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Quantification and Role of Insect Pollinators in Enhancing Productivity in Cucumber

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ABSTRACT: Pollination is a critical aspect in cucumber production, since each cucumber flower is open only for a day. Generally two approaches quantify pollination viz., the direct estimate of pollinators' performance in terms of its behaviour and/or pollen deposition on stigmas, whilst the second indirectly estimates pollinators' contribution to yield, usually measured as seed set or fruit weight, both of which contribute to overall production of the crop. Six insect pollinators belonging to the two orders *viz.*, Hymenoptera and Diptera were found visiting the cucumber flowers during the study conducted in 2021-2022. The insect pollinators include *Apis mellifera, A. cerana, Xylocopa* spp, Bumble bees and Syrphids. The mean foraging rate was maximum in Xylocopa spp. (8.72) followed by Halictidae (7.65), Bumble bee and Syrphids (7.27), *Apis cerana* (5.02) and *Apis mellifera* (4.75). The mean foraging speed was found maximum in *Apis mellifera* (8.82), followed by *A. cerana* (8.40), Bumble bee (8.32), Syrphids (7.15), Halictidae (4.40) and Xylocopa (4.37). Among all the attractants treatments evaluated to insect pollinators, Geranoil had maximum effect on quantitative as well as qualitative parameters of the crop viz., fruit set, fruit volume, number of sound seeds per fruit and weight as a result of efficient pollination by virtue of attracting more pollinators. The minimum effect was observed under Control (Pollination Exclusion) treatment. The positive correlation coefficient was computed between the mean number of pollinators and the various weather parameters except rainfall, which showed the negative correlation with the mean number of the flower pollinators.

Keywords: Cucumber, Pollinators, *Apis* spp, Attractants, Correlation, Quantitative.

INTRODUCTION

Cucumber (*Cucumis sativus* L.), an important vegetable from the cucurbitaceae family, is grown extensively as a commercial crop. There are 750 species in the family spread across 90 genera. Nearly 40 species make up the genus *Cucumis*, three of which are significant cultivars: *C. anguria* L., *C. sativus* L., and *C. melo* L. Higher quantitative and qualitative fruit yield is a sign of economic success. According to Klein *et al.* (2007), pollination is one of the most important factors impacting the quality and productivity of agricultural crops, including cucumber. The cucumber plant is monoecious, susceptible to cold, and produces yellow, regular, unisexual, pentamerous blooms that are mostly either male or female. It also has huge, prickly, hairy triangular leaves that are borne alternately on petioles 5-20 cm long and form a canopy over the fruit. The female flowers begin to bloom shortly after the male flowers. The enlarged ovary at the base of the female flowers, which develops into the edible fruit, can be used to identify them. Pollen grains are sticky and are transferred from male to female flower by bees or other insects (Keith, 1995; Codony and Morato-Mas 2005). The stigma is receptive during the day particularly in early morning (Collison, 2007). There are different types of cucumber hybrids such as gynoecious varieties that produce predominantly female flowers, and seeds of monoecious varieties are mixed with it for pollination. They are very productive in presence of the pollinizer (McGregor, 2007). Minerals, water, protein, lipids, iron, phosphorus, calcium, vitamins, and dietary fiber are all present in cucumbers in good amounts (Rashid 1999; Gopalan *et al*., 1982). It is eaten in raw form as refreshment, typically as a salad with fast food and meals (Reshma *et al*., 2011). The cooling effects of cucumber's tender fruits help to avoid indigestion and jaundice. Cucumber seeds and raw fruits are employed in ayurvedic and cosmetic preparations, respectively (Hatwal *et al*., 2015). The plant is having extensive superficial root system, covered with scaberulous hairs. Fruit is roughly elongated, cylindrical with tapering ends and can be as large as 60cm long and 10cm in diameter.

Cucumber flowers open early in the morning, when both stigma receptivity and pollen viability are at their

greatest and diurnal pollen transfer is likely to be important in cucurbits since flowers of cucurbits open only once and stigma receptivity rapidly declines within a day (Bomfim *et al*., 2016), so pollination is a crucial step, there are two approaches for quantifying pollination: the first directly estimates pollinator performance in terms of pollinator behaviour and/or pollen deposition on stigmas, whilst the second indirectly estimates pollinators' contribution to yield, usually measured as seed set or fruit weight (Ne'eman *et al*., 2010). Therefore, pollinator visitation to crop flowers, their abundance at crop flowers, and pollen deposition (whilst stigmas are receptive) are all considered to be measures of pollinator performance. On the other hand, seed set, fruit weight, fruit weight per plant, fruit number, and percentage fruit set are all considered measures of yield all contributed by insect pollinators. Complete pollination ensures uniform and perfectly formed fruits with even maturity while as improper pollination results in formation of misshapen and small sized fruits, thus leads to low yield of marketable fruits.

MATERIAL AND METHODS

The study was conducted during the year 2021-2022 at Entomological field of SKUAST K, Shalimar. The crop was raised as per the package of practices recommended by the University. Five plants were selected randomly to record the different insect pollinator's species visiting the flowers daily from 0900 to 1600h of the day at hourly interval for five minutes during the flowering period. Pollinators visiting the flowers before and after application of the attractants were collected and identified properly. The foraging activity of insect pollinators on flowers either for collecting pollen or nectar; and or both was observed during flowering period. The observations were recorded on five flowers, selected randomly irrespective of the sex of the flower from 0900 to 1600 h at hourly interval for five minute and was expressed as the mean number of foragers per flower per five minute. The effect of attractants *viz*., Citral, Geraniol, on pollination in cucumber upon fruit set, fruit weight, fruit volume, number of sound seeds per fruit were assessed against the open pollination and control (pollination exclusion) treatment. The experiment was laid in Randomized Block Design (RBD) with four treatments and five replications.

Cucumis sativus blooming phase

RESULTS AND DISCUSSION

The six different insect pollinators belonging to the two different orders viz., Hymenoptera and Diptera, as shown in (Table 1 & Fig. 1) were found visiting cucumber flowers during the study period. The insect pollinators belonging to the order Hymenoptera include *Apis mellifera*, *Apis cerana*, *Xylocopa* spp and *Bumble bee* spp all belonging to the family Apidae.

Table 1: Diversity of insect pollinators on cucumber plants.

Order	Family	Genus
Hymenoptera	Apidae	*Apis mellifera*
		Apis cerana
		Xylocopa spp
		Bumble bee spp
	Halictidae	*Lassioglossum* spp
Diptera	Syrphidae	Syrphids

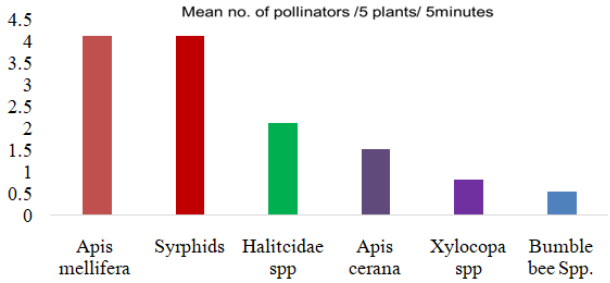

Fig. 1. Mean number of different insect pollinators visiting cucumber flowers.

The insect pollinator from the order Diptera belonged to genus Syrphus; Family Syrphidae. The results are in accordance with the findings of Grewal and Sidhu (1978) who recorded *Apis florea*, *Apis dorsata*, *Apis mellifera* and solitary bees, as main visitors of cucumber. Cervancia and Bergonia (1991) too reported *Xylocapa chlorina*, *X. philipinensis*, *Megachileatrata*, and *A. dorsata* as common insect pollinators visiting cucumber flowers. The results are further supported by Deyto & Cervancia, (2009) who opined insect pollinators viz: Hymenoptera (*A. cerana*, *A. mellifera*, *Trigonia* spp, *Halictus* spp, *Xylocopa* spp, and Formicidae), Coleoptera (Chysomelidae), Lepidoptera (butterflies), and Diptera (*Calliphora* spp) as visitors to other cucurbit crop bitter gourd. Furthermore, Balina *et al*. (2012) too reported nine different bee species visiting the blooms of bitter gourd, from three different families (Apidae, Halictidae and Megachillidae) *Halictus* sp., *Megachile* sp., and *Apis dorsata* as most common visitors. The results are further corroborated by the work of Bodlah and Waqar (2013); Kumar and Rai (2020) who concluded that important insect pollinators of cucurbits are identified from orders Hymenoptera and Diptera.

Table 2: Foraging behavior of insect pollinators on cucumber bloom during different hours of the day.

Hours of observation	*Apis mellifera*		*Apis cerana*		*Halitidae spp*		*Xylocopa spp*		Bumble bee Spp.		Syrphids	
	Foraging rate	Foraging speed	Foraging rate	Foraging speed	Foraging rate	Foragingspeed	Foraging rate	Foragingspeed	Foraging rate	Foraging speed	Foraging rate	Foraging speed
900	1.20±0.103	10.20±0.868	1.80±0.152	9.20±0.783	3.40±0.287	3.20±0.273	5.00±0.425	4.20±0.358	5.20±0.443	5.20±0.443	5.20±0.443	5.00±0.425
1000	2.40±0.202	9.40±0.798	3.40±0.287	10.40±0883	5.60±±0.478	3.60±0.308	6.20±0.528	5.00±0.425	6.40±0.542	5.80±0.493	6.40±0.542	6.80±0.578
1100	2.80±0.238	8.60±0.733	4.40±0.372	8.80±0.748	8.40±0.713	4.40±0.372	8.40±0.713	3.20±0.273	7.00±0.595	6.20±0.528	6.80±0.578	8.40±0.713
1200	3.20±0.273	6.20±0.528	8.20±0.698	6.20±0.528	11.20±0.953	3.40±0.287	10.60±0.903	4.20±0.358	8.40±0.713	7.60±0.648	7.80±0.663	9.20±0.783
1300	5.60±0.478	5.40±0.457	7.80±0.663	4.60±0.393	9.60±0.818	4.80±0.408	11.80±1.003	4.60±0.393	8.80±0.748	9.20±0.783	8.20±0.698	10.40±0.883
1400	8.20±0.698	8.80±0.748	5.60±0.478	6.40±0.542	8.20±0.698	4.00±0.340	12.20±1.038	6.20±0.528	10.00±0.850	10.00±0.850	9.40±0.798	7.20±0.613
1500	7.80±0.663	10.40±0.883	4.20±0.358	9.20±0.783	7.60±0.648	5.20±0.443	8.20±0.698	5.40±0.457	7.60±0.648	12.20±1.038	8.20±0.698	6.00±0.510
1600	6.80±0.578	11.60±0.988	4.80±0.408	12.40±1.053.	7.20±0.648	6.60±0.563	7.40±0.627	2.20±0.188	4.80±0.408	10.40±0.883	6.20±0.528	4.20±0.358
Mean	4.75	8.82	5.02	8.40	7.65	4.40	8.72	4.37	7.27	8.32	7.27	7.15
CD	0.700	0.550	0.561	0.656	0.622	0.295	0.679	0.326	0.466	0.653	0.353	0.547
CV	8.332	3.526	6.331	4.415	4.601	3.792	4.401	4.210	3.621	4.436	2.747	4.329

Table 3: Pearson's correlation between different insect pollinators and various weather parameters.

Mean no. of pollinators	Max. Temp.	Min. Temp.	Rain (mm)	RH (Morning)	RH (Evening)
Apis mellifera	0.810*	0.755*	-0.681*	0.850*	0.419
Apis cerana	0.810*	0.744*	-0.709*	0.787*	0.651*
Halictidae	0.906*	0.861*	-0.809*	0.920*	0.589*
Xylocopa spp.	0.891*	0.838*	-0.811*	0.865*	0.726*
Bumble bees	0.716*	0.700*	-0.602*	0.822*	0.115
Syrphids	0.770*	0.708*	-0.632*	0.808*	0.393

* Significant at p = 0.05

The data presented in Table 2 shows that mean foraging rate of different insect pollinators visiting the cucumber crop was found to be maximum in *Xylocopa* spp. (8.72) followed by *Halictidae* (7.65), Bumble bee and Syrphids (7.27), *Apis cerana* (5.02) and *Apis mellifera* (4.75). The maximum mean foraging speed was found in *Apis mellifera* (8.82), followed by *Apis cerana* (8.40), Bumble bee (8.32), Syrphids (7.15), Halictidae (4.40) and *Xylocopa* (4.37). Simple correlation matrix revealed positive correlation coefficient between the mean number of pollinators and the various weather parameters except rainfall, which had negative correlation with t pollinators visiting the flowers (Table 3). The results are in conformity with the findings of Kohli and Vikram (2005) who reported honey bees as predominant pollinators of cucumbers, with its foraging activity and foraging speed at greater level even at low humidity during the ideal pollination period between 9:00 a.m. and 12:00 p.m. Besides, bees spent significantly more time (10.95 sec) in morning hours and visit few numbers of flowers as compared to noon and evening hours (Rana *et al.*, 2006). The findings are further in close proximity with Shah *et al.* (2015) who observed differences in foraging activity and foraging speed of different pollinators; the foraging rates were significantly higher in early hours of the morning, between 0600 and 0700 a.m. and pollinators of Hymenoptera order were the most frequent and diverse in their foraging activity and speed.

Table 4: Role of attractants in enhancing the crop yield.

Treatments	Fruit set (%)	Fruit weight (g)	Fruit volume (cu.cm)	No. of sound seeds /fruit
Open pollination	57.50± 4.899	193.46± 16.425	75.36± 6.411	57.20± 4.865
Citral	76.50± 6.505	209.32± 17.802	209.32± 17.802	79.40± 6.751
Geraniol	86.00± 7.314	245.78± 20.901	160.76± 13.67	92.20± 7.842
Control (pollinator exclusion)	34.50± 2.933	97.52± 8.294	56.52± 4.807	32.60± 2.774
CD	6.826	18.974	13.732	7.854
CV	5.268	4.994	6.700	5.901

The attractants play an important role in driving the insect pollinators particularly honeybees towards the target crop. Perusal of the data presented in Table 4 depicted that both the attractants treatments had maximum effect on quantitative as well as qualitative parameters of the cucumber. The attractant, Geranoil showed the maximum effect on the quantitative as well as qualitative parameters of the crop viz., fruit set (86.00 ± 7.314 %), fruit volume (160.76± 13.67 Cu cm), fruit weight (245.78± 20.901) no. of sound seeds per fruit (92.20± 7.842) and test weight followed by Citral; the fruit set, fruit volume, fruit weight, no. of sound seeds per fruit and test weight as 76.50± 6.505, 209.32± 17.802, 209.32± 17.802, and 79.40± 6.751,

respectively. The effectiveness of attractants in increased pollination and enhancing various crop parameters and ultimately crop yield is supported by Viraktamath and Anagoudar (2002); Pateel and Sattagi (2007). The attractants like cacambe and jaggery attracts the maximum foragers' of *Apis dorsata* up to 5 days (Kalmath and Sattigi 2002), the attractants too had the greatest effect on *Apis florea* at 10 days after the first spray. Further, the use of attractants Cacambe (10%) and jaggery (10%) on cucumbers have a major impact on attracting the most insect pollinators towards the crop. Narayanan and Gavigowda (2005), who observed increased foraging activity during the first spray (3.54 bees/m^2 /5 min), followed by the second and third sprays (3.35 and 3.20 bees/m^2 /5min, respectively) (Jayaramappa *et al.*, 2011), provide additional support for the findings. Number of fruits per plant, fruit weight (gms), fruit yield (q/ha), and fruit length were improved with the use of fruit boost and bee Q. Bee Q attracts bees to both pistillate and staminate blooms, resulting in sufficient pollination (Sivaram *et al*., 2013). The findings of Wankhede *et al.* (2019), who claimed that attractants like jaggary solution, sugar solution, molasses, and sugarcane juice are more effective at luring insect pollinators to cucumber. This, they claimed, leads to better pollination because of better pollen distribution and an increased seed yield of cross-pollinated crops like cucumber. According to Manchare *et al.* (2020), the most pollinators are drawn to attractants like honey solution 10%, molasses solution 10%, and jaggery solution 10% up to the fifth day after the first spray and the seventh day after the second spray in the case of *Apis mellifera.*

CONCLUSIONS

The studies highlighted the importance of pollination for improving cucumber yield. The pollinators' abundance, their behaviour, pollen deposition on stigmas, and over all contribution towards the fruit and seed yield is obvious from the study. The relative attractiveness of flowers, and/or the pollinator dependency of the cucurbit species (cucumber), also influence the insect visits to the crop. Whilst from a management view, the spatial and temporal context of study sites, which include the influence of various weather parameters, upon the abundance and richness of insect pollinator species which could be further enhanced by the use of attractants.

FUTURE SCOPE

Use of insect pollinators is considered as one of the cheapest and ecofriendly approaches in maximizing the yield of cross pollinated crops in order to produce high-quality fruits and vegetables. However, cucumber still had insufficient pollination, due to the high dependence upon the pollinators because of the monoecious habit/condition, resulting in reduced yield, low crop quality and occasional crop failure and therefore, the growers rely upon cross pollination for effective yields. A systematic and efficient use of attractants would increase insect visits to the crop that would be of great practical value to harvest benefit of cross pollination and to boost productivity of cucumber.

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Conflict of Interest. None.

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