and glass house and it have a great potentiality to serve as a supplemental pollinator in cultivation of crops such as tomato, eggplant, cucumber, melon, strawberry, pumpkin, cherry, sweet pepper *etc.* and resulted in to produced higher yield and increase the number of fruit and seed, fruit diameter, fruit length, fruit weight and also improve the quality of the fruit in crops and thus can render farming more profitable. Pesticides including neonicotinoid (imidacloprid) have been proven to the cause of bumblebee population decline and may be avoided in zones with crops that require pollination by bumblebees.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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