**Assessment of *Apis mellifera* and other Insect Pollinators in Augmenting Seed Yield of Onion (*Allium cepa*. L).**

**Abstract**

To identify the pollinator community of insects and its role in onion (*Allium cepa* L.) pollination, an investigation was carried out at the vegetable research field of SKUAST-K, Shalimar at two hourly basis from 8:00hr-18:00 hr in the bloom period of crop during the year 2021-2022. The observations on diversity of pollinators showed that large number of insect pollinators were found visiting onion bloom. The insect pollinators were found active during the blooming period, however the foraging activity differs significantly at different time intervals of the day, that too among the different insect pollinators. It was also concluded that the insect visitors may not necessarily be the potential pollinators as well. Out of seven insect species visiting onion bloom Hymenopterans (*Apis mellifera, Apis cerana* and *Vespa spp*) were the main visitors, but the foraging activity of Syrphids was highest, followed by *Apis mellifera*, *Apis cerana* and others. The highest foraging activity of syrphids (6.88) was observed at 1000-1200 hr followed by (5.72) at 1200-1400 hr, whereas, in case of *Apis mellifera* highest foraging activity (4.86) was observed at 1200-1400hr followed by (4.30) at 1000-1200 hr. The impact of managed pollination on the yield and quality of onion seeds was assessed by using four treatments: plants enclosed in nets without pollinators (T1), plants enclosed with honey bees (Apis mellifera) as the sole pollinator (T2), plants enclosed with syrphids as the sole pollinators (T3), and plants exposed to all pollinators (T4). The number of umbels produced per plant was not influenced by pollination. However, both honey bee pollination and open pollination resulted in 232.14 seeds/umble and 227.60 seeds/umble and 3.95 and 3.87 as 1000 seed weight/gm respectively, and seed yield of 568.22 and 590.98 kg/ha honey bee as pollinator and open pollination conditions, respectively. Pollination by honeybees showed better performance followed by open pollination and least performance in the yield and yield attributing parameters were observed in pollination exclusion treatment*.*

**Key words**: ***Allium cepa* L., pollination effectiveness, pollinators, seed setting, yield.**

**Introduction**

Onion (*Allium cepa* L.) is an extremely important vegetable crop, and its seed is a source of condiments (Baswana, 1984). Globally, among vegetable crops, Onion ranks second in terms of area , following tomato, with global production reaching around 36 million tons from 2.5 million hectares. India is the second-largest onion producer globally, after China, accounting for 19.90% of the total world production. However, the productivity of onions in India remains low, at 16.29 tons per hectare, primarily due to the limited availability of high-quality seeds. In India, approximately 187.36 lakh metric tons of onions are grown across an area of 11.50 lakh hectares. Major onion-producing states in India include Maharashtra, Gujarat, Orissa, Karnataka, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Bihar, Punjab, Rajasthan, and Jammu and Kashmir. Maharashtra leads the production, contributing 33%, followed by Karnataka with 17% and Gujarat with 10% of the country's production. Onion umbels are visited by honey bees, small syrphid flies, bumble bees, halictid bees, drone flies, butterflies and insects of minor importance with respect to pollination (Sajjad *et al*., 2008). Honeybees are key pollinators for the majority of angiosperm plants globally. They contribute to pollination in one or more cultivars of approximately 66% of the 1,500 crop species worldwide, accounting for 15–30% of global food production. Around 80% of insect-mediated crop pollination is performed by honeybees (Ollerton *et al*., 2021). The European or western honeybee, Apis mellifera L. (Hymenoptera: Apidae), is the most widely managed pollinator globally. Onion, a biennial crop, requires two seasons for seed production—bulbs are grown from seeds in the first season and then replanted to produce seeds in the second season. Poor pollination of onion flowers leads to smaller, deformed seeds with low germination rates (McGregor, 1976). Inadequate pollination also hampers onion hybrid seed production, resulting in lower seed quality (Free, 1993). Factors such as prolonged pesticide use and habitat degradation contribute to the decline in natural insect pollinator populations (Saeed *et al*., 2008).The seed industry and onion growers are increasingly facing economic losses due to low seed yields in commercial onion fields. This issue arises because onion flowers cannot self-pollinate due to protandry (Lema, 1998), making cross-pollination essential (Muller, 1883). The rate of out-crossing can range from 8% to 71% depending on various conditions (Van Der Meer and Bennken, 1972). As per Banik (1990), wind pollination has a limited role (10%) in onions due to their sticky pollen, while other pollinators contribute about 3%, and honeybees are responsible for 87% of onion pollination. Onion is predominantly a cross-pollinated crop. Its flowers serve as an excellent source of nectar and pollen, which significantly influence the behavior of pollinators based on their requirements (Abrol, 1990). The lack of natural pollinators on onion seed plantations presents a major challenge for breeders worldwide. Honeybees are considered efficient pollinators for onion crops due to the ample availability of both pollen and nectar from the plants (McGregor, 1976). This highlights the importance of ensuring effective pollination by insect pollinators, particularly honeybees, to maintain or enhance onion productivity. It also emphasizes the potential of utilizing insect pollinators to boost crop yields. With this perspective, the present study was designed to identify and evaluate the efficiency of insect pollinators in onion pollination and to assess the role of managed pollinators under different treatments in improving seed yield and germination rates of onion plants

Since no work has been done on insect pollinators of onion crop and their effects on the yield attributes of onion, the study pertinent to the current topic was taken in account in field of Vegetable science SKUAST-K, Shalimar.

**Materials and methods:**

**Collection and Identification of insect visitors/pollinators visiting onion bloom**

The insects visiting the flowers/umbles were collected with the help of hand sweeping nets from the onion crop during the year 2021-2022 grown in the vegetable field of SKUAST-K, Shalimar (with geometric coordinates as 34.1453º N and 74.8780º E). Four sweeps of the hand net were made at two hourly intervals starting from 08.00 hr- 18.00 hr at weekly basis. For every sweep the contents of the nets were kept separate and were sorted properly in the laboratory for identification.

**Abundance and foraging activity of insect pollinators on onion bloom.**

The foraging behavior including foraging speed (time spent in seconds/umble) of insect pollinators on flowers for collecting pollen or nectar and foraging rate (no. of foragers/flower/ minute) were observed during bloom period. Besides the foraging activity was also recorded by the given formula (1). The observations were recorded on randomly selected five plants, irrespective of the sex of the flower from 08.00 to 18.00 hr at two hourly intervals for 5 min. and were expressed as the mean number of foragers per flower per 5 min.

**No. of individuals of a given species visiting the flower x100**

**Relative abundance = ……(1)**

**Total number of insects visiting flowers**

**Effect of pollination on onion seed yield and yield attributing parameters**

The study was based on four different treatments viz., pollination by honey bees, pollination by syrphids, open pollination and pollination exclusion as T1, T2, T3 and T4 respectively. In T1, the plot was enclosed within a large net measuring 14m × 6m × 4m. Inside the net, two 7-frame colonies of A. mellifera, each with an adequate supply of stored food, were introduced when approximately 5% of the plants began to bloom. The bee colonies were supplemented with sugar syrup as additional feeding, and water was provided throughout the flowering period. Once flowering was complete, the nets and honeybee colonies were removed to ensure consistent post-pollination conditions across all treatments.In T2 the syrphids were collected prior from the open pollination fields and were released inside the net to ensure no pollinator other than syrphids in the given plot. In T3pollinating insects irrespective of the type were allowed to visit the flowers with no net barriers provided. In T4, 1m2 area in each replication was covered by mosquito nets measuring 1m X 1m X 2m before the opening of ray florets to prevent the entry of pollinators. To ensure absence of pollinators within these nets, these were further sprayed with Fipronil 5% SC @ 0.01% along with the entire crop. This treatment also helped in controlling onion thrips.

**Results and discussion:**

1. **Collection and identification of insect pollinators of onion crop**

The insect visitors/pollinators were collected with the help of hand sweeping nets from the onion crop during the year 2021-2022 grown in the vegetable field of SKUAST-K,Shalimar at two hourly basis from 8:00hr-18:00 hr during the bloom period of crop. The insects collected were identified and seven different species of insect visitors were observed on the crop namely: *Apis mellifera* (L), *A. cerana* Fab, *Pieris* spp., *Coccinella* sp., Syrphid flies, *Vespa* spp, and *Lasioglosum* spp. during the study period. Number of insect visitors/ pollinators collected during bloom period, were 225 out of which the most abundant was the order Hymenoptera (48.97%), followed by order Lepidoptera (18.03%), Diptera (15.25%), Coleoptera(10.5%) and others (7.25%)(Fig. 1 and Table 1).Similar type of study was conducted by Devi *et al*. (2014) and reported twenty five species of insects visiting onion crop during bloom period of which fifteen species belong to order Hymenoptera, five species to Lepidoptera, three species to Diptera and two species to Coleoptera. Moreover, Birader *et al*. (2017) reported that onion crop was visited by fifteen species of insects/pollinators and among them Hymenopterans were most abundant followed by Lepidoptera, Diptera, Coleoptera and Hemiptera. Three *Apis* species viz., *Apis dorsata*, *A. cerana* and *A. mellifera* were recorded as top workers on onion as pollen and nectar gatherers. Karuppaiah *et al.* (2018) also documented 11 species of insect/pollinators on onion bloom. Among these visitors Hymenopterans were the most abundant and Dipterans were in relatively smaller numbers. Among the bees *A. dorsata*, *A. mellifera*, *A*. *cercana*, *A. florea* and *Tetragonula* species were the most frequent pollen and nectar foragers. Moreover, Hosamani *et al* (2019) reported Hymenopterans contributed 87.79 per cent (83.55 pollinators), followed by Dipterans 8.62 per cent (8.20 pollinators), Lepidopterans 1.91 per cent (1.82 pollinators) and others 1.66 per cent (1.59 pollinators during their study time.

Table 1: List of insect visitors/ pollinators on onion (*Allium cepa* L.) bloom:

|  |  |  |  |
| --- | --- | --- | --- |
| S.No. | Insect (Scientific name) | Family | Order |
| 1 | *Apis mellifera* L | Apidae | Hymenoptera |
| 2 | *Apis cerana* Fab. | Apidae | Hymenoptera |
| 3 | *Pieris* spp. | Pieridae | Lepidoptera |
| 4 | *Coccinella*sp. | Coccinellidae | Coleoptera |
| 5 | Syrphid flies | Syrphidae | Diptera |
| 6 | Vespa spp. | Vespidae | Hymenoptera |
| 7 | *Lasioglosum* spp. | Halictidae | Hymenoptera |

|  |  |
| --- | --- |
|  |  |
| Fig.1 Percent share of different insect visitors on onion crop | Fig.2 Effect of different treatments on yield attributing parameters of onion crop. |

**2. To study the abundance and foraging activity of insect pollinators on onion**.

Among the insect pollinators visiting onion bloom, the syrphids were found visiting the onion bloom more frequently, followed by *Apis mellifera, Apis cerana* and others. The highest foraging activity of syrphids (6.88) was observed at 1000-1200 hr followed by (5.72) at 1200-1400hr, whereas, in case of *Apis mellifera* highest foraging activity (4.86) was observed at 1200-1400hr followed by (4.30) at 1000-1200hr as shown in the Table 2 data set. A similar study conducted by Karuppaiah *et al*. (2018) identified eleven insect species, including Apis florea, A. cerana, A. dorsata, A. mellifera, Tetragonula sp., Xylocopa sp., Vespa sp., Pieris rapae, Danais chrysippus, Eristalis sp., and Musca domestica. Among these, 98% of the foraging visits were made by hymenopterans, with the majority occurring between 1330 and 1430 hr. The population index revealed A. dorsata as the dominant species. Foraging behavior analysis showed that A. cerana exhibited the highest foraging rate (3.17 umbels/min), followed by A. dorsata (3.0 umbels/min), while A. florea had the lowest rate (2.0 umbels/min). In terms of time spent per flower, Tetragonula sp. spent the most time (27.50 sec/umbel), followed by A. florea (18.83 sec/umbel) and A. dorsata (17.83 sec/umbel), with A. cerana spending the least amount of time*.* Similarly Devi *et al*.(2014) reported Hymenopterans to be the most abundant (60%) followed by Lepidoptera, Diptera and Coleoptera during their study.

**Table 2: Foraging activity of different insect pollinators visiting onion bloom at different timings of a day**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time (hr) | Mean number of insects collected per four sweeps per five minutes | | | |
| Syrphid flies | *Apis mellifera* | *Apis cerana* | Others |
| 0800-1000 | 4.32 | 3.86 | 1.84 | 1.82 |
| 1000-1200 | 6.88 | 4.30 | 2.88 | 1.62 |
| 1200-1400 | 5.72 | 4.86 | 3.54 | 1.70 |
| 1400-1600 | 5.00 | 3.70 | 3.42 | 2.38 |
| 1600-1800 | 4.28 | 3.56 | 2.86 | 1.82 |
| Mean | 5.24 | 4.05 | 2.90 | 1.86 |

**P=0.05**

**Table 3: Effect of pollination on yield and yield attributing parameters of onion**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Parameter | | | |
| No, of umbles/ sq m | Average no. of seeds / umble | 1000 seed weight / (gm) | Seed yield  Kg/ha |
| With Honey bee as pollinator (T1) | 47.43 | 232.14 | 3.95 | 568.22 |
| With Syrphidsas pollinator(T2) | 46.14 | 200,17 | 3.23 | 457.72 |
| Open pollination (T3) | 46.44 | 227.60 | 3.87 | 590.98 |
| Pollination exclusion(T4) | 47.14 | 6.39 | 1.97 | 16.78 |

Observations for the quantitative characters viz no. of umbels /plant, no. of seeds/umbel, 1000 seed weight (gms) and seed yield (kg/ha), under different treatments were recorded. The data presented in Table 3 and Figure 2 indicate that the number of umbels produced per plant in the pollination exclusion treatment, honey bee pollinated, syrphid pollinated, and open pollinated crops, as well as those without pollinators, was 47.43, 46.14, 46.44, and 47.14, respectively. This suggests that pollination did not significantly affect the number of umbels produced. However, the number of seeds per umbel was considerably higher in honey bee and open-pollinated fields, with values of 232.14, 227.60, and 200.17, respectively, compared to just 6.39 in the pollination exclusion treatment. These findings are consistent with the results reported by Padamshali and Mandal (2018), where the number of seeds per umbel was also much higher in honey bee and open pollinated fields (802.21 and 851.29, respectively) compared to the pollination exclusion treatment (18.72). The seed production in open pollination was statistically similar to that in honey bee pollination. Chandel *et al.* (2004) found that induced bee pollination resulted in a 2.5-fold increase in seed yield, with an average of 971 seeds per umbel, compared to 406 seeds in the control group. Yucel and Duman (2005) reported that seed yield per bulb was significantly higher in open field plots (5.74 g/flower) compared to 1.29 g/flower in caged plots. Woyke (1981) noted that the number and weight of onion seeds from self-pollination were much lower than those produced in open fields with honeybee colonies

**Table 4: (Foraging behavior) foraging rate and foraging speed of different insect pollinators on onion**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Day hours  (hrs) | Foraging speed (time spent in seconds/ umble/ minute) | | | | Day hours  (hrs) | Foraging rate (no. of foragers/ flower/ minute) | | | |
| *Apis mellifera* | *Apis cerana* | *Syrphid* | *Mean* | *Apis mellifera* | *Apis cerana* | *Syrphid* | *Mean* |
| 1000 | 12.90 | 10.87 | 9.17 | 11.01 | 1000 | 1.47 | 1.60 | 1.39 | 1.68 |
| 1200 | 13.41 | 11.08 | 9.12 | 11.20 | 1200 | 1.01 | 1.39 | 1.98 | 1.26 |
| 1400 | 12.99 | 10.90 | 10.10 | 11.3 | 1400 | 1.60 | 1.85 | 1.91 | 1.78 |
| 1600 | 9.78 | 8.80 | 8.16 | 8.91 | 1600 | 0.85 | 1.06 | 1.00 | 0.97 |
| 1800 | 7.65 | 6.78 | 6.76 | 7.06 | 1800 | 0.68 | 0.97 | 0.95 | 0.86 |
| *Mean* | 11.34 | 9.68 | 8.66 | 9.89 | *Mean* | 1.12 | 1.37 | 1.44 | 1.31 |

1. **Foraging behaviour of insect pollinators of onion**

The foraging speed varies among the different foragers and also at different intervals as describe in (Table 4). It was recorded highest for the *A. mellifera* as (13.41%) at 1200hr followed by (12.99%) at 1400h, followed by *A. cerana* (11.08%) and (10.90%) at the 1200hr and 1400hr respectively. The foraging speed of syrphids was recorded as lowest of all at all the intervals. However the time interval had the similar effect on the foraging activity of all the insect pollinators under observation. The study was conclude that the foraging speed is directly proportional to the size of insect, as the honeybees being with intense hairs and larger body size than syrphids, allows them to spent relatively larger duration on the umble resulting in higher foraging/ effective pollination services as compared to that of the syrphids. On the other hand the foraging rate was observed to be highest for the syrphids (1.98%) followed by (1.91%) at 1200hr and 1400hr respectively and that of *A. cerana* (1.85%) and (1.60%) at 1200hr and 1400hr respectively. *A. mellifera* showed the lowest foraging rate among all the insect pollinators. The foraging rate is directly correlated with the body size which determines the frequency of visitation per umble by a particular insect species at the given interval under observation. Syrphids being minute in size as compared to the honeybees showed higher foraging rates than honeybees.

The current study find the support from the findings of (Padamshali and Mandal, 2018) who reported the significant increase in the yield attributes of onion under different managed pollination treatments. The results of analysis showed that onion seed yields, analytical purity, thousand seed weight, germination percentage, seedlings length (shoot and root), seedling dry weight, seedling vigor index-I and II were significantly affected by main effects of treatments and their interactions. Mean seed yield of variety produced with honeybee pollination methods showed highly significant results. Similar studies indicated that under honeybee pollinated field the increase in seed production ranged from 175 (Deodikar and Suryanaryana, 1972) to 1000 percent (Singh and Dharamwal, 1970).

**Conclusion**

On the onion bloom seven species of insects were observed and identified. Out of seven insect species visiting onion bloom Hymenopterans (*Apis mellifera, Apis cerana and Vespa* spp) were the main visitors, but the foraging activity of Syrphids was highest, followed by *Apis mellifera, Apis cerana* and others.The observations on diversity of pollinators showed that large number of insect pollinators were found visiting onion bloom. The insect pollinators were found active during the blooming period however the foraging activity differs significantly at different time intervals of the day, that too among the different insect pollinators. It was also concluded that the insect visitors may not necessarily be the potential pollinators as well. The effect of different treatments on the yield attributing parameters of onion crop showed the significant results for different yield attributing characters, for the treatment honey bee as pollinators followed by the open pollination treatment. However, pollination exclusion showed poor results for all the parameters under study.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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