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Response of insect pollinators to different cucumber, *Cucumis sativus* L. (Cucurbitales: Cucurbitaceae) varieties and their impact on yield

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Abstract

The vast majority of cucurbits tend to be monoecious, therefore pollination is very important element with regard to strengthening their particular yield. Field experiment was conducted at New Developmental Farm of the University of Agriculture, Peshawar during the year 2014 to investigate the population density of insect pollinators on four different varieties (Peshawar Local, Beta Alpha, Market More and Moon Star (hybrid)) of cucumber and also to evaluate their impact on the yield of cucumber. The experiment was laid down in RCBD with four different varieties as treatments. Experimental field was divided into two portions i.e totally Covered (with nylon cloth net) to the entrance of insect pollinators and Uncovered. The results regarding mean population of pollinators showed the highest population of honey bees (1.21/plot) among all pollinators and varieties while population of carpenter bees was recorded to be the lowest (0.03/plot). Population density of pollinators was observed to be highest during morning and evening times. Uncovered plots yielded significantly higher than covered plots in all the comparative treatments. The uncovered and covered Peshawar Local produced 21863kg ha^{-1} and 9869 kg ha^{-1} , Beta Alpha 20156kg ha^{-1} and 7650kg ha^{-1} , Market More 21543kg ha^{-1} and 9748kg ha^{-1} and Moon Star 24619kg ha^{-1} and 11557kg ha^{-1} , respectively, throughout the reproductive season of cucumber crop. Cucumber crop requires insect pollination as an additional input in enhancing the yield.

Keywords: Pollination, Cucumber, Honey bees, Carpenter bees

1. Introduction

Cucumber (*Cucumis sativus* L.) commonly known as “khira” belongs to Asia and Africa. It has been used for 3000 years. Today cucumbers are grown worldwide for salad and pickling. The fruit is commonly harvested while still green. They are used as raw, cooked or pickled cucumbers. Fresh cucumber is a source of vitamin C, thiamine, niacin, iron, phosphorus calcium and dietary fiber [1].

Cucumber is a usually monoecious vegetable, where male and female flowers are present on the same plant. Male flowers are come about in clusters together with each flower using slender stem and housing three stamens. Female flowers occur singly and so are distinguishable by actual large ovary for the flower base. This ovary has several chambers, several series of ovules and it is connected to a short thick style together with three stigma lobes. Plants have yellow, wrinkled petals, both flowers produce nectar that attracts insect pollinators. The female flowers produce higher volume of nectar as compared to male flowers, but sugar concentration is larger in male flowers of cucumber. Cucumber pollen grains are sticky and suitable to pollination by bees as compared to wind. The stigma is receptive during the day but more receptive in early morning [2].

Permanently for fruit setting the pollinators play an essential part in cross pollination. Wind and insects are the main agents of the pollen transfer in cross pollination. Plants are referred to as self-pollinated when the percentage associated with cross pollination is usually below 4% in addition to being cross pollinated can be leading. For cucurbit plants this is almost true [3]. Mostly honeybees visit maximum number of flowers for getting nectar. The dusted pollinators with pollen grains drops on the stigma causing gynoecious fertilization [4].

Cucurbits like cucumber, melons, pumpkin and squash are cross pollinated crops. They need insect pollinators, especially honey bees for pollination and proper fruit set. In case of poor pollination, deformed and small sized fruit are produced. Prosperous pollination regarding several cucurbits demands approximately twenty bees visit for every flower [5].

In general, fluctuation in foraging activity occurs and same crop in the same region is impacted by race, colony strength, food resource, month and the time of the day. Pollinators are very crucial to agro-ecosystem as 75% of the important crop species of the world depends on them for fruit or seed set [6].

2. Materials and Methods

The experiment was conducted at New Developmental Farm of The University of Agriculture Peshawar-Pakistan during March-August 2014. Field was divided in two main plots with a distance of 2m (buffer zone) between them. Size for each sub plot was kept 4x4m². Each main plot was further subdivided into subplots to receive four treatments (four varieties) with three replications. Four different varieties were V1 (Peshawar Local), V2 (Beta Alpha), V3 (Market More) and V4 (Moon Star (hybrid)). The experiment was conducted in factorial RCB split plot design. Row-to-row distance and plant-to-plant distance was maintained as 1 meter and 30 cm respectively. Data regarding visits of insect pollinators was initiated after appearance of flowers and was recorded twice in a week. Common agricultural practices were used throughout the research studies.

Nylon cloth was used to cover the sub plots before initiation of flowering to deny access to pollinators except air and sunshine. In the uncovered portion, all the sub plots were kept open to all kind of pollinators to investigate the population dynamics of insect pollinators and their foraging timings on four different varieties of cucumber.

2.1. Statistical Analysis

The data recorded for each parameter was analyzed statistically by using Statistix 8.1 Software and means were separated by using Fisher Protected Least Significance Difference Test at 5% level of significance [7].

2.2. Data Collection

2.2.1 Population dynamics and foraging timings of

pollinators

The population of insect pollinators was recorded by observing three randomly selected plants in each experimental unit during three different timings of the day i.e. morning (7-9am), mid-day (12-2pm) and evening (4-6pm). Observation time for each plant was three minutes. The data was recorded twice in a week.

2.3. Yield

Data regarding yield of cucumber was recorded after flowering till the end of fruiting season of cucumber. The ripe cucumbers of different varieties were separately picked from covered and un-covered treatments once a week and were weighed. Yield was converted to kg/ha.

3. Results

Table 1 showed the mean population of honey bees on four different varieties of cucumber. Highest mean population (1.21 bees/ plot) of honey bees was recorded visiting Peshawar Local and lower (0.68 bees/ plot) on Moon star. The highest bees population of honey bees was non significantly followed by the population on Market More (0.98 bees/ plot) and then (0.90 bees/ plot) on Beta Alpha. Statistical analysis of the population density of honey bees regarding three different timings showed no significant difference. However, highest bees (1.03 bees/ plot) were observed during evening time and lowest population (0.78 bees/ plot) was seen in the afternoon. The honey bees noted during morning time were 1.02 bees/ plot. The table further revealed that significantly higher population (1.51 bees/ plot) was recorded as a result of the interaction of varieties, different timing and weekly time intervals in week 7. This population was not significantly different from the populations noted during week 1(1.07 bees/ plot), week 2 (1.13 bees/ plot) and week 6 (1.14 bees/ plot). The lowest population recorded was 0.51 bees/ plot in week 11, followed by week 10 (0.64 bees/ plot), week 8 (0.82 bees/ plot), week 4 (0.82 bees/ plot), week 9 (0.85 bees/ plot), week 3 (0.90 bees/ plot) and week 5 (0.96 bees/ plot).

Table 1: Mean population of honey bees on four different varieties of cucumber at three different timings from May to August, 2014.

Treatments		Intervals (i) weeks											Mean
		1	2	3	4	5	6	7	8	9	10	11	
Varities (v)		v x i											
Peshawar local		1.17	1.67	1.17	0.94	1.22	1.28	2.06	0.94	1.33	0.83	0.67	1.21 a
Beta Alpha		1.00	1.00	0.72	0.67	1.11	1.61	1.67	0.83	0.56	0.44	0.33	0.90 bc
Market More		1.06	0.78	1.06	1.28	0.67	1.28	1.06	1.00	1.00	0.89	0.67	0.98 ab
Moon Star		1.06	1.06	0.67	0.39	0.83	0.39	1.28	0.50	0.50	0.39	0.44	0.68 c
Timings (t)		t x i											
Morning		1.29	1.25	0.88	0.83	1.08	1.83	1.21	0.50	1.04	0.58	0.67	1.02 a
Afternoon		0.96	1.17	0.92	0.71	0.83	0.46	0.54	1.08	0.67	0.71	0.58	0.78 a
Evening		0.96	0.96	0.92	0.92	0.96	1.13	2.79	0.88	0.83	0.63	0.33	1.03 a
		v x t x i											v x t
Peshawar local	Morning	1.67	2.00	1.83	1.00	1.17	1.33	1.00	0.83	1.67	0.50	0.67	1.24
	Afternoon	0.67	1.83	0.33	0.67	1.33	1.00	0.50	1.17	0.83	1.17	1.00	0.95
	Evening	1.17	1.17	1.33	1.17	1.17	1.50	4.67	0.83	1.50	0.83	0.33	1.42
Beta Alpha	Morning	0.83	1.17	0.17	0.67	1.50	2.33	1.33	0.67	1.00	0.00	0.00	0.88
	Afternoon	1.50	1.00	1.67	0.33	1.00	0.50	0.67	1.00	0.33	0.83	0.67	0.86
	Evening	0.67	0.83	0.33	1.00	0.83	2.00	3.00	0.83	0.33	0.50	0.33	0.97
Market More	Morning	1.17	0.50	0.50	1.50	0.67	2.83	1.33	0.17	1.17	1.17	0.67	1.06
	Afternoon	0.67	0.67	1.33	1.50	0.33	0.33	0.33	1.50	1.17	0.67	0.67	0.83
	Evening	1.33	1.17	1.33	0.83	1.00	0.67	1.50	1.33	0.67	0.83	0.67	1.03
Moon Star	Morning	1.50	1.33	1.00	0.17	1.00	0.83	1.17	0.33	0.33	0.67	1.33	0.88
	Afternoon	1.00	1.17	0.33	0.33	0.67	0.00	0.67	0.67	0.33	0.17	0.00	0.48
	Evening	0.67	0.67	0.67	0.67	0.83	0.33	2.00	0.50	0.83	0.33	0.00	0.68
Mean		1.07ac	1.13ab	0.90bd	0.82bd	0.96bd	1.14ab	1.51a	0.82bd	0.85bd	0.64cd	0.51d	

Lsd for varieties = 0.28
 Lsd for timings = 0.24
 Lsd for intervals = 0.47

The results in table 2 indicated no significant difference among the overall mean population of butterflies on four different varieties of cucumber crop. The maximum population (0.30 butterflies/ plot) was recorded on Peshawar Local and Market More, respectively, while minimum population was recorded (0.18 butterflies/ plot) on variety Beta Alpha. The highest population was followed by Moon Star which was 0.27 butterflies/ plot. The mean population of butterflies regarding three different timings was recorded as 0.29 butterflies/ plot at morning, 0.24 butterflies/ plot at afternoon and 0.26

butterflies/plot at evening. Highest population was noticed during morning time while lowest was observed in afternoon. Statistically there was no significant difference among the recorded population of butterflies in three different timings. Furthermore the results revealed no significant difference for the interaction of varieties, timings and weekly time intervals. However, the highest population (0.35 butterflies/ plot) was recorded in week 9 while the lowest population was recorded as 0.14 butterflies/ plot during week 11.

Table 2: Mean population of butterflies on four different varieties of cucumber at three different timings from May to August, 2014.

Treatments		Intervals (i) weeks											Mean
		1	2	3	4	5	6	7	8	9	10	11	
Varities (v)		v x i											
Peshawar local		0.61	0.22	0.28	0.33	0.39	0.33	0.33	0.39	0.22	0.22	0.00	0.30 a
Beta Alpha		0.28	0.28	0.39	0.06	0.33	0.11	0.06	0.06	0.22	0.11	0.11	0.18 a
Market More		0.22	0.39	0.00	0.28	0.44	0.17	0.33	0.33	0.72	0.22	0.22	0.30 a
Moon Star		0.22	0.33	0.28	0.17	0.06	0.61	0.44	0.22	0.22	0.17	0.22	0.27 a
Timings (t)		t x i											
Morning		0.29	0.42	0.33	0.25	0.08	0.46	0.29	0.29	0.29	0.21	0.25	0.29 a
Afternoon		0.33	0.25	0.08	0.21	0.42	0.13	0.21	0.29	0.42	0.17	0.17	0.24 a
Evening		0.38	0.25	0.29	0.17	0.42	0.33	0.38	0.17	0.33	0.17	0.00	0.26 a
		v x t x i											
Peshawar local	Morning	0.33	0.00	0.00	0.33	0.00	0.33	0.67	0.33	0.00	0.17	0.00	0.20
	Afternoon	0.83	0.17	0.33	0.50	0.50	0.33	0.33	0.83	0.50	0.17	0.00	0.41
	Evening	0.67	0.50	0.50	0.17	0.67	0.33	0.00	0.00	0.17	0.33	0.00	0.30
Beta Alpha	Morning	0.33	0.33	0.67	0.00	0.17	0.00	0.00	0.17	0.33	0.17	0.00	0.20
	Afternoon	0.00	0.33	0.00	0.00	0.50	0.17	0.17	0.00	0.00	0.17	0.33	0.15
	Evening	0.50	0.17	0.50	0.17	0.33	0.17	0.00	0.00	0.33	0.00	0.00	0.20
Market More	Morning	0.33	0.83	0.00	0.50	0.17	0.33	0.17	0.50	0.67	0.17	0.33	0.36
	Afternoon	0.33	0.17	0.00	0.17	0.67	0.00	0.17	0.17	0.83	0.33	0.33	0.29
	Evening	0.00	0.17	0.00	0.17	0.50	0.17	0.67	0.33	0.67	0.17	0.00	0.26
Moon Star	Morning	0.17	0.50	0.67	0.17	0.00	1.17	0.33	0.17	0.17	0.33	0.67	0.39
	Afternoon	0.17	0.33	0.00	0.17	0.00	0.00	0.17	0.17	0.33	0.00	0.00	0.12
	Evening	0.33	0.17	0.17	0.17	0.17	0.67	0.83	0.33	0.17	0.17	0.00	0.29
Mean		0.33 a	0.31 a	0.24 a	0.21 a	0.31 a	0.31 a	0.29 a	0.25 a	0.35 a	0.18 a	0.14 a	

Lsd for varieties = 0.13
 Lsd for timings = 0.12
 Lsd for intervals = 0.2

The results regarding the population of carpenter bees on four different varieties of cucumber crop is shown in table 3. The mean population of carpenter bees was recorded as 0.05, 0.06 bees/plot on Beta Alpha, 0.03 bees/plot on Market More and variety Moon Star. Statistically non significant higher population was recorded on variety Beta Alpha which was 0.06 bees/ plot while lower mean population was observed as 0.03 bees/ plot on variety Market More and Moon Star, respectively. The higher population was followed by 0.05 bees/plot on Peshawar Local. Statistical analysis showed no significant difference among the population of carpenter bees on four different varieties. Statistically significant higher mean population (0.08 bees/

plot) of carpenter bees regarding three different timings of the observation was recorded at morning, followed by 0.03 bees/ plot at afternoon and lower (0.02 bees/ plot) at evening. The table also indicated the effect on visiting behavior of carpenter bees by the interaction of varieties, different timings in a day and weekly intervals in the whole flowering season. The results in the table 4.3 indicated significantly highest population of 0.17 bees/ plot during week 4 and was not significantly different from the population recorded during week 2 (0.10 bees/ plot) while no bees (0.00 bees/ plot) were observed to visit the crop in week 5,6,7,8 and 11 respectively, during the whole fruit set flowering season of cucumber crop.

Table 3: Mean population of carpenter bees on four different varieties of cucumber at three different timings from May to Aug, 2014.

Treatments		Intervals (i) weeks											Mean
		1	2	3	4	5	6	7	8	9	10	11	
Varities (v)		v x i											
Peshawar local		0.00	0.11	0.06	0.28	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.05 a
Beta Alpha		0.06	0.17	0.00	0.22	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.06 a
Market More		0.00	0.06	0.11	0.00	0.00	0.00	0.00	0.00	0.11	0.06	0.00	0.03 a
Moon Star		0.00	0.06	0.06	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03 a
Timings (t)		t x i											
Morning		0.00	0.13	0.17	0.33	0.00	0.00	0.00	0.00	0.17	0.04	0.00	0.08 a
Afternoon		0.04	0.13	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.03 b
Evening		0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.02 b

		v x t x i											v x t
Peshawar local	Morning	0.00	0.33	0.17	0.33	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.09
	Afternoon	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.06
	Evening	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beta Alpha	Morning	0.00	0.17	0.00	0.50	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.08
	Afternoon	0.17	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	Evening	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.05
Market More	Morning	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.33	0.17	0.00	0.08
	Afternoon	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	Evening	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moon Star	Morning	0.00	0.00	0.17	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	Afternoon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Evening	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Mean		0.01 cd	0.10ab	0.06 bd	0.17 a	0.00 d	0.00 d	0.00d	0.00 d	0.08 bc	0.03 bd	0.00d	

Lsd for varieties=0.04

Lsd for timings=0.04

Lsd for intervals=0.07

The yield obtained from all the four varieties of cucumber during the whole cropping season is presented in table 4. The results indicated that the yield obtained from uncovered plots was significantly higher than the yield resulted from covered plots for all the four varieties comparatively. The uncovered and covered plots of Peshawar Local produced 21863 kg ha^{-1} and 9869 kg ha^{-1} , Beta Alpha 20156 kg ha^{-1} and 7650 kg ha^{-1} , Market More 21543 kg ha^{-1} and 9748 kg ha^{-1} and Moon Star 24619 kg ha^{-1} and 11557 kg ha^{-1} , respectively, throughout the reproductive season of cucumber crop. The mean yield for all the varieties from uncovered plot was 22045.25 kg ha^{-1} and covered plots was 9706 kg ha^{-1} . Substantial yield difference was recorded relating to the uncovered and covered plots.

Table 4: Effect of pollinators on the yield in kg ha^{-1} of four different varieties of cucumber

Varieties	Treatments	
	Uncovered	Covered
Peshawar Local	21863a	9869b
Beta Alpha	20156a	7650b
Market More	21543a	9748b
Moon Star	24619a	11557b
Mean	22045.25 a	9706 b

4. Discussion

Part of pollinators inside of raising the yield as well as quality of crops is really a significantly explored subject. Pollination can be an essential move within the sexual production associated with cucurbits and also Angiosperms. Almost all angiosperm depends upon insects as well as various other animals as compared to wind, regarding move of pollen among particular crops. Insect pollinators in-turn help by means of get floral belongings including nectar as well as pollen [8]. Our results indicated that only honey bees showed the varietal preference among all the pollinators and showed their abundance mostly in evening time because of ideal temperature. But the other pollinators showed no varietal preference throughout the reproductive period of cucumber crop. Nicodemo *et al.*, (2009) [9] stated that large and monoecious flowers of cucurbits produce plenty of nectar and pollen and attract a wide array of insect visitors, particularly honey bees. The population of carpenter bees has been recorded to be the lowest among the three pollinators. Although carpenter bees have been recorded as efficient pollinators of many crops but we could not found their abundance as compared to honey bees and butterflies. This may be due to absence of their colonies and climatic conditions. The population of pollinators tended to increase from the start of flowering and reached to its peak during the

mid of season i.e. week 7 because of the flowering period of crop was on peak at this stage and then started to decrease due to maturity of crop and finished season of flowering. Honey bees population was recorded the highest population among all the pollinators. Our findings are in accordance to results of Shultz JI [10] who demonstrated that 95% of honey bees are involved in visiting bitter gourd and cucumber which implies that cucurbits are good forage for bees. It was also confirmed by Kieth M [11] who assured that over 50% of pollination is affected by hymenopteran insects, while 20%, 15% and 10% of pollination is done by dipterans, beetles and lepidopteran insects, respectively, while the remaining 5% is done by insects belonging to other insect orders.

Yield data showed that more yield was obtained from uncovered plot. The results of yield in table 4.5 clearly indicated that the actual yield is usually frequently and considerably larger inside insect pollinated plots through the entire growing time. Fruit set likewise taken place inside covered plots. This can be because of pollination was accomplished by wind. The higher yield may be due to maximum visits of pollinators (bees along with butterflies) towards treatment where the insect had open access while the treatments with no access to pollinators resulted in lower observations regarding yield. Sneep FD [12] noted that natural pollination along with manually enhanced pollination as a combined method provided greater yield. This signifies that setting of fruit set may also be done by flowers pollinated by wind. Our findings are in conformity with Laberge HM [13], who recorded 60 percent increase in yield of cucumber achieved by utilization of pollinators. Our results are also in accordance with that of Parker FD [14] who observed in plants covered together with pollinators generated 25 % more yield in comparison to other crops which were caged without pollinators.

5. Conclusion

On the basis of results we concluded from this research that honey bees are the most frequent visitors of cucumber crop as compared to other pollinators. Most of pollinators were recorded in the time of evening and morning due to moderate temperature but we could not clearly found any varietal preference among pollinators except honey bees which showed preference on variety Peshawar local. Significant difference was recorded between yields obtained from covered and uncovered plots. The uncovered plot yielded significantly higher than the covered plot because of insect pollination.

6. Recommendations

Cucumber crop requires bee pollination as an additional input in enhancing the yield. Future research regarding developing

conservation strategy for both most efficient as well as less efficient pollinators should be conducted. The growers should keep the bee colonies near the cucumber field as soon as first fruit producing flower appears to get higher yield.

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