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Diversity of Pollinators in Onion, *Allium Cepa* L

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ABSTRACT: The present study was carried out at Vegetable Seed Production Farm and Seed Science Farm of CSKHPKV, Palampur District Kangra, Himachal Pradesh, India, during the year 2023-2024. Diversity and abundance of insects was studied at different time intervals. The major orders of insects that included floral visitors were Hymenoptera, Diptera, Lepidoptera, Coleoptera and Hemiptera. Among all the visitors, *Apis cerana* (35.25) was in the highest numbers among all species of insect visitors/m²/5 minutes sweepings, followed by *Eristalis tenax* (13.75) and eight insect species were found least (0.25). Among different hours of the day, highest number of visitors (4.83) were found at 1000h whereas lowest (2.83) were found at 1600h under unsprayed conditions. In unsprayed conditions, the species richness (29), Shannon-Wiener Index (H') (2.41) and Simpson Dominance Index (6.89) were recorded higher as compared to insecticidal sprayed conditions (18, 2.11 and 6.25) respectively. By continuous spray of pesticides, a decline in availability of floral visitors was observed resulting in adverse effect on ecosystem functioning and biodiversity conservation.

I. INTRODUCTION

Pollinators are in threat because of rising temperatures, increased carbon-dioxide, climatic changes, diseases, habitat loss, disturbed ecosystem functioning and other pesticide usage [4]. In many cross-pollinated crops, insect pollination plays a major role in the hybrid seed production e.g. onion (*Allium cepa* L) [16]. For the global food production, animal pollinators contribute nearly 15-30% [21]. Onion flowers are known for its protandrous nature as the pollen is going to shed within 2-3 days before the stigma becomes receptive in nature [13] and the availability of sticky pollen, also effects the self-pollination within a flower and thus pollination occurring through insects produces high quality seeds [9].

The pollinator species diversity and its composition may change with latitude, geographical area and time [18]. In several areas of India, syrphids such as *Episyrphus balteatus*, *Metasyrphus conferator*, *M. corollae* etc. are important contributors in the pollination process along with the most effective honeybee species viz., *Apis dorsata* and *A. florea* [3]. Keeping in view the importance of pollinators on onion crop, the present studies were undertaken with the objective of studying their diversity and abundance.

II. MATERIAL AND METHODS

The present study entitled "Diversity of pollinators in onion, *Allium cepa* L." was carried out at Vegetable Research farm and Seed Science farm of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, under Department of Entomology, Palampur, District Kangra, Himachal Pradesh, India during rabi-summer of 2023-2024.

1. The diversity of insects visiting onion flowers during the flowering period were assessed by keeping the experimental plot free from the sprays in Vegetable farm whereas crop in Seed Science farm was sprayed with pesticides like cypermethrin, acetamiprid and fungicides like azoxystrobin during pre-flowering period (7 days before flowering and 7 days after flowering) in this trial. The pollinators visiting the crop were collected using insect collection nets. Sweeping was carried out throughout the flowering period at two days interval from 10AM to 4PM of the day at two hourly intervals for 5 minutes.

Abundance of different insect visitors/pollinators on onion crop was studied during the flowering period. The method used to work out the relative abundance of number of different pollinators was as per [5].

$$\text{Relative abundance (\%)} = \frac{\text{Population of a specific species visiting flowers}}{\text{Total population of all species visiting flowers}} \times 100$$

2. The survey data were subjected to various diversity indices to estimate the pollinator species abundance and diversity. In the present study, species richness, Simpson’s diversity index (D) and Shannon-Wiener diversity index (H’) were calculated. The details of the analysis are given in the following sections.

Species richness (S) represents the total number of pollinator species present in an area. It was calculated by adding up the number of different species present in a particular area.

Simpson’s diversity index (D) calculates the probability of obtaining the same species from randomly taken two samples from a set of individuals belonging to the same community [27]. Simpson’s diversity index (1949) is calculated by using the following formula. The dominance index is 1/D.

$$D = \frac{\sum ni(ni-1)}{N(N-1)} \quad \text{Where,}$$

D = Simpson’s Diversity index N= Total number of individuals in a particular species
 Σ= Summation N= Total number of individuals in the sample including all the species

The Shannon - Wiener index (H’) was calculated to know the species diversity in a community. It considers the number of species and evenness of their occurrence in a community [25]. The higher the index value represents more species diversity and the lower the value represents less diversity. This index is calculated with the following formula.

$$H = \sum \left(\frac{ni}{N} \cdot \ln \left(\frac{ni}{N} \right) \right) \quad \text{Where,}$$

H= Shannon-Wiener Index ln= Natural logarithm Σ= Summation
 N= Number of all individuals ni= Number of individuals in species

III. RESULTS AND DISCUSSION

1. Relative abundance of insect visitors during flowering (without insecticidal spray)

Abundance of different insect visitors on onion crop was studied during the flowering period during different hours of the day on onion blooms and the data are presented in table 1. A cursory look at the table indicates that there was a significant interaction between insect pollinators and different time intervals (day hours). Mean relative abundance based on insects caught through sweepings at different time intervals was the highest at 1000h (4.83), which is at par with 1200h (4.31). The corresponding figures for 1400h and 1600 h were 3.45 and 2.83 respectively with significant difference in population. Irrespective of the time intervals, the mean relative abundance of *Apis cerana* (35.25) with 31.54% as depicted in Fig 1 was significantly higher than other insect visitors followed by *Eristalis tenax* (13.75) with 12.33% followed by *Calliphora* spp. (11.75) with 10.51% followed by *Episyrphus balteatus* (10.75) with 9.62% followed by *S. scripta* (7.00) with 6.27%, *Apis dorsata* (6.50) with 5.82% followed by *Eristalinus taeniops* (3.75) with 3.35% followed by *Eupeodes corollae* (3.50) with 3.14% followed by *Syrirta* spp. (3.25) with 2.91% where both were at par with no significant difference followed by *Musca* spp. (2.75) with 2.46%, *Episyrphus* spp. (2.25) with 2.01%, *Pieris brassicae* (1.25) with 1.12%, *Halictus* spp. (1.00) with 0.89% and *Polistes* spp. (0.75) with 0.67%. Among the insect orders, Diptera (55.96%) were the highest in relative abundance with more species followed by Hymenoptera (40.26%), Lepidoptera (2.44%), Coleoptera (0.89) and Hemiptera (0.45%) recorded the least.

Table 1: Relative abundance of insect visitors during flowering (without insecticidal spray)

No. of insect visitors/m ² /5 min sweepings						
Day hours \ Insect visitors	1000	1200	1400	1600	Mean	Order %
<i>Apis cerana</i>	52.00 (7.28)	38.00 (6.24)	29.00 (5.45)	22.00 (4.78)	35.25 (5.94)	Hymenoptera (40.26)

<i>Apis dorsata</i>	8.00 (2.99)	8.00 (2.97)	5.00 (2.39)	5.00 (2.34)	6.50 (2.67)	
<i>Apis mellifera</i>	1.00 (1.38)	1.00 (1.41)	0.00 (1.00)	0.00 (1.00)	0.50 (1.11)	
<i>Bombus haemorrhoidalis</i>	0.00 (1.00)	1.00 (1.41)	1.00 (1.41)	0.00 (1.00)	0.50 (1.21)	
<i>Halictus</i> spp.	2.00 (1.66)	1.00 (1.41)	1.00 (1.41)	0.00 (1.00)	1.00 (1.37)	
<i>Xylocopa</i> spp.	0.00 (1.00)	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.25 (1.10)	
<i>Delta</i> spp.	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Polistes</i> spp.	0.00 (1.00)	1.00 (1.41)	1.00 (1.17)	1.00 (1.00)	0.75 (1.30)	
<i>Eristalis arbustorum</i>	2.00 (1.72)	3.00 (2.00)	2.00 (1.73)	1.00 (1.38)	2.00 (1.71)	Diptera (55.96)
<i>Episyrphus balteatus</i>	16.00 (4.12)	11.00 (3.46)	9.00 (3.14)	7.00 (2.81)	10.75 (3.38)	
<i>Episyrphus</i> spp.	2.00 (1.72)	3.00 (2.00)	2.00 (1.73)	2.00 (1.66)	2.25 (1.77)	
<i>Eristalinus taeniops</i>	4.00 (2.16)	2.00 (1.72)	5.00 (2.34)	4.00 (2.23)	3.75 (2.11)	
<i>Eristalis tenax</i>	20.00 (4.58)	13.00 (3.74)	12.00 (3.58)	10.00 (3.31)	13.75 (3.80)	
<i>Eristalis</i> spp.	2.00 (1.73)	1.00 (1.38)	1.00 (1.41)	1.00 (1.38)	1.25 (1.48)	
<i>Eupeodes corollae</i>	4.00 (2.17)	5.00 (2.43)	3.00 (1.99)	2.00 (1.72)	3.50 (2.08)	
<i>Sphaerophoria scripta</i>	8.00 (2.95)	10.00 (3.31)	6.00 (2.51)	4.00 (2.21)	7.00 (2.74)	
<i>Syrirta</i> spp.	3.00 (1.96)	5.00 (2.43)	4.00 (2.21)	1.00 (1.38)	3.25 (1.99)	
<i>Calliphora</i> spp.	11.00 (3.45)	12.00 (3.59)	10.00 (3.26)	14.00 (3.85)	11.75 (3.54)	
<i>Musca</i> spp.	3.00 (1.93)	3.00 (1.93)	2.00 (1.72)	3.00 (1.88)	2.75 (1.87)	
<i>Tachina</i> spp.	0.00 (1.00)	1.00 (1.41)	1.00 (1.41)	0.00 (1.00)	0.50 (1.21)	
<i>Danaus chrysippus</i>	0.00 (1.00)	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.25 (1.10)	Lepidoptera (2.44)
<i>Aglais urticae</i>	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	1.00 (1.38)	0.25 (1.10)	
<i>Parnara bada</i>	0.00 (1.00)	0.00 (1.00)	1.00 (1.41)	0.00 (1.00)	0.25 (1.10)	
<i>Pieris brassicae</i>	1.00 (1.41)	1.00 (1.33)	1.00 (1.41)	2.00 (1.66)	1.25 (1.45)	
<i>Spindasis</i> spp.	0.00 (1.00)	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.25 (1.10)	
<i>Vanessa cardui</i>	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Ypthima</i> spp.	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Coccinella septempunctata</i>	1.00 (1.41)	1.00 (1.41)	1.00 (1.41)	1.00 (1.41)	1.00 (1.41)	Coleoptera (0.89)
<i>Nezara hilaris</i>	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	1.00 (1.41)	0.50 (1.20)	Hemiptera (0.45)
Mean	4.83 (1.95)	4.31 (1.99)	3.45 (1.84)	2.83 (1.70)		

The present findings are in agreement with the study conducted by [22] who found Diptera (87%) and Hymenoptera (13%) and the community of pollinators comprising of four bee species (*Apis dorsata*, *Apis florea*, *Xylocopa* spp. and *Nomia* spp.) with twelve true flies including *Episyrphus balteatus*, *Eupeodes* spp., *Sphaerophoria scripta*, *Eristalinus arvorum*, *Calliphoridae* spp. and *Musca domestica* etc. Also, [19] revealed that Indian bee (*A.indica*) was the most efficient and abundant pollinator of onion flowers in the Himalayas of Uttarakhad, India and our results were also corroborated by [7] where the honey bees were reported more abundant than other floral visitors on onion flowers. Results of the present findings also find support from [24] who documented that syrphid flies were observed at all timings followed by *A. mellifera* followed by hornets. It was also the insect pollinator complex and their role in pollination efficiency in Pakistan was studied [23]. The results revealed that the pollinator community comprised mainly of two hymenopteran bees and eight dipteran flies. Among bees, *A. dorsata* was found to be an abundant pollinator which is in contrast to our results that *A. cerana* was abundant. Similarly, [6] found that among the pollinators, Hymenoptera (60%) was highest followed by Lepidoptera, Diptera and Coleoptera. Of all identified floral visitors, *A. florea* was the dominant constituting 62% of total pollinators followed by *A. dorsata* (28%) and *Trigona* sp. (4.5%). Similarly, *A. florea* was considered as most significant pollinator on crop [2]. Four groups of pollinators were identified, Hymenoptera was most significant order constituting 90.15%, followed by Diptera with 6.63%, Lepidoptera with 1.70% and others 1.52%. [11]. In this study other honey bee species were not very high except *A. cerana*, when compared to syrphid flies. This could be feasible as that onions are not favorites of honey bees because

onion nectar is high in potassium and as temperature increases nectar viscosity increases, so bees prefer to forage on alternate nectar sources if available [28]. Presence of wall hive of *A. cerana* near experimental field was the reason for high population this bee species in the present studies.

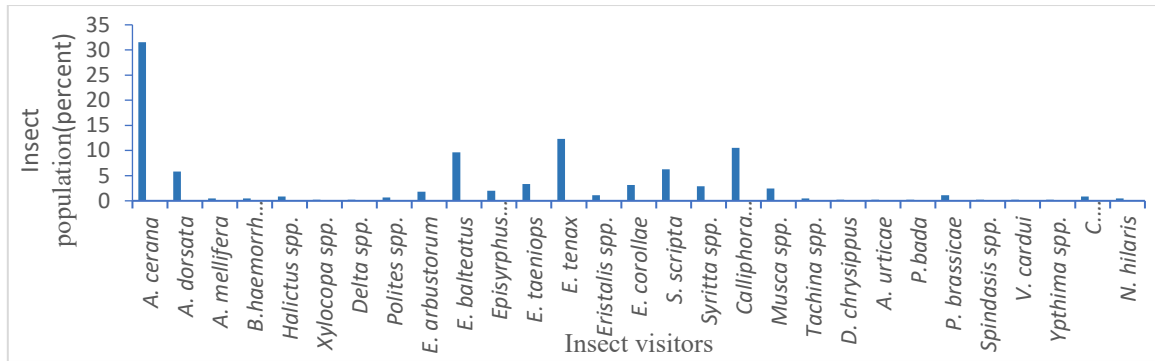


Figure.1. Relative abundance of individual insect visitor (without insecticidal spray)

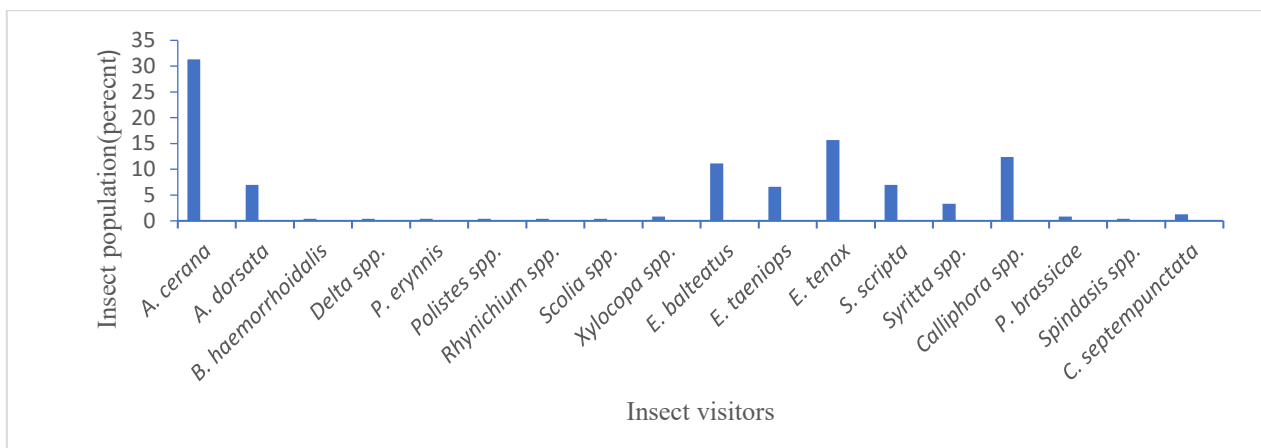


Figure. 2. Relative abundance of individual insect visitor (with insecticidal spray)

2. Relative abundance of insect visitors during flowering (with insecticidal spray)

The insecticides like acetamiprid, cypermethrin and fungicides like azoxystrobin were sprayed during pre-flowering period (7 days before flowering and 7 days after flowering) in this trial and diversity of different insect visitors was studied. Data on the relative abundance of insect visitors during different hours of the day on onion blooms are presented in table 2. It is evident from table that there was a significant interaction between insect pollinators and different day hours. Mean relative abundance based on insects caught through sweepings at different time intervals was the highest at 1000h (3.78) followed by 1400h (3.61) which were at par to each other with no significant difference, 1200h (3.11) and least (3.00) found during 1600h which were at par to each other with no significant difference in population. Irrespective of the time intervals, the mean relative abundance of *A. cerana* (19.00) with 31.28% as depicted in Fig 2 was significantly higher than other insect visitors followed by *Eristalis tenax* (9.50) with 15.64% followed by *Calliphora* spp. (7.50) with 12.35% followed by *Episyrphus balteatus* (6.75) with 11.11% followed by *Sphaerophoria scripta* and *A. dorsata* (4.25) with 6.99% which were at par with each other with no significant difference followed by *Eristalinus taeniops* (4.00) with 6.58% followed by *Syritta* spp. (2.00) with 3.29% followed by *Coccinella septempunctata* (0.75) with 1.25% and *Pieris brassicae* (0.50) with 0.83% which were at par with each other with no significant difference. All wasp species were recorded to have same percentage of abundance as shown in Fig 2. Among the orders relative abundance was highest recorded in Diptera (55.96%) followed by Hymenoptera (41.55) followed by Coleoptera (1.25%) and least was recorded by Lepidoptera (1.24%). The results of the findings are in conformity to those of [17] who found that Diptera (30%) was the most abundant followed by Hymenoptera (21%), Coleoptera, Lepidoptera (14%) and Neuroptera, Thysanoptera and Hemiptera constituted (7%).

Table 2. Relative abundance of insect visitors during flowering (with insecticidal spray)

Number of insect visitors/m ² /5 min sweepings						
Day hours Insect visitors	1000	1200	1400	1600	Mean	Order (%)
<i>Apis cerana</i>	24.00 (4.98)	17.00 (4.19)	18.00 (4.35)	17.00 (4.19)	19.00 (4.43)	Hymenoptera (41.55)
<i>Apis dorsata</i>	6.00 (2.60)	3.00 (1.88)	5.00 (2.44)	3.00 (2.00)	4.25 (2.23)	
<i>Bombus haemorrhoidalis</i>	0.00 (1.00)	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.25 (1.10)	
<i>Delta</i> spp.	1.00 (1.41)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Pachodynerus erynnis</i>	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Polistes</i> spp.	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Rhynchium</i> spp.	0.00 (1.00)	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Scolia</i> spp.	1.00 (1.38)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	
<i>Xylocopa</i> spp.	0.00 (1.00)	1.00 (1.38)	1.00 (1.41)	0.00 (1.00)	0.50 (1.20)	
<i>Episyrphus balteatus</i>	7.00 (2.81)	6.00 (2.63)	7.00 (2.79)	7.00 (2.81)	6.75 (2.76)	Diptera (55.96)
<i>Eristalinus taeniops</i>	4.00 (2.21)	2.00 (1.66)	6.00 (2.63)	4.00 (2.21)	4.00 (2.17)	
<i>Eristalis tenax</i>	9.00 (3.12)	11.00 (3.46)	9.00 (3.16)	9.00 (3.15)	9.50 (3.22)	
<i>Sphaerophoria scripta</i>	4.00 (2.16)	2.00 (1.72)	7.00 (2.79)	4.00 (2.24)	4.25 (2.23)	
<i>Syrpita</i> spp.	2.00 (1.73)	3.00 (1.88)	2.00 (1.66)	1.00 (1.38)	2.00 (1.66)	
<i>Calliphora</i> spp.	8.00 (2.95)	7.00 (2.79)	7.00 (2.81)	8.00 (2.99)	7.50 (2.88)	
<i>Pieris brassicae</i>	0.00 (1.00)	2.00 (1.71)	0.00 (1.00)	0.00 (1.00)	0.50 (1.18)	Lepidoptera (1.24)
<i>Spindasis</i> spp.	0.00 (1.00)	0.00 (1.00)	1.00 (1.41)	0.00 (1.00)	0.25 (1.10)	
<i>Coccinella septempunctata</i>	1.00 (1.41)	0.00 (1.00)	1.00 (1.41)	1.00 (1.41)	0.75 (1.31)	Coleoptera (1.25)
Mean	3.78 (1.90)	3.11 (1.78)	3.61 (1.90)	3.00 (1.74)		

Earlier, [3], recorded two honey bees (*Apis dorsata* and *A. c. indica*) and three syrphid species (*Episyrphus balteatus*, *Metasyrphus confertator* and *M. corollae*) to be important onion pollinators in the hilly terrains of the Indian Himalayas and showed that *A. dorsata* was the most visiting and *A. florea* was recorded as the least visiting pollinator in onion. The present results are in contrast to those of [10] who reported that among the different pollinators, hymenopterans were highest followed by dipterans, lepidopterans and others. Honey bees of four species were the largest group of visitors. Also, [1] reported *A. dorsata* (34.97%) to be most dominant followed by *A. florea* (31.04%), *Tetragonula* sp. (18.42%), *A. cerana indica* (12.26%), *Sphaerophoria* sp. (01.13%), *Delta* sp. (0.30%), *Scolia* sp. (0.15%), *Spindasis* sp. (0.15%), *Pieris brassicae* (0.07%), *Danaus chrysippus* (0.07%) and least dominant was *Xylocopa* sp. (0.04%). The spray of insecticides and fungicides (acetamiprid, cypermethrin and azoxystrobin) during pre-flowering, flowering periods at 15 days interval in this area, had a profound effect on the population of visitors. The insect population and diversity were less in insecticidal sprayed conditions as compared to unsprayed conditions. Pest management can indirectly affect yields in pollinator-dependent crops by impacting the pollination process. This has been well expatiated by [14] and [8] who reported that insecticide use may reduce pollinator attraction, post-pollination processes such as pollen viability or pollen tube growth and retention to a crop or interfere with pollen–stigma interactions of the flower [29]; [8]. The present findings are in conformity to those of [26] who recorded highest population of pollinators in untreated crops as compared to crop sprayed with chemicals like carbofuran and cypermethrin.

Table 3: Comparison of diversity indices in insecticidal unsprayed and sprayed conditions

Diversity indices of onion pollinators					
Sr. No.	Insecticidal conditions	Species Richness (S)	Shannon-Wiener Index (H')	Simpson Index (D)	Simpson Dominance Index (1/D)
1	Unsprayed conditions	29	2.41	0.14	6.89
2	Sprayed conditions	18	2.11	0.16	6.25

3. Comparison of diversity indices in unsprayed and insecticidal sprayed conditions

In unsprayed conditions, the species richness (29), Shannon-Wiener Index (H') (2.41) and Simpson Dominance Index (6.89) were recorded higher as compared to insecticidal sprayed conditions (18, 2.11 and 6.25) respectively. The simplest form of expressing the species richness is by counting the number of species in a community [15]. Among different mathematical expressions of diversity index, Shannon Wiener index and Simpson diversity index are the most commonly used diversity indices to clearly understand and compare the pollinator composition in a community at different locations. The results on the diversity indices showed that Simpson index as 0.74, Shannon-Weiner diversity index (H) was 1.52 [1]. Similarly, it was also observed that Shannon-Weiner index was 1.81 and majority of insects belong to same orders [12]. The highest species richness, Simpson diversity index and Shannon-Wiener diversity index in unsprayed conditions was due to the more prevalence of pollinators as the conditions for their foraging were salubrious.

IV. CONCLUSION

Among all the visitors, *A. cerana* (35.25) was in the highest numbers among all species of insect visitors/m²/5 minutes sweepings, followed by *Eristalis tenax* (13.75) and eight insect species were found least (0.25). Among different hours of the day, highest number of visitors (4.83) were found at 1000h whereas lowest (2.83) were found at 1600h under unsprayed conditions. Similar trend was followed under insecticidal sprayed conditions. Under unsprayed conditions, more species richness (29) was recorded as compared to sprayed conditions (18). Also, other diversity indices were found to be higher in the unsprayed conditions as compared to insecticidal sprayed conditions. Hence, use of less insecticides in onion crop attracts more pollinators and produces high yield.

REFERENCES

- Attigeri, S. G., Kandakoor, S. B., Kambrekar, D. N., & Hiremath, S. M. "Comparative pollination studies using *Apis cerana indica* and *Tetragonula iridipennis* in onion (*Allium cepa* L.) seed production.," Applied Ecology & Environmental Research vol 22, no. 1, 2023.
- Badade, G. M. "Foraging behaviour of honey bee on onion (*Allium cepa* L.)," Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, 2014.
- Chandel, R. S., Thakur, R. K., Bhardwaj, N. R., & Pathania, N. "Onion seed crop pollination: a missing dimension in mountain horticulture," Acta Horticulturae, vol. 631, pp. 79-86, 2004.
- Dar, S. A., Lone, G. M., Parey, S. H., Hassan, G. I., & Rather, B. A. "Insect pollinators and their conservation.," Journal of Entomology and Zoology Studies, vol. 5, no. 3, pp. 1121-1131, 2017.
- Das, R & Jha, S. "Record of insect pollinators and their abundance on Indian mustard (*Brassica juncea* L.) in New Alluvial Zone of West Bengal.," Journal of Pure and Applied Biosciences vol. 6, no. 5, pp. 848-853, 2018.
- Devi, S., Gulati, R., Tehri, K. & Poonia A. "Diversity and abundance of insect pollinators on *Allium cepa* L.," Journal of Entomology and Zoology Studies, 2(6): 34-38, 2014.
- Free, J. B. "Insect pollination of Crops (2nd edn.).," Academic Press, London, U.K. pp. 684, 1993.
- Gillespie, S., Long, R., Seitz, N. & Williams, N. "Insecticide use in hybrid onion seed production affects pre- and post-pollination processes.," Journal of Economic Entomology vol. 107, no. 1, pp. 29-37, 2014.

9. Gjorgji, M. & Rukie, A. "The effects of pollination and the use of bees on number and quality of onion seed 1.," Balkan Symposium on vegetables and potatoes, ISHS. Acta Horticulture vol.462, pp. 12, 1997.
10. Hosamani, V., Reddy, M. S., Hanumanthaswamy, B. C., Venkateshalu, K. R., Lingamurthi, K. R., Ravikumar, B. and Ashoka, N. "Pollinator diversity, abundance and their stay time in onion, *Allium cepa* L.," Journal of Entomology and Zoology Studies vol. 7, pp.158-161, 2019.
11. Kalmath, B. S. Impact of bee pollination on onion seed production. University of Agricultural Science, Dharwad, 2002.
12. Karuppaiah, V., Soumia, P. S. & Wagh, P. D. "Diversity and foraging behaviour of insect pollinators in onion.," Indian Journal of Entomology vol. 80, no. 4, pp. 1366-1369, 2018.
13. Lesley, C. & Ockendon, D. C. "Protandry and sequence of flower opening in the onion (*Allium cepa* L.)," New Phytologist vol. 81, pp. 419-428, 1978.
14. Long, A. F. & Morandin. L. "Low hybrid onion seed yields relate to honey bee visits and insecticide use.," California Agriculture, vol. 65 no. 3, 2011.
15. Makkar, G. S. & Chhuneja, P. "Diversity assessment of regional crop pollinating bee fauna in ecological perspective.," Ecology Environment and Conservation vol. 21, no. 4, pp. 1811-1816, 2015.
16. Mayer, D. F., & Lunden, J. D. "Honey bee management and wild bees for pollination of hybrid onion seed," Acta Horticulturae, vol. 561, pp. 275-278, 2001.
17. Mazeed, R. A. & Marey, R. A. "Pollinators activity on onion flowers and its effect on seeds yield at Sohag governorate, Egypt.," Egyptian Journal of Agricultural Research vol. 96, no.2, pp. 465-475, 2018.
18. Ollerton, J., & Louise, C. "Latitudinal trends in plant- pollinator interactions: are tropical plants more specialized?," Oikos, vol. 98, pp. 340-350, 2002.
19. Paschapur, A. U., Bhat, S., Subbanna, A. R.N. S., Choudhary, G. & Kumar, N. "Role of entomophily and artificial pollination in enhancing quality and yield of seed onion (*Allium cepa* L.) in Indian Himalayas.," Journal of Apicultural Science vol. 66 no.2, pp. 133-147, 2022.
20. Pushpalatha, M., Patil, C. S., & Firake, D. M. "Diversity and role of flower visitors in onion seed production," Current Science, vol. 124, no. 3, pp. 304-312, 2023.
21. Roubik, D. W. "Pollination of cultivated plants in the tropics," FAO, Rome, 1995.
22. Saeed, S., Sajjad, A., Kwon, O. & Kwon, Y. J. "Fidelity of Hymenoptera and Diptera pollinators in onion (*Allium cepa* L.) pollination.," Journal of Entomological Research vol. 38, no.4, pp. 276-280, 2008.
23. Sajjad, A., Saeed, S. & Masood, A. "Pollinator community of onion (*Allium cepa* L.) and its role in crop reproductive success.," Pakistan Journal of Zoology vol. 40, no.6, pp. 451-456, 2008.
24. Saleh, M., Bashir, M. A., Khan, K. A., Mahmood, R., Sarwar, G., Rafiq, K., Khan, M. H., Ghramh, H. A., Ahmad, Z., & Al-Solami, H.M.A. "Onion flowers anthesis and insect pollinators preferences on onion (*Allium cepa* L.) crop.," Fresenius Environmental Bulletin vol. 30, pp. 2580-2585, 2021.
25. Shannon, C. E. & Wiener, W. "The mathematical theory of communication.," University Illinois Press, Urban pp. 324, 1949.
26. Sharma, S. D. & Kumar, S. "Foraging behaviour of different pollinators in *Brassica rapa* var. *sarson* in Kullu valley of Himachal Pradesh.," Indian Journal of Plant Protection vol. 42, no.2, pp.183-185, 2014.
27. Simpson, E. H. "Measurement of diversity.," Nature vol. 163, pp. 688, 1949.
28. Voss, R.E., Murray, M., Bradford, K., Mayberry, K.S. & Miller, I. "Onion Seed Production in California.," University of California Division of Agriculture and Natural Resources Publication, vol.8008, pp. 1-10, 1999.
29. Yi, W., Law, S.E. & Wetzstein, H. Y. "Fungicide sprays can injure the stigmatic surface during receptivity in almond flowers.," Annals of Botany vol. 91, pp. 335-341, 2003.



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