

Estimation of Honeybees (*Apis mellifera* L.) impact in pollination of cucumber (*Cucumis sativus* L.) crops for yield enhancement and seed quality

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Abstract

To regulate the reaction of honeybee (*Apis mellifera* L.) pollinator on cucumber seed yield, experimental trials were demonstrated at BARI, Chakwal, in complete randomized block design by using different method of comparison (open pollinated and caged method) to determine the contribution of honeybees in pollination of cucumber crop. Seven parameters were assessed including i. Pollinator diversity (The result revealed that maximum visitation frequency of pollinator was carried out by *Apis mellifera* (71.6 %) and minimum (6.7%) by Dipteran *Episyrphus balteatus*), ii. Pollinators density (the results showed that cucumber crop was visited by five insect species of three orders of Hymenoptera, Diptera and Coleopteran at three different time intervals 1000-1100 hrs, 1200-1300 hrs, 144-1500 hrs respectively. Average visit of insects on cucumber flower per 5 minutes interval per plant contributed by *Apis mellifera* 6.8, 5.4, 3.7 respectively was found to be significantly most abundant and least contribution of syrphus beetle was observed 0.45, 0.68 and 0.76 respectively. iii. Flower attractiveness i.e. results revealed that Insects' visitor occurrence was unswervingly linked to the advancement of *C. sativa* blooming. The association of *C. sativa* flowers and accepted forger bees amount during the flowering retro was determined progressive. (the profusion of nutrition properties offered by *C. sativa* improved the flower attraction and subsequently bee fertilization lead to the high seed productivity), iv. Pollination efficacy determine on the basis of Yield parameters including a-mean weight of fruits b-length of fruit (cm), c-fruit diameter(cm), d-seed weight and e-no. of seed per fruit indicated that (Pollination efficacy by all pollinators in open pollinated method is significantly higher than caged method) that leads to higher yield.

Keywords: *Honeybee, Pollination, Cucurbits, Seed quality, Yield.*

Introduction

Apiculture is a cost-effective argic -trade in Country. Around 7,000 apiculturist are nowadays raising outstanding types of *Apis mellifera* in the up-to-date apiaries. There are about 4.5 lacs collections producing nearly 12000-14000 metric ton honey annually .The country exports 24% of its annual honey production overs the global average production of 40% (PCB Report. 2022). Friendly environmental circumstances and bee flowers in the country deliver

exceptional prospects for the enlargement of bee farming (SMEDA 2007). Honeybee vegetation is existing on massive parts of Sindh and Punjab plains in South plus North ranges, tribal agencies and Azad Jammu and Kashmir and can sustenance about one million honeybee clusters (Mahmood et al., 2019). Bee farming is a foremost substitute foundation of means of support for many resource-poor growers, but in spite of the positive consistent atmosphere and the possibility for forming ecological source of revenue in countryside, it frequently decline

the economic and technical facility for sustaining jungles, natural biomes and reducing scarcity (Affognon et al., 2015). Honey is a key nourishing diet comprising numerous types of glucose, vitamins, proteins, enzymes, minerals etc. that are huge source of strength (A Ajibola. 2012). Subject to the favourable site, foraging rate and colony strength, a single colony of *Apis mellifera* can harvest 16-30 Kg honey and 4.5-8.75 Kg of pollen per year. Furthermore sell out of other bee products, such as beeswax, pollen, royal jelly, propolis, bee venom or queen, bee handlers can also offer pollination features (hive rentals) to farmers and related Orchardists (V.A .Ricigliano. 2019). Unable skills, inadequate awareness, conservational deprivation and low productivity level are the key tasks facing the sub-sector (UNEP Report, 2013). Ninety percent of the total claim of honey for business use is covered by smallholding honey dealers from Punjab and Khyber Pakhtunkhwa, while rest of the mandate is met by wild honey from Tribal Areas (SMEDA, 2007). Punjab province is very ironic in bee floral plants with many honey producing wild plants. The utmost cultured species like Acacia species, Shesham *Delbergia* spp, Eucalyptus, Zizyphus and many other wild species are significantly important honey yielding species. These species are common throughout province (Khan, K.A. 2020).

Insect pollination has a significant contribution in crop assembly in accumulation to several other inputs. Amongst the insects, Honeybee *Apis mellifera* L. is the bounteous environment friendly pollinator and is coped for crop and honey making (DM, Katumo.2022). This European honeybee is of critically commercial rank in relationships of improved yield and value of commercially developed insect pollinated agricultural crops

(Ignasi Bartomeus et al., 2014). It also contributes for self-pollinated crops in the world. In our Country practice of bees, accepting honeybees in rare cases, for pollination is still a disappeared element in crop production. There are three indigenous wild species, i.e., *Apis floria*, *Apis cerana* and *Apis dorsata* existing in Pakistan ecology having annual yield of 1, 2 and 16 kg honey respectively (S.A.M Khalifa, 2019). While *Apis mellifera* presented bee yielded 8-25 kg per annum, Mango, Jaman, or Cheer. A standard honey bee colony, having 07-10 frames included of 25000 - 30000 adult bees (queen, workers and drones).

Cucumber (*Cucumis sativus* L.), Family Cucurbitaceae is an essential profitable crop grown in Pakistan. These are hermaphrodite, generating mutually both genders flowers on the similar plant distinctly (G. Chomicki, 2020). Cucumber is mainly a cross-pollinated crop. As the pollen grains are weighty, large sized and sticky, wind cannot transmit away the pollens from one flower to another and pollination is mainly done by the insects (Chisholm, Hugh. E.D. et al., 1911). The extent of this pollination ranges from 60-80% depending upon the environment and visitation by insect pollinators. (Shaden A.M. Khalifa .2021). Over-all, the scavenge rate and scavenging speed of one insect type defines its propagation efficacy (S.G.T .Klumpers et al., 2019). Among all the insect pollinators, Honeybee is considered as the major responsible pollinator founds 84 to 96% of the entire flower visitors in relation to cucurbits (Giulia Papa et al., 2022). Honeybee's mainly *A. mellifera* is able in hives for refining pollination. The bee pollination reflected vital in cross-pollinated *Cucumis sativus* L.

In Pakistan, the practice of managing crop pollination using honeybees is limited as farming community in the region is not well-aware of the pollination role of honeybees. Hence, the objective of research is to devise such a research work aims to progress the use of honeybee pollination for cross pollinated cucurbits, Therefore different experiments were conducted on Cucumber (*Cucumis sativus*) at Barani Agricultural Research Institute, Chakwal at various locations for appraisal of *Apis mellifera* role in cross-fertilisation of cucumber crops for yield enhancement and seed quality.

Materials and methods

The study was conducted on cucumber crop under the supervision of Barani Agricultural Research Institute Chakwal. The experiments were set up in (RCBD) with four repetitions. Cucumber crop var. Waris F1 was sown and sheltered with wire mesh. The two particular tunnels /channels sized 351 ft² and 1595 ft² were used for cucumber crop. Seeds sown initially as the nursery in mid-February in pliable dishes. And later the seedlings of 3-5 days were transferred to channels. The line to line distance (50 cm) and plant to plant (25cm) was maintained in the vegetable tunnels. The cucumber climbers were laterally braced by using the elastic net (3 x 3'') or wooden - sticks help in mounting the creepers. Two *Apis mellifera* hives were positioned close the tunnels where the bees have free access to approach the flower and the bee visit was documented accordingly. In order to find out the diversity and effect of pollinators on cucumber yield, related observations were made during the whole flowering season and the Cucumber flowers were found to be visited by different insect species. Bees effects on cucumber crops were assessed by insects uniformity and bulk, floret colour appeal

towards foragers, Distinct fruit mass, size, width and harvest / plant calculated on two treatments (i. Free choice for foragers to access plants in defined area ii. Captivated crop plants without bees as control).

Four bee colonies were placed in the centre of the field. Three repeats at distance of 1.5 kilometers were maintained. The data was taken-out from pre-blooming to pod harvesting of the crop. Following parameters evaluated during the experiment.

Pollinators Density: The measurements for pollinators/ floral unit were taken in a suitable climatic condition for forager's bees having temperature almost 16-20 C⁰, little wind, no heavy rain and dry vegetation (West phal et al., 2008). Colonies shifted in the field with 5-10% blooming of crop. Pollinator density identified by test selection of about 200 flowers in each of experimental site (Vaissiere. et al., 2011) Data was recorded on weekly basis throughout blossoming period. In this method the insect probe noted as found at the given time on flower first seen. Sample selection have been done by moving calmly on four spots in the trial location. The data collected at 10h00, 12h00 and 14h00 at weekly throughout the blooming period.

Pollinator Diversity: For determining diversity of pollinators, the insects captured from 4 transects of 25 m length for 5minutes at 10h00, 12h00 and 14h00 at weekly interval throughout the blooming period to assess the following parameter.

Flower attractiveness: In order to monitor the blooming progression, ten spots selected in the experimental field; one each on four corners and six inside the field. Ten plants labelled with red ribbon on each spot. The no. of flower on each plant inflorescence recorded twice a week. To determine the flower

attractiveness, the relation between average no. of pollinators recorded during each observation was calculated with no. of flowers during entire blooming period.

Pollination efficacy

To evaluate pollination efficacy regarding seed productivity, following four treatments with four replicates were made:

- Casing the inflorescence for anthesis period (autogamy)
- Physical pollination between the flowers of the similar plant (geitonogamy)
- Manual pollination between the flowers of the different plants (xenogamy)
- Allowing spontaneous insect access

To evaluate the treatment of autogamy, geitonogamy and xenogamy the plants were protected with iron frames (1×1×2m), covered with thin mesh to allow air circulation. To allow spontaneous insect access the iron frames have no mesh. There were 7 plants in each frame. After harvesting, total number of pods/plant, number of seeds per plant and seed/100 pods were determined. All the data analysed statistically to draw the inferences.

Cage Method

There were installed 2 cages (mesh iron) of size (6 X 4 X 6) in the field, in one cage bees were released while other kept as control

Results and Discussion:

Pollinator's diversity and density in Cucumber crop

Pollinators' diversity and density

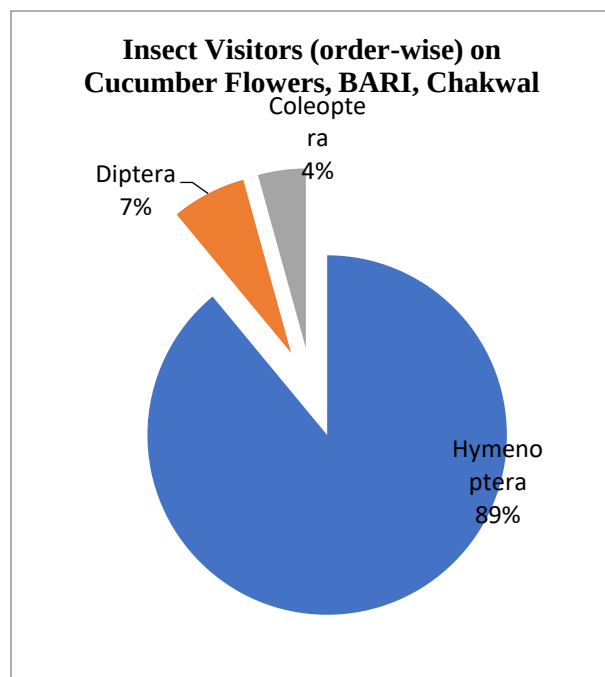
In order to find out the diversity and effect of pollinators on cucumber yield. Related observations were made during the whole flowering season it had been recorded that the Cucumber flowers set up for staying on it by 04 diverse pollinators of three orders. Bees were observed the rich flowery guests with overall abundance of 89%, followed by *Episyrphus balteatus* (6.7%) and *Aulacophora foveicollis* (4.3%). This study indicated that the managed honeybee *Apis mellifera* was the leading pollinator with the maximum quantity (71.6%) representing in (Fig. 01). It represented that *A. mellifera* is an effective pollinator and agriculturalists can acquire extreme advantage from their pollination facilities by permitting bee farmers to keep *A. mellifera* colonies adjacent to cropping lands. *A. dorsata* ranked 2nd (9.6%) followed by *A. flora* (7.8%) in our study. *A. foveicollis* belonged to the orders Coleoptera was found as casual visitor of the flowers and is not reported to participate in nectar or in pollen collection instead it was found feeding on the flowers and leaves (Table 1).

Table 1: Insect pollinators of *Cucumis sativa* florets at BARI, Chakwal

S. No.	Name of the species	Order	Family	Total abundance	Percentage (%)
1	<i>Apis mellifera</i>	Hymenoptera	Apidae	463	71.6
2	<i>Apis dorsata</i>		Apidae	62	9.6

3	<i>Apis florea</i>		Apidae	50	7.8
4	<i>Episyrphus balteatus</i>	Diptera	Syrphidae	43	6.7
5	<i>Aulacophora foveicollis</i>	Coleoptera	Chrysomelidae	28	4.3

Fig. 1 Insects Visitors on Cucumber flowers



Pollinators' density

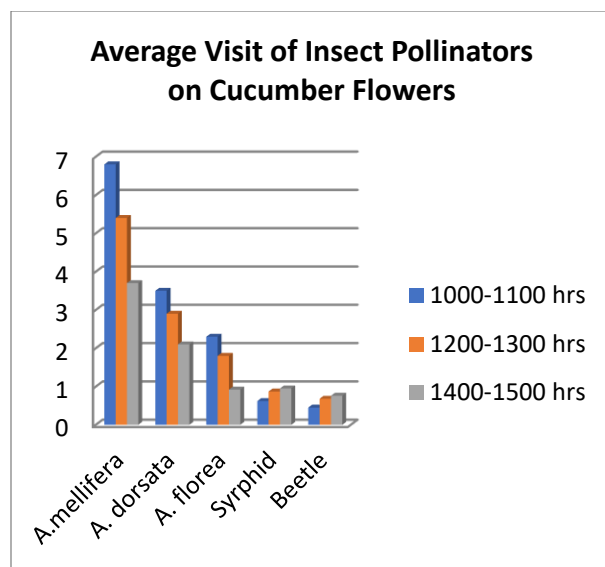
Data on the pollinator's visitation of different insect pollinators and their relative abundance

in different hours of the day are presented in Table 2. Data recording was performed throughout three time intervals (i.e. 10hrs00, 12hrs00, 14hrs00) on weekly basis. Except 1400 hrs, the European honeybee *A. mellifera* was significantly most abundant (6.8, 5.4, and 3.7 counts/plant /5 min respectively) followed by the Rock bee *A. dorsata* (3.5, 2.9, and 2.1 counts/plant /5 min respectively), Small bee *A. florea* (2.3, 1.8, and 0.92 counts/plant /5 min respectively) and Syrphid *Episyrphus balteatus* (0.62, 0.87, and 0.95 counts/plant /5 min respectively) whereas Beetle *A. foveicollis* was least abundant (0.45, 0.68, and 0.76 counts/plant /5 min respectively) in all periods. The experiment revealed that the highest abundance of insects was at 1000-1100 hrs while the lowest abundance was recorded from 1400-1500 hrs. The minimum insect population observed during 1400-1500 hrs due to the closing of flower and partly as a result of high temperature (>35o C).

Table. 2. Average visit of insects on Cucumber flowers per 5 minutes per plant

Hours	<i>A.mellifera</i>	<i>A. dorsata</i>	<i>A. florea</i>	<i>Syrphid</i>	<i>Beetle</i>	Mean
1000-1100 hrs	6.8	3.5	2.3	0.62	0.45	2.734
1200-1300 hrs	5.4	2.9	1.8	0.87	0.68	2.33
1400-1500 hrs	3.7	2.1	0.92	0.95	0.76	1.686
Mean	5.3	2.833333	1.673333	0.813333	0.63	

Fig. 2. Average visit of insects on Cucumber flowers per 5 minutes per plant



Flowers attractiveness of Cucumber flowers to different pollinators

Insects' visitor rate was rightly in straight manner correlated to the progress of *C. sativa* blooming (Figure 3) showing that a positive association between the *C. sativa* flowers and bee visitation on it. The fluctuation in visits of insect pollinators on different days on cucumber flowers was observed. The visits were recorded at high numbers during mid-flowering period and bit smaller at the beginning and end of flowering time, this change was because of disparity in the florescent density during the extent of thriving and weather fluctuations. At full blossom, the accessibility of flowers was more than initiation of flowering, and more amount of insects went the crop to rise the pollination process. So, the no. of flowers noticeably effects the pollinator profusion, and in turn, the pollination level.

Fig 3. Frequency of insect occurrence during *C. sativa* blooming progression.

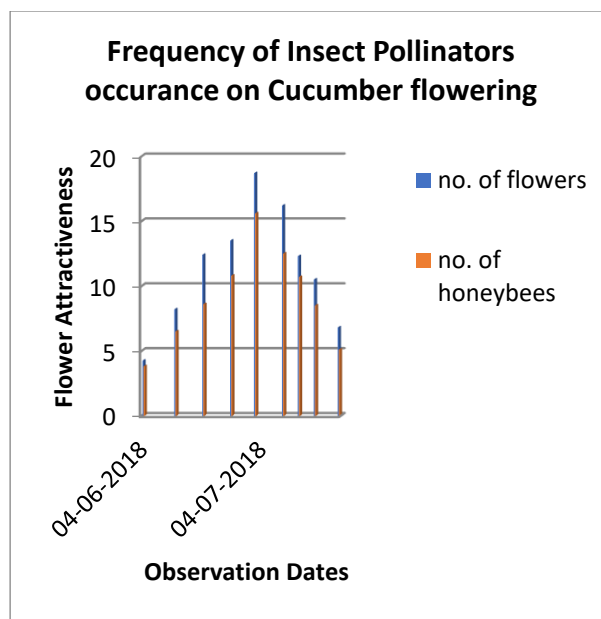


Table 3. The relationship between numbers of flowers and number of insect visitors during *C. sativa* inflorescence

Indicators	r	P
Flowers	0.95	0.0000***

Yield parameters of *Cucumis sativa*

a. Mean Weight of Fruits (g):

The results of the individual fruit weight has shown significant difference among different treatments ($F = 233.95$, $P < 0.05$, Fig 4). Comparison of mean values showed that T1 (open plot free visits of bees + other pollinators) and treatment T2 (Cages covered without bees) were statistically different from one another (Fig. 3). The weight of fruit was influenced by honeybee pollination.

Fig 4. Comparison of mean fruit weight of cucumbers in response to different treatments (T1 and T2)

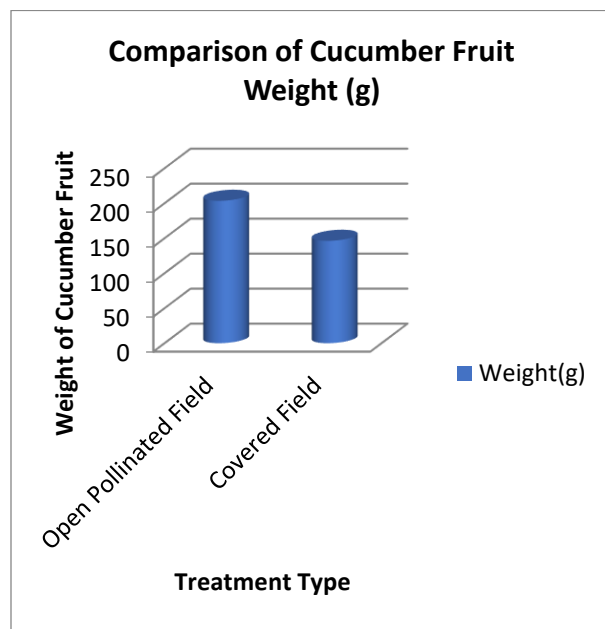
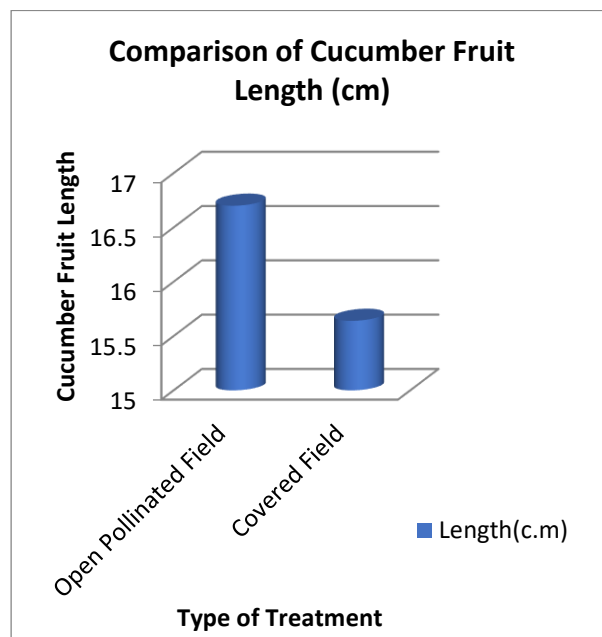


Fig 5. Comparison of mean fruit length of cucumber in response to different treatments (T1) and (T2)



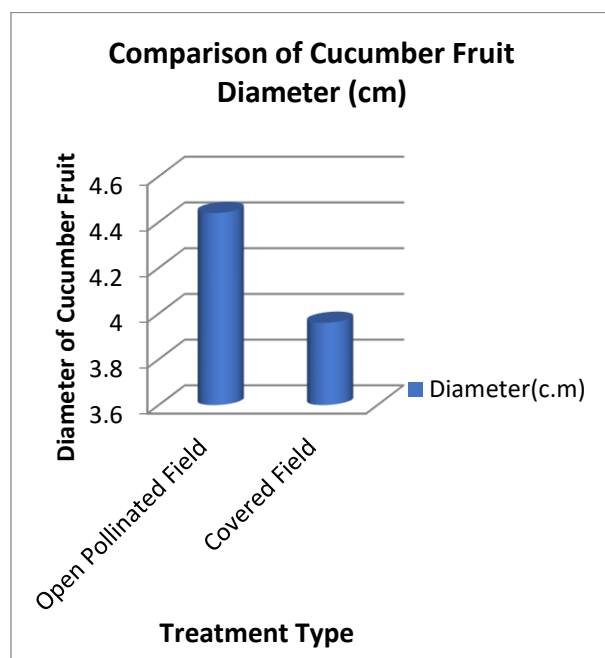
b. Length of Fruit (cm):

The results regarding the length of cucumber fruit indicated that difference among the treatments were statistically significant ($F=68$, $P < 0.05$, Fig 5). Comparison of mean values through LSD (5%) revealed that length of individual fruits among treatments T1 and T2 was statistically different. It was concluded that honeybees (*A. mellifera* L.) pollination was correlated positively with length of cucumbers.

c. Fruit diameter (cm):

The results regarding the diameter of fruit indicated that difference among the treatments were statistically significant ($F=98.5$, $P < 0.05$, Fig 6). Comparison of mean values presented that diameter of individual fruits among treatments T1 and T2 (was statistically different. It was concluded that honeybees (*A. mellifera* L.) pollination was correlated positively with diameter of cucumbers.

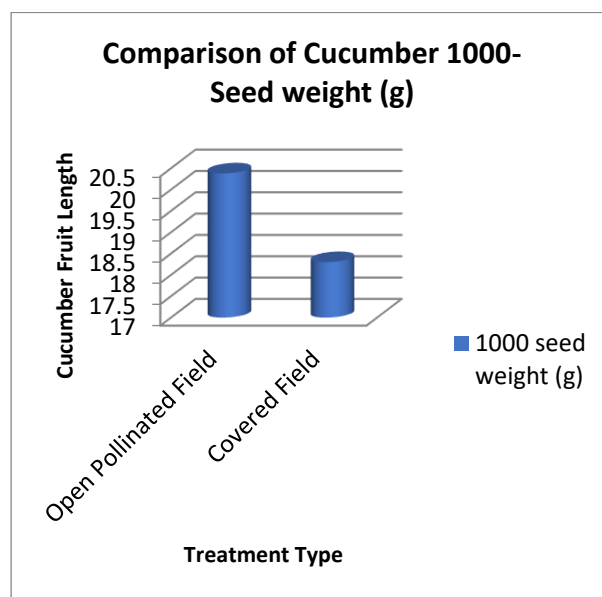
Fig 6. Comparison of mean fruit diameter of cucumber in response to different treatments (T1 and T2)



d. 1000 seed weight (g):

T1 had 20.38 (g) 1000 seeds weight per matured fruit while T2 (Cages covered without bees) pollinated cucumber consisted of 18.3 (g) 1000 seeds weight per matured fruit (Fig. 7).

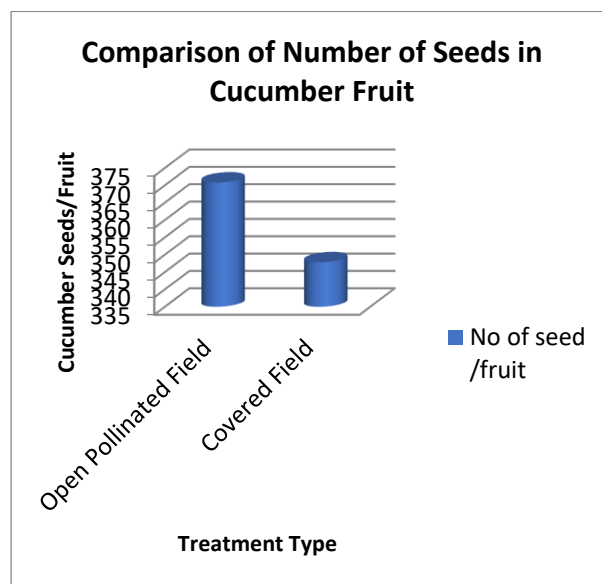
Fig 7. Comparison of mean 1000 seed weight of cucumber in response to different treatments (T1 & T2)



e. No. of seeds per fruit:

T1 pollinated plants had 370.8 seeds per matured fruit. T2 (Cages covered with bees) pollinated cucumber consisted of 347.8 seeds per matured fruit (Fig. 8).

Fig 8. Comparison of mean numbers of seed per plant of cucumber in response to different treatments (T1 and T2)



Conclusions

Pollen collection varied across three different times of the day, revealing that the most pollen was collected before noon showing that pollinator foraging activities were maximum during early hours of the day when bright light is maximum. It is also find out that freely visited pollinators including honeybees having considerably better-quality fruit load, length, and diameter in comparison with control. Yet exposed pollinated cucumber plants enhance the output about 70% as compare to control.

Recommendation

It is recommended for the indigenous grower that boosts the existence of honeybee hives to place near the turfs of their crop, plantation, and agricultural land etc. where the honey bee activities as pollinator remain maximum during 10:00 am to 11:00 am as primary hours of the day and play a significant role in pollination ultimately may help to improve fruit quality, quantity and finally yield.

Acknowledgments

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Data Availability Statement

All data and materials are available from the corresponding author. Therefore, at a reasonable request, the corresponding author shared it via email.

Competing Interests

Authors have declared that no competing interests exists

Ethical Approval: The ethical issues is not applicable

Consent of Participate: Not applicable

Consent of Publication: Not applicable

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