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POLLINATOR'S DENSITY ASSESSMENT ON LITCHI AND SWEET GOURD FLOWER AND THEIR CONTRIBUTION TO YIELD

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ABSTRACT

In the present experiment, the population density of insect pollinators and their influence on the fruit yield of litchi and sweet gourd were studied near Hajee Mohammad Danesh Science and Technology University campus, Dinajpur, Bangladesh from November 2019 to August 2020. Two treatments: open and net-pollinated plots were established in litchi orchards and sweet gourd field. Insect pollinator's diversity was observed from 8.00 am to 16.00 pm with the interval of 2 hours for three successive weeks from the initiation of flowering until approximate 95% of the flower faded. Altogether 8 species of insects' pollinators belonging to 2 different orders and 6 families in both litchi and sweet gourd flowers were recorded. Among them, *Apis dorsata* was recorded the most important pollinator in both litchi (47.93) and sweet gourd (49.53%). The peak foraging activities of majority of the insects were detected from 10.00 to 12.00am in both crops. Significant differences were observed on reproductive parameters of litchi and sweet gourd on open-pollinated over netted treatments. The increased yields were found in both opened pollinated litchi plants and sweet gourd than netted plants. Fruits inflorescence^{-1} and fruits weight inflorescence^{-1} (gm) were increased as 171.31 and 197.05%, respectively in open-pollinated litchi plant over netted plant. Similarly, single fruit weight, number of seeds and seed weight fruit^{-1} were increased as 200.00, 212.86, 216.38%, respectively in open-pollinated plant over netted sweet gourd.

***Keywords*:** Pollination, litchi and sweet gourd flower, fruit yield, assessment, diversity

INTRODUCTION

Globally nearly 90% of wild flowering plants spp. depend on natural pollination

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in plant reproduction by transferring pollen from the male to the female parts of flowers. Of them insects serve as the leading pollinators in agricultural systems and the indispensable part of global eco-network. Among them, mostly bees, butterflies, flies, wasps, beetles, moths, ants and midges are prevailing. It is assessed that one third of the total human food supply depend on insect pollination (Jivan 2013, Said *et al*. 2015). They are responsible for pollinating approximately 80% of flowering plants and also provide support when natural pollination is insufficient (Klein *et al*. 2007). Definitely, 75% of the crop species used as food depends on insect pollination to some extent (Klein *et al*. 2007).

However, surprisingly have slight information available on the actual extent of pollinator dependency for certain major crops. Accurately assessing pollination dependence using appropriate controls is essential to properly determine the contribution of insect pollinators to crop yields. Second, most available studies quantify the number of fruits per plant a good measure for yield (Garibaldi *et al*. 2013). Again, the use of appropriate control plants from which pollinators are excluded is a way to better estimation the real contribution of pollinators to yield in such crops. Pollinator richness significantly declines agricultural landscapes lose natural habitats and suffer more intensive cultivation (Kennedy *et al*. 2013) and this relationship is much weaker for fruit set (Garibaldi *et al*. 2011, Chacoff *et al*. 2008, Ricketts *et al*. 2008). It is tough enough to determine the declining pollinator species, and is challenging to conserve them. Numerous factors have been suggested to explain the declines in pollinator populations in Bangladesh. Among these factors, pesticides misuse, climate change, market dynamics, intra and inter-specific species competition, genetic alterations, exposure to pathogens and parasites (Maus 2015, Paton *et al*. 2008). Besides, continuous breeding process resulting an increasing number of new cultivars, which are successively introduced in cultivation practices. Therefore, identifying and conserving native pollinating insects is essential for enhancing productivity and yield, and this can be effectively achieved through a meta-analysis approach. Hence, the present study was carried out to investigate the richness of insect pollinators as floral visitors, their effectiveness as crop pollinators and assess the extent of pollination dependence in relation to crop yield in litchi and

sweet gourd.

MATERIALS AND METHODS

This research was conducted to determine the population density of pollinators in litchi (*Litchi chinensis*) and sweet gourd (*Cucurbita moschata*) as well as their contribution to fruit yield.

Study sites: The fieldwork was carried out in three different villages, each situated in distinct locations near the University campus of same this university, Dinajpur, Bangladesh during November 2019 to August 2020. For sweet gourd a single field was selected while for litchi three trees were selected randomly from litchi orchard (Bombay variety). These fields and the orchard were separated by a distance of 3 km, consistent to the highest foraging range of the most bees (Green Leaf *et al*. 2007).

Insect sampling: The diversity, abundance, and species richness of the major groups of flowers visiting insects were evaluated. Three litchi trees were chosen from the designated orchard. In case of sweet gourd, nine plants were randomly selected from three plots of the selected field. Pollinator insect activity was recorded through scan sampling (Martin and Bateson 1993) for 30 minutes per two hours started from 8.00 am until 16.00 pm on bright days with no precipitation, dry vegetation and normal atmospheric wind- speed (< 40kmh^{-1}, Westphal *et al*. 2008) to assess the incidence and species composition of floral visitors. Observations were carried out on 5 to 25 March 2020 (21 Days) for litchi and 1 June-20 June 2020 (21 Days) for sweet gourd from the initiation of flowering until approximate 95% of the flower faded. All insects visiting flowers of the plants along the plots/plant were visually surveyed by slow walking. The visiting insects were identified to the species level, while unidentified species were captured using sweep nets or aerial nets for further identification, either through available literature or with the assistance of expert entomologists.

Experimental design: To assess the effects of insect pollinators on reproductive success of two selected plant species consisting of three blocks for each species. Each block had two treatments consisted of three inflorescences for litchi while three flowers for sweet gourd. In the first treatment (open pollination) all flowers

on each plant were accessible to natural self, wind, and insect pollination. In the second treatment (net), all selected flowers were enclosed in mosquito net with 1*1 mm opening (Diatex F510; https:// www. Diatex .fr/- Agriculture -.html) of an appropriate size to cover a litchi inflorescence or an individual flower (sweet gourd). Thus, in the netted-treatment all flowers were exposed to wind-pollination and self- pollination, but not to insect pollination. Because such nets do not hinder the airborne pollen flow (Sacchi and Price 1988, Wragg and Johnson 2011), the difference between these treatments represents the contribution of insect pollination. Net manipulation was performed carefully and in most cases before or after anthesis to avoid increased levels of self-pollination. The nets were put over the flower buds before the onset of flowering. Leaves and plant parts with no flower were left as much as possible outside the net to minimize any effects of the net on the photosynthesis (Howpage *et al*. 2001). As soon as flowers had wilted, the nets were removed, and the tagged fruits were left to ripen in the field until harvest.

Analysis for crop yield: The commercial harvest procedure was followed and the ripe fruits were harvested and stored them separately. Different quantitative parameters were recorded. Fruits weight per inflorescence was measured for litchi. Fruit weight, number of seeds and weight of seeds per fruit were measured for sweet gourd. Finally, yield was measured as the total fruit weight per inflorescence for litchi, total weight of seeds per fruit for sweet gourd using a precision scale.

Statistical analysis: The data were analyzed by using MSTAT-C Software to test the significance of variance among the treatments and means are separated by using Tukey's HSD test at the 5% level of probability.

RESULTS

Diversity of pollinator insects visiting litchi flowers: A number of insect pollinators associated with flowers of litchi were surveyed. They were included 8 species belonging to 6 different families under 2 orders, Hymenoptera and Diptera. The highest average number of flower visitors were *Apis dorsata* (145.0) but the lowest (9.33) were *Formica* sp and they were statistically different (Table 1). However, among the insect pollinators, *A. dorsata* was found the most abundant (47.93%) followed by *A. mellifera* (12.40%), *A. cerana* (10.73%) and

Syrphus sp. (8.29%). Conversely, the lowest visiting pollinator was recorded as *Formica* sp. (3.04%).

Table 1. Species and individual number of insect pollinators recorded on litchi flowers

Pollinators	Species	Observed pollinators	
		Mean	Percentage
Rock bee	*A. dorsata*	145.0 a	47.93 a
Indian bee	*A. cerena*	33.33 b	10.73 bc
Italian bee	*A. mellifera*	38.33 b	12.40 b
Ant	*Formica sp*	9.33 f	3.04 f
Wasps	*Vespa tropica*	13.33 ef	4.25 ef
Syrphid fly	*Syrphid sp*	25.33 c	8.29 cd
Robber fly	*Promachus hinei*	18.00 de	5.77 def
Blow fly	*Lucilia sericata*	23.33 cd	7.57 cde
CV (%)		10.15	14.85

Within column values followed by different letter(s) are significantly different at 5% level of probability by DMRT.

Diversity of insect pollinators visiting sweet gourd flowers: A various number of pollinators associated with sweet gourd flower were recorded (Table 2). They were belonged to 8 species and 7 different families under 2 orders (Hymenoptera and Diptera). Among the different insect pollinators, *A. dorsata* was found the dominant species visited the sweet gourd flower during the blooming season. The highest number of visitors was recorded as *A. dorsata* (65.33) but the lowest (2.33) as *Vespa tropica*. Among pollinators, the highest flower visiting insects were recorded as *A. dorsata* (49.53%) followed by *A. mellifera* (19.39%). Besides, two species of Hymenoptera (*V. tropica* 1.48%, *Formica* sp. 4.13%) and two species of Diptera (Blowfly 4.14% and Syrphid fly 2.14%) were found visited the sweet gourd flowers but they accounted in less than 5% of the overall number of observed

pollinators.

Table 2. Species and individual number of pollinator insects recorded on sweet gourd flowers

Pollinators	Species	Observed pollinators	
		Mean	Percentage
Rock bee	*A. dorsata*	65.33 a	49.53 a
Italian bee	*A. mellifera*	25.33 b	19.39 b
Bumble bee	*Bombus sp*	10.33 c	7.78 cd
Wasps	*Vespa tropica*	2.33 c	1.48 e
Ant	*Formica sp*	6.00 c	4.13de
House fly	*Musca domestica*	16.00 bc	11.41 c
Blow fly	*Lucilia sericata*	5.66 c	4.14 de
Syrphid fly	*Syrphid sp*	3.66 c	2.14 e
CV (%)		42.98	18.10

Within column values followed by different letter(s) are significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Diversity of pollinator insects in related to time and flower phenology: The richness of insect pollinator's diversity differed significantly in related to time and flower phonology in litchi and sweet gourd (Fig. 1). The species richness of insect pollinators was found the highest from 10.00h to 12.00h of the day in litchi and sweet gourd flowers. However, in sweet gourd flowers, the number of individual pollinators reached the peak at 10.00h and decreased subsequently. On the other hand, in litchi flowers, the number of individual pollinators reached the peak at 12.00h and decreased consequently.

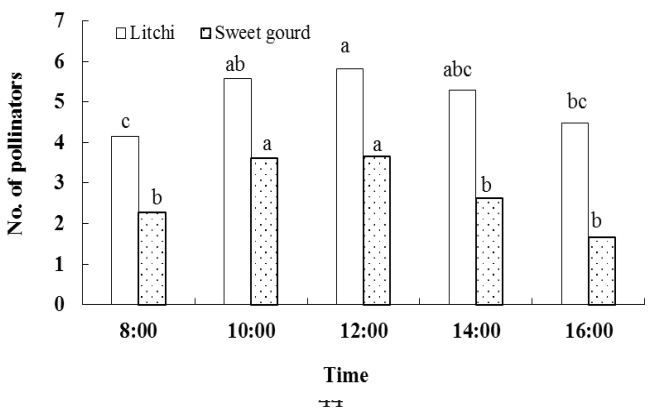


Fig. 1. Mean number of pollinators were observed on litchi and sweet gourd flowers in related to time

Contribution of pollinators to crop yield

Fruit set of litchi on pollinators' diversity: The reproductive potential of *L. chinensis* statistically differed (P<0.05, F = 108.11, df = 2) among the diversity of insect pollinators (Table 3). The number of fruits per inflorescence and fruit weight per inflorescence were higher in open-pollinated inflorescences (12.67 and 186.10g respectively) than those of net- pollinated inflorescences (4.67 and 62.66g, respectively). When the inflorescences were exposed to pollinators, the number of fruits and fruit weight per inflorescence increased by 171.31% and 197.05%, respectively.

Fruit set of sweet gourd on pollinators' diversity: Diversity of pollinator insects significantly (P<0.05, F =787.76, df = 6) affected the reproductive success of *C. moschata* (Table 3). The single fruit weight, number of seeds and seed weight per fruit were found statistically higher in open-pollinated flowers (1.68 Kg, 372.30 seeds and 74.35g, respectively) than those net-pollinated (0.56 Kg, 119.00 seeds and 23.50%, respectively). When the flowers exposed to pollinators, the single fruit weight, number of seeds and seed weight per fruit were found increased by 200.00%, 212.86% and 216.38%, respectively.

Table 3. Reproductive success of litchi and sweet gourd plants accessible by pollinators opened and netted conditions

Litchi				Sweet gourd			
Parameters	Treatment conditions		Increased yield (%)	Parameters	Treatment conditions		Increased yield (%)
	Opened	Netted			Opened	Netted	
Fruits inflorescence^{-1}	12.67 b	4.67 b	171.31	Single fruit weight (Kg)	1.68 c	0.56 c	200.00
Fruits weight inflorescence^{-1} (gm)	186.10 a	62.66 a	197.05	Seeds fruit^{-1}	372.30 a	119.00 a	212.86
-	-	-	-	Seed weight fruit^{-1} (gm)	74.35 b	23.50 b	216.38
CV (%)	23.73	9.39	-	-	8.11	5.78	-

Within column values followed by different letter(s) are significantly different at 5% level of probability by DMRT.

DISCUSSION

Litchi: The results revealed that pollinators were found on litchi flower which comprised of 8 different species belonging to 6 families of 2 different orders. Among them, Hymenoptera (78.40%) was the most visiting pollinators insect on litchi flowers followed by Diptera (21.60%). Kumar *et al*. (2013) found a total of 12 insect species belonging to the order Hymenoptera and Diptera visited the flowers during the entire blossom period of litchi in India. These findings are almost similar to the present study. In another study, Srivastava *et al*. (2017) reported 20 pollinator species under 23 genera of 8 families belonging to orders Hymenoptera, Diptera and Coleoptera were found visiting as litchi flowers in Muzaffarpur, Bihar. The increase of species may be due to environmental conditions, availability of forests etc. The present findings are in line with the findings of Abrol (2006) and Protim *et al*. (2023). They reported that honeybee species of *A. dorsata*, *A. mellifera*, *A. cerana* and *A. florea* were evident as most dominant and efficient insect pollinators of litchi and mustard flowers and represented more than 65% of the total pollinating insects. Kumar *et al*. (2013) recorded that among the total insect visitors, hymenopterans were the most dominant constituting 74.69% of the total fauna and the rest 25.21% represented by others. These findings are quite similar to the present study.

The present study revealed that fruit set of *L. chinensis* increased significantly with increasing number of pollinators. Significant difference ($P<0.05$, $F=81.10$ $df = 1$) was observed in the number of fruits per inflorescence and the fruit weight per inflorescence/panicle between open and net treatments. The number of fruits per inflorescence and the fruit weight per inflorescence increased in open-pollinated inflorescence than netted pollinated plants. The effect of insect pollination increased the number of fruits per inflorescence and the fruit weight per inflorescence/panicle up to 171.31% and 197.05%, respectively in open-pollinated inflorescences. Present study is parallel with those of Badiyala and Garg (1990). They reported that number of fruits increased as much as 100 to 190% per inflorescence while 82 to 182% increased in fruit yield in litchi due to pollination by *A. mellifera* in Himachal Pradesh. No doubt the present findings are in confirmed and established the predominant role of bees as a pollinator of litchi for higher yield.

In open-pollinated inflorescence, the number of fruits per inflorescence and the fruit weight per inflorescence increased three times as compared to netted panicles. The higher yields of *L. chinensis* in open-pollinated panicles are mostly caused by cross-pollination by insects. Population of cross-fertilizing plants contains a large number of heterozygous genes. Obviously, heterozygosity was advantageous for plants. The breeding of cross-fertilizing plants is now based on the heterosis effect (Mohr and Schopfer 1995).

Sweet gourd: The results of the present study revealed that 8 different species belonging to 7 different families comprises 2 orders visited as insect pollinator on sweet gourd. Among them, Hymenoptera (82.31%) was recorded the most abundant insect order visited sweet gourd flowers followed by Diptera (17.69%). However, honeybee (*A. dorsata, A. mellifera*) was observed as the most abundant insect that visited sweet gourd flowers. The present findings are similar to that of Vidal *et al*. (2010). They opined that honey bees are important pollinators of sweet gourd during the entire blooming season.

A significant difference ($P<0.05$, $F=787.76$ $df=6$) was observed in single fruit weight, number of seeds per fruit and seed weight per fruit between open and netted-pollinated flowers. The effect of insect pollination increased single fruit weight, number of seeds per fruit and seed weight per fruit up to 200, 212.86 and 216.38%, respectively in open-pollinated flowers. The single fruit weight, number of seeds per fruit and seed weight per fruit in open-pollinated flowers increased more than three times compared with net-pollinated flowers. These findings are similar to Stanghellini *et al*. (1997) who reported that the increasing number of bee visit resulted in higher fruit set in cucumber and watermelon. The findings are in agreement with the reports of Delaplane and Mayer (2000) who concluded that the number of pollen grains deposited on the stigma by pollinators is directly related to seed formation, which determines fruit size and yield.

CONCLUSION

Results revealed that the yield and quality of litchi and sweet gourd increased significantly by honeybees and other insect pollinators. The decline in the species diversity could pose a rigorous threat on crop pollination and fruit production.

Though it was a preliminary attempt to make a report of insect pollinators of litchi and sweet gourd it will undoubtedly help the future workers as a baseline data of pollinators in the area. Hence, pollinator's friendly cultivation practices should be practiced for the conservation and management of insect pollinators for higher production.

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