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Stingless bee *Tetragonula iridipennis* Smith for pollination of greenhouse cucumber

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Abstract

The present studies were carried out to know the activity and effect of stingless bee *Tetragonula iridipennis* in pollination of cucumber cultivated greenhouses located in Orchard, Tamil Nadu Agricultural University, Coimbatore (11.01°N 76.93°E, 427m above MSL) and Srivilliputhur (9°30'N 77°38', 137m above MSL) of southern India. Two stingless bee colonies with an approximate population of 2000 bees each were placed at the middle of experimental area of 500 m² greenhouse (treatment plot). Greenhouse without stingless bee colonies served as control. A Multistar hybrid of cucumber was chosen for treatment. Foraging activity of stingless bee in the cucumber greenhouse of TNAU orchard started at 07:00 hrs and continued up to 18:00 hrs. At Srivilliputhur, foraging activity of bees started much earlier at 06:00 hrs and continued up to 18:00 hrs. Among the foragers, the floral handling time varied between the foragers which collected nectar (7.8 ± 1.6 sec in TNAU orchard and 7.4 ± 1.7 in Srivilliputhur) and pollen (3.9 ± 0.5 sec in TNAU orchard and 3.5 ± 0.3 in Srivilliputhur). A significant increase was seen in the yield attributes such as fruit length, fruit girth, fruit weight, number of fruits per plant and yield/plant among treated and control plots. Stingless bee pollinated plots in TNAU orchard had an average fruit length of 19.1 cm compared to 17.6 cm in control while the pollinated plots in Srivilliputhur had an average fruit length of 18.8 cm compared to 17.3 cm in control. Prominent increases were also observed in the fruit girth, and yield attribute in the pollinated plots which was 11.4 cm (in pollinated) compared to 10.7 cm (in control) in TNAU orchard and 9.5 cm compared to 9.0 cm in Srivilliputhur. It is concluded that keeping stingless bees in greenhouse cucumber can improve its pollination and thus fruit weight and yield. However, additional studies with respect to the suitable microclimate inside greenhouses for stingless bees under tropical conditions are essential to utilize the bees for pollination.

Keywords: Stingless bee, Greenhouse, pollination, *Tetragonula iridipennis* and cucumber

Introduction

Most of the plants depend on the pollination services by honey bees and other pollinators, among them stingless bees play a pivotal role in pollination of many commercial crops. Utilization of pollinators especially honeybees is considered as one of the cheapest and ecofriendly approach in maximizing the yield of cross pollinated crops [1]. Numerous studies have steadily confirmed that yield levels can be improved to a range of 50 to 60 per cent in fruits and plantation crops, 45 to 50 per cent in sunflower, sesamum and niger and 100 to 150 per cent in cucurbitaceous crops, through reasonable utilization of pollinators.

In tropical conditions stingless bees (Meliponini) are vital pollinating agents of many native plant species [2]. The stingless bees are important pollinators of various food crops and can be domesticated [3]. Many species of stingless bees contribute to the pollination of commercially important crops, including the coconut, cotton and mango [4]. Modern studies reveal that stingless bees are also an effective substitute to honeybees for the pollination of many greenhouse crops of considerable economic and social importance, such as strawberries [5-7], tomatoes [8] and sweet peppers [9]. Even so, management techniques for these bees under greenhouse conditions have so far barely been investigated. Now-a-days many commercial vegetables (cucumber and tomato) and flower crops (gerbera and rose) are grown under protected cultivation such as greenhouses. Recent studies suggest that stingless bees can be promising pollinators inside the greenhouse environment [10-13]. Stingless bees are true generalists and they collect pollen and nectar from a wide range of plants [14-16]. A single species can collect floral rewards from up to 100 plant species on a yearly basis [17]. However these bees also tend to specialize on a single floral species for a certain amount of time, which is a behavioral trait commonly referred to as flower constancy [18-19]. Stingless bees have advantages over other bees as these bees lack a functional sting which help in easy

management compared to other type of honey bees and are suitable for pollination of crops that are cultivated in inhabited areas and in enclosures such as cages and greenhouses. These bees are also naturally long-lived [20] unlike *Bombus* spp., which die after reproduction. Cucurbits form a significant and vast group of vegetable crops grown widely in India. The cucurbitaceae family comprises of many species of vines with creeping growth habit viz. watermelon, pumpkin, cucumber, muskmelon, chow-chow, coccinia, bittergourd, ridgegourd, ashgourd, etc. Cucumber (*Cucumis sativus*) is the most widely grown crop in greenhouses worldwide [21] and its cultivation in greenhouses has increased in India too. Flowering phenology of cucurbits ensures better cross-pollination for higher fruit set and yield. Cucumber is a monoecious plant, as they produce male and female flowers separately on the same plant at different internodes. The flowering ratio of male to female is 15:1. As the pollen of cucumber plant is sticky and large sized, it requires an external agent for relocating the pistillate flower. Like most of the Cucurbitaceae, the production of cucumber increases when insects pollinate the crop. In case of scarcity of enough bees in the area to efficiently transfer pollen to the flower stigmas, it becomes necessary to introduce hives to attain good yields [22-25]. Most studies suggest that there is a reduction in fruit production in the absence of pollinators. Presently most of the greenhouse farmers are using parthenocarpic cucumbers inside the greenhouse as a reply to pollination failure. It is generally believed by growers that it is not advantageous to place bee colonies in greenhouses with parthenocarpic cucumber varieties. But some studies [26] suggest that there is an increase in qualitative and quantitative parameters of parthenocarpic cucumber too as a result of placing stingless bee hives inside the greenhouse. Thus, it was thought pertinent to observe the foraging activity and the usefulness of stingless bees in applied pollination of cucumber greenhouses and hence the present study was undertaken.

Materials and Methods

The present studies were carried out in greenhouses located in the Orchard, Tamil Nadu Agricultural University, Coimbatore (11.01°N 76.93°E, 427m above MSL) and a farmers holding in Srivilliputhur (9°30'N 77°38', 137m above MSL) of southern India. A multistar hybrid of cucumber was chosen for treatment, greenhouse without stingless bee colonies served as control. The following observations were recorded to find out the role of stingless bees (*Tetragonula iridipennis*) in applied pollination of cucumber greenhouses.

Foraging activity of stingless bees

Foraging activity of the stingless bee is a vital factor in order to study the effect of stingless bee pollination in green house conditions as this study provides the pivotal information on the relation between the cucumber flowers and the bees. Experiment was conducted in 500 m² greenhouse with cucumber crop at its full bloom. Observations were recorded to find out the foraging activity of the bees by counting the pollinating visits of stingless bees for ten minutes in a square meter area starting from 06:00 hrs to 19:00 hrs for every hour in a day for five days.

Floral handling of stingless bees

Floral handling time of stingless bees varies for male and female flowers. Observation of floral handling time was done at 10:00 hrs to 12:00 hrs of the day (which was perceived as

highest foraging time of the day). Observation time was 15mins for each hour from 10:00 hrs to 12:00 hrs (A total of 45mins). Time spent by the stingless bee on six flowers selected randomly were recorded. Observations for floral handling time of male and female cucumber flowers were recorded separately. Pollen collectors were differentiated based on their pollen collecting behaviour from nectar collectors and recorded separately.

Effect of bee pollination on qualitative and quantitative parameters of cucumber

Study of qualitative and quantitative parameters of the cucumber crop is an essential factor to study as these factor provide the economic fitness of stingless bees in green house. In order to study the effect of bee pollination in enhancing the productivity and quality of cucumber, the following quantitative and qualitative parameters were recorded from randomly selected twenty plants, leaving the border plants (for minimizing the error). Fruit length, fruit girth, fruit weight, number of fruits per plant and yield/plant are the characters selected for this experiment study.

Length and girth of the fruits

Length and girth of the fruit provides better consumer acceptance. For this study the observations were recorded by selecting fruits randomly from each treatment, length and girth of fruits was measured using measuring tape.

Weight of each fruit

Weight of the fruit fetches better price to the producer. The observation was made by selecting twenty plants at random during harvesting. The average fruit weight was computed by taking the total weight of all fruits.

Number of fruit in each plant

Number of fruits per plant will increase as a result of pollination as the pollination helps in reduction of flower dropping. Twenty plants were selected randomly. The number of fruits in each plant were counted and mean number of fruits per plant were calculated.

Yield per plant

Yield per plant is the definite character to know the advantage of stingless bee pollination in green house pollination. Twenty plants were randomly selected and the fruits harvested from each plant were weighed and recorded during each picking and noted the net plant yield.

Results and Discussion

Foraging activity of stingless bee

As the stingless bees are confined in greenhouses, they fed on pollen and nectar from cucumber flowers which were the only food source they got apart from the food reserves in their hive. Observations recorded on the foraging activity of stingless bees suggest that the activity of the bees inside the greenhouse of Srivilliputhur started at 6:00 hrs and continued up to 18:00 hrs. Maximum number of foragers were seen between 10:00 hrs and 12:00 hrs with a mean number of 12 and 7 bees respectively for each hour (Fig. 1). In the greenhouse located in TNAU orchard foraging activity of these stingless bees started at 7:00 hrs and continued up to 18:00 hrs with maximum number of foragers between 9:00 to 11:00 hrs. In both the greenhouses the stingless bee activity was peak in the late morning hours than in the afternoon hours probably due to the high temperature in the greenhouses

(polyhouses) compared to afternoon hours. Our studies are also in concurrence with [26] who observed that the stingless bee species introduced into the greenhouses, *Scaptotrigona* aff. *Depilis* and *Nannotrigona testaceicornis*, visited the flowers between 8:00 and 16:00 hrs, with a visitation peak between 10:00 and 13:00 hrs this visiting time to cucumber flowers was similar to our observation even though different

cucumber varieties and different species of stingless bees were used. [26] also suggested that the Africanized and Irai stingless bees began to visit flowers at approximately 7:00 hrs, and visits became more frequent between 10.00 and 12.00 hrs. In the experiment of the foraging activity it can be concluded that the stingless bees are more active in the morning hours compared to afternoon hours.

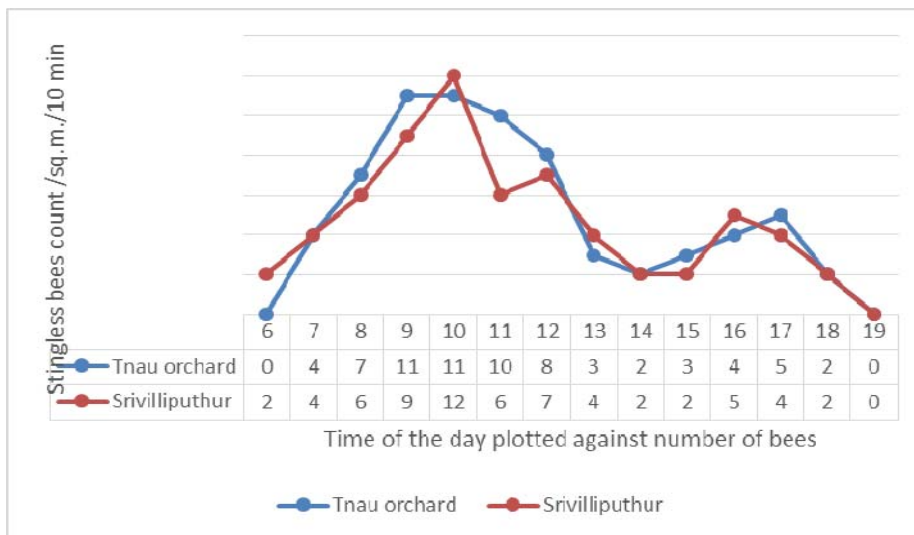


Fig 1: Foraging activity of stingless bee inside the greenhouse

Floral handling of stingless bee

Among the foragers, the floral handling time varied between the foragers which collected nectar (7.8 ± 1.6 sec in TNAU orchard and 7.4 ± 1.7 in Srivilliputhur) and pollen (3.9 ± 0.5 sec in TNAU orchard and 3.5 ± 0.3 in Srivilliputhur). Floral handling time was long in case of female flowers which produces more nectar compared to male flowers which produces pollen (Fig. 2). Our observations on floral handling

time was in agreement with Nicodemo *et al.*, 2013, who suggested that the floral handling time was long in female flowers compared to male. Result of this experiment suggests that there is a benefit in placing the stingless bee colonies in the green house as these bees have less floral handling time in male flowers: which aids in high male flower visitation rate and so contributes for betterpollination.

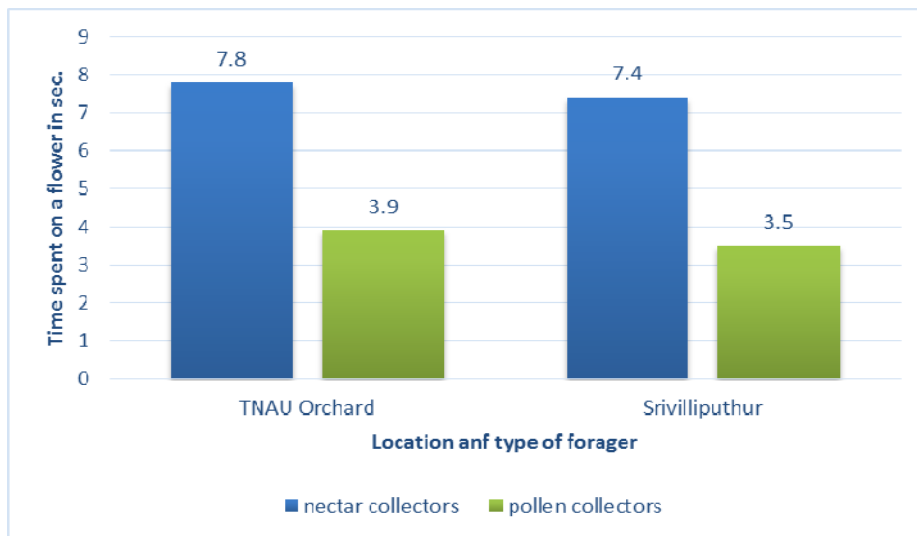


Fig 2: Floral Handling time of Stingless bee inside Greenhouse

Effect of bee pollination on qualitative and quantitative parameters of cucumber

Significant differences were seen in the yield attributes such as fruit length, fruit girth, fruit weight, number of fruits per plant and yield/plant among stingless bee pollinated and control plots in both of the experimental plots (TNAU orchard and Srivilliputhur). Stingless bee pollinated plots in TNAU

orchard had an average fruit length of 19.1 cm compared to 17.6 cm in the control (8.5% increase) while the pollinated plots in Srivilliputhur had an average fruit length of 18.8 cm compared to 17.3 cm in the control (5.7% increase). Prominent increases were also observed in fruit girth, an yield attribute in pollinated plots, which was 11.4 cm (pollinated) compared to 10.7 cm (control) in TNAU orchard and 9.5 cm compared

to 9.0 cm in Srivilliputhur (Table 1). The individual fruit weight was 119.0 g (pollinated) compared to 113.7 cm (control) in TNAU orchard and 109.9 g compared to 101.2 g in Srivilliputhur (8.6 % increase). It was also observed that there was an increase in the number of fruits in the pollinated plants compared to control. In TNAU orchard plot the number of fruits/plant was 20.6 in pollinated compared to 20.1 in the control (2.5 % increase), similarly a number of fruits / plant in Srivilliputhur experiment was higher in pollinated plot (19.3) compared to control (18.7) (Fig. 3). [27] also described that honey bees help in cucumber fruit set due to their visits to the

flowers, thus promoting pollination. [28-30] described that Africanized bees can efficiently pollinate several species of the genus *Cucurbita*. The results of the present investigation are also similar to that of [31] who reported that *S.aff. depilis* and *N. testaceicornis* effectively pollinated greenhouse cucumber in Brazil, resulting in a higher fruit production, higher fruit weight and a higher percentage of perfect fruits compared to the control, where no pollinators were present. [31] also reported that good pollination results in uniform and better fruits in cucumbers.

Table 1: Effect of pollination by stingless bees on the yield and yield attributes of cucumber

| Parameter | TNAU Orchard | | percent increase | CD 0.05 | Srivilliputhur | | Per cent increase over control | CD (0.05) |
|------------------------|--------------|--------------------------|------------------|---------|----------------|--------------------------|--------------------------------|-----------|
| | Control | Stingless bee Pollinated | | | Control | Stingless bee Pollinated | | |
| Fruit length (cm) | 17.6 | 19.1 | 8.5 | 1.2 | 17.3 | 18.8 | 5.7 | 1.1 |
| Fruit girth (cm) | 10.7 | 11.4 | 6.5 | 0.6 | 9.0 | 9.5 | 5.6 | 0.4 |
| Fruit weight (g) | 113.7 | 119.0 | 4.7 | 5.1 | 101.2 | 109.9 | 8.6 | 5.6 |
| No of fruits/ plant | 20.1 | 20.6 | 2.5 | 0.3 | 18.7 | 19.3 | 3.2 | 0.4 |
| Fruit yield (Kg/plant) | 2.8 | 3.07 | 9.6 | 0.2 | 2.6 | 2.9 | 11.5 | 0.1 |

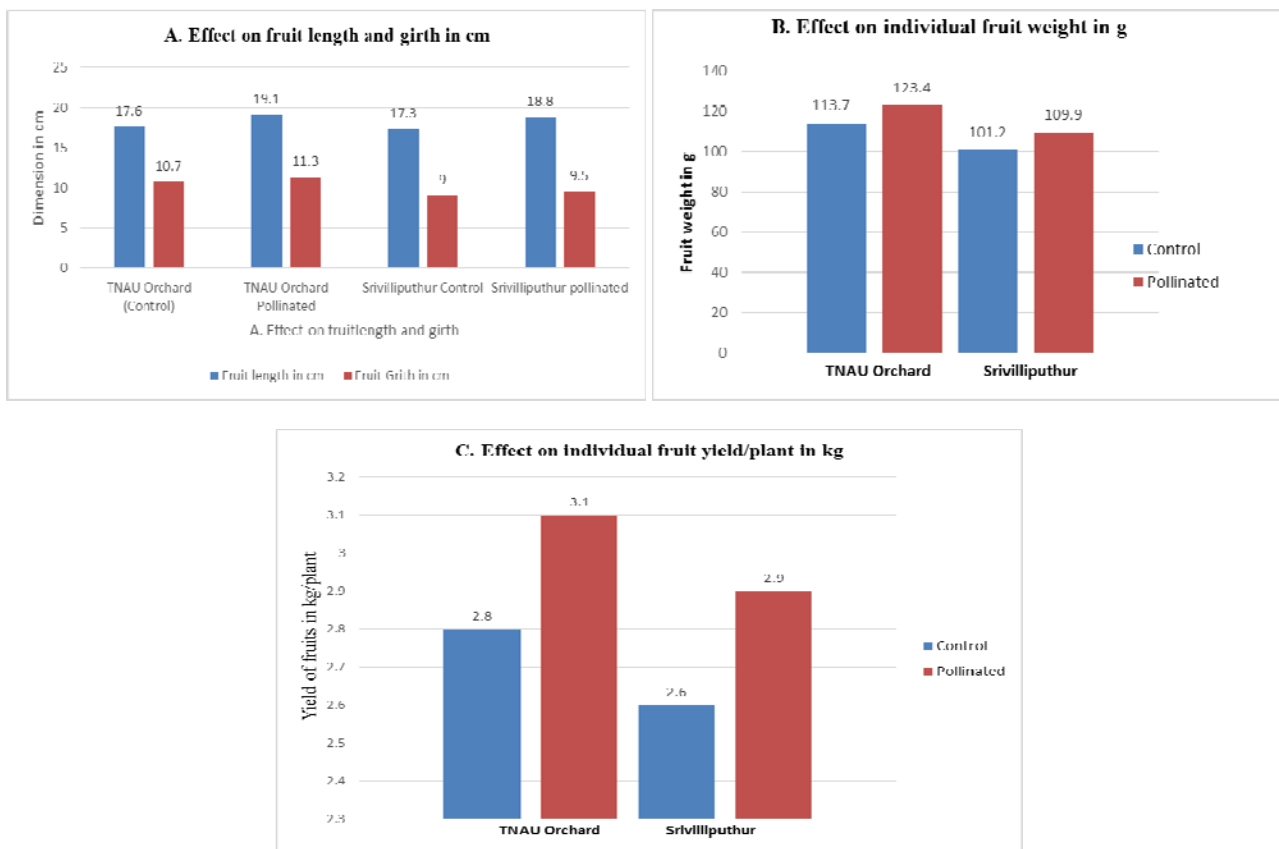


Fig 3: Effect of bee pollination on qualitative and quantitative parameters of cucumber

Conclusion

Stingless bees plays a prominent role in pollination of greenhouse cucumber crop. It was also observed that the yield and marketing value of the cucumber crop had increased as a result of the betterment of qualitative and quantitate yield parameters of cucumber crop.

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