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Yield of Bitter Gourd (*Momordica Charantia* L.) Affected by Insect Pollinators Population Abundance and Foraging Time

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ABSTRACT: Keeping in view the importance of insect pollinators in global food production the current study was conducted at The New Developmental Farm of The University of Agriculture, Peshawar, Pakistan: to investigate population densities of insect pollinators visiting bitter gourd *Momordica charantia* flowers, with peak foraging time, and their impact on yield. Insect pollinators belonging to three orders Hymenoptera, Lepidoptera and Diptera were recorded visiting five bitter gourd *Momordica charantia* varieties (Anmol, Gudka, Malawi, Paracha and Sonam). Among all insect pollinators that visited bitter gourd *Momordica charantia* flowers, highest population density (1.45 bees plant^{-1}) of honey bees species (Apidae) was recorded in morning time (09: 00am - 12: 00pm) on variety Anmol followed by carpenter bees (Apidae) (0.98 bees plant^{-1}) on variety Sonam and Syrphid fly (Diptera) (0.82 flies plant^{-1}) on variety Paracha while butterflies species were recorded least abundant visitor that forage bitter gourd *Momordica charantia* flowers (0.74 butterflies plant^{-1} on variety Sonam in morning). Similarly yield obtained from uncovered plots; having access to insect pollinators was recorded significantly higher (Anmol (9140 Kg ha^{-1}), Malawi (6924 Kg ha^{-1}), Gudka (6751 Kg ha^{-1}), Sonam (6560 Kg ha^{-1}) and Paracha (6198 Kg ha^{-1}) than the yield obtained from covered plots; having no access to insect pollinators (Malawi (1288 Kg ha^{-1}), Sonam (1097 Kg ha^{-1}), Anmol (1007 Kg ha^{-1}), Gudka (976 Kg ha^{-1}) and Paracha (891 Kg ha^{-1}).
Key words: Bitter gourd, Insect pollinators, Hymenoptera, Lepidoptera, Diptera, Yield.

INTRODUCTION

Yield and quality of crop rely on farming sources and contribution of ecosystem services with pollination by naturally occurring pollinators, or managed pollinators' population as main feature, and approximately 35% of the global food is supplied by plants which depend on animals for pollination, particularly bees (Brittain*et al.*, 2012). It has been estimated that about 90% of all

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flowering plant species depend on pollination through insects, while different kinds of insects like honey bees, butterflies, wasps, flies, bugs and moths are in charge of giving basic environmental services of plants pollination (Saed*et al.*, 2012). Among insect pollinators that pollinate major fruits and vegetables, members of the family Apidae are the most dependable insects for successful pollination; particularly honey bees are the most significant pollinators as they are equipped specially for carrying pollens, and in this way the plants visited by them are benefited (Subhakar*et al.*, 2011). As insect pollinators assume a significant part in affecting ideal pollination of major crops; subsequently adding to both expanded production and quality: hence presence of insect pollinators is more important in Cucurbitaceae plants including bitter gourd *Momordica charantia*, which are monoecious (male and female blossoms are borne at various position on a similar plant) (Subhakar., 2011). Bitter gourd (*Momordica charantia* L.) is a prevalent vegetable grown all over through Asia, particularly Pakistan, India, Sri Lanka and China, and is likewise cultivated as a decorative plant in different parts of the world. Every last piece of this plant has a nutritive or a restorative value and has a long relationship with humans (Dhillon *et al*, 2005). Being cross pollinated and monoecious, in bitter gourd both male and female flowers sprout on same plant and sprouting ratio between male and female flowers is around 25:1. Moreover, long days make male blossoms sprout up to two weeks before female flowers (Plada and Chang, 2003). Pollinators attract to bitter gourd flower (*Momordica charantia* L.) due to its open position and get the floral rewards, Therefore, high male to female proportion accomplishes the production of adequate amount of pollen deposits, hence brings about successful fertilization (Deyto and Cervancia, 2009). All cucurbits and particularly Bitter gourd (*Momordica charantia* L.) totally depend on insect pollinators for successful pollination, maximum seed setting and better fruit production, and their flowers that are not visited by pollinators cannot produce fruits (Ashworth and Galetto, 2002; Lenzi*et al*., 2005).

MATERIALS AND METHODS

The experiment entitled as "Yield of bitter gourd (*Momordica charantia* L.) affected by insect pollinators densities and foraging time" was conducted at the New Developmental Farm (NDF), The University of Agriculture, Peshawar (UAP) during the cropping season (June - August) 2017. The experiment was laid out in (RCBD) Randomized Complete Block Design with split plot arrangement and replicated three times. Five varieties of bitter gourd (*Momordica charantia*)i.e., Anmol, Paracha, Gudka, Malawi and Sonam were studied in the experiment for recording insect pollinators visiting densities, foraging time and their impact on yield. All the varieties were grown on raised beds with a plot size of 6 x 5 m^2. Each main plot was further divided in to two sub plots (open plot and caged plot). Five bitter gourd verities i.e., Anmol, Gudka, Malawi, Paracha and Sonam (Factor A) were assigned to main plots while, factor B that is caging was applied to sub plots.Harvesting was done on weekly basis from both covered and uncovered plots.

Population densities and foraging timings of pollinators

The population of insect pollinators was recorded by observing three randomly selected plants from each uncovered plot on alternate days at two foraging time from 9: 00am - 12: 00pm morning and 03: 00 - 06: 00pm evening; from the start of flowering stage up to the crop maturity for a period of 12 weeks. Species of all insect pollinators visiting bitter gourd varieties and their abundance was recorded during a period of 5 minutes from each uncovered plot.

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Collection of insect pollinators

Insect pollinators were collected from uncovered plots. Typical hand net was used for this purpose. The collected Specimens were properly mounted and identified up to species level by comparing them with insect collection in Entomology Museum and available literature. Photos of recognized pests and pollinators were made. After identification and proper pinning, the insect specimens were submitted to the Entomology Museum of The University of Agriculture Peshawar.

Yield ($kgha^{-1}$)

Yield was collected from each open and caged plot and was weighed through electrical balance and converted into kg ha^{-1}.

Statistical analysis

The collected data were subjected to statistical analysis. Significance of the data was tested at 5% level of significance by using ANOVA, for further highlighting significance of variance among each treatment LSD test was applied (steel and torrie., 1997).

Results

The population densities of different insect pollinators were recorded on five varieties of bitter gourd *Momordica charantia* during the flowering stage at two different foraging times i.e. at morning from 09am to 12pm and evening from 3pm to 6pm. The data was recorded on randomly selected three plants from each uncovered plot on weekly basis for a period of 12 weeks i.e. from 1st week of June up to 3rd week of August 2017.

Mean Population of Honey bees

Table 1 shows mean population of honey bees (Apidae) that have provided services as pollinators on five varieties of bitter gourd (Anmol, Gudka, Malawi, Paracha and Sonam) during 12 weeks from June to August 2017. Highest mean population of honey bees (1.45 bees $plant^{-1}$) was recorded at morning from 09am to 12pm on variety Sonam followed by Anmol (1.42 bees $plant^{-1}$), Paracha (1.40 bees $plant^{-1}$) and Gudka (1.38 bees $plant^{-1}$) while lowest population of honey bees in morning was recorded on variety Malawi (1.32 bees $plant^{-1}$). Similarly in evening from 3pm to 6pm highest mean population of honey bees was recorded on variety Gudka (0.78 bees $plant^{-1}$) which is in par with Malawi (0.78 bees $plant^{-1}$) followed by Sonam (0.77 bees $plant^{-1}$) and Anmol (0.75 bees $plant^{-1}$) while lowest population of honey bees in evening was observed on variety Paracha (0.69 bees $plant^{-1}$).

Mean population of carpenter bees

Table 2 shows mean population of carpenter bees that foraged bitter gourd flowers during a period of 12 weeks from June to August 2017. The analysed data shows that highest mean population of carpenter bees in morning from 9am to 12 pm was recorded on variety Sonam (0.98 bees $plant^{-1}$), followed by Gudka (0.88 bees $plant^{-1}$), Paracha (0.85 bees $plant^{-1}$) and Anmol (0.84 bees $plant^{-1}$) while lowest population of carpenter bees in morning was recorded on variety Malawi (0.81 bees $plant^{-1}$). Similarly in evening highest mean population of carpenter bees was noted on variety Paracha (0.44 bees $plant^{-1}$) followed by Malawi (0.40 bees $plant^{-1}$), Anmol (0.39 bees $plant^{-1}$) and

Gudka (0.38 bees plant^{-1}) while lowest population in evening was noted on variety Sonam (0.37 bees plant^{-1}).

Mean population of butterflies

Table 3 shows mean population of butterflies species that visited bitter gourd flowers during a period of 12 weeks. Highest mean population of butterflies in morning was observed on variety Sonam (0.74 butterflies/plant) followed by Anmol (0.73 butterflies/plant), Gudka (0.65 butterflies/plant) and Paracha (0.64 butterflies/plant) while lowest population of butterflies in morning was recorded on variety Malawi (0.62 butterflies/plant). Similarly in evening highest mean population of butterflies was noted on variety Paracha (0.49 butterflies/plant) followed by Anmol (0.48 butterflies/plant), Malawi (0.45 butterflies/plant) and variety Gudka (0.42 butterflies/plant) while lowest population in evening was recorded on variety Sonam (0.38 butterflies/plant).

Mean population of Syrphid flies

Table 4 shows analysed data regarding population of syrphid flies that visited bitter gourd flowers during a period of 12 weeks from June to August 2017. The data shows that highest mean population of syrphid flies in morning was recorded on variety Paracha (0.82 flies/plant) followed by Malawi (0.78 flies/plant) which is in par with Gudka (0.78 flies/plant), and Anmol (0.77 flies/plant) while lowest population in morning was observed on variety Sonam (0.70 flies/plant). Similarly in evening highest mean population of syrphid flies was recorded on variety Gudka (0.33 flies/plant) which is in par with Paracha (0.33 flies/plant), followed by Sonam (0.26 flies/plant) which is in par with Malawi (0.26 flies/plant) while lowest population of syrphid flies in evening was noted on variety Anmol (0.22 flies/plant).

Mean yield of bitter gourd (*Momordica charantia*) varieties

Fig 1 show analysed data regarding yield of bitter gourd varieties. The given data shows that highest yield of bitter gourd was obtained from variety Anmol (9140 kg/ha) from uncovered plots, followed by Malawi uncovered plots (6924 kg/ha), Gudka uncovered plots (6751 kg/ha) and Sonam uncovered plots (6560 kg/ha) while lowest yield from uncovered plots was obtained from variety Paracha (6198 kg/ha). Similarly, from covered plots highest mean yield was obtained from variety Malawi (1288 kg/ha), followed by Sonam (1097 kg/ha), Anmol (1007 kg/ha) and Gudka (976 kg/ha) while lowest mean yield from covered plots was obtained from variety Paracha (891 kg/ha).

Discussion

Almost all cucurbits are generally monoecious acquiring individual male and female flower on a single plant. Permanently for fruit setting the pollinators play an essential part in cross pollination. Insects belonging to three orders i.e. Hymenoptera, Diptera and Lepidoptera were observed visiting bitter gourd *Momordica charantia* varieties (Anmol, Gudka, Malawi, Paracha and Sonam). Hymenopteran insects were found to be the most abundant visitors of bitter gourd *Momordica charantia*flowers. Table 1 shows that among all insects pollinators that visited bitter gourd varieties population of honey bees (Apidae) was recorded highest with mean population of 1.45 bees plant^{-1} in morning on variety Sonam followed by Anmol (1.42 bees plant^{-1}), Paracha (1.40 bees plant^{-1}), Gudka (1.38 bees plant^{-1}) and Malawi (1.32 bees plant^{-1}) while lowest mean population of honey bees was

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recorded in evening time on variety Paracha (0.69 bees plant^{-1}) followed by Anmol (0.75 bees plant^{-1}), Sonam (0.77 bees plant^{-1}), Malawi and Gudka (0.78 bees plant^{-1}). Species of honey bees play an important role in bitter gourd pollination and about 95% of honey bees are involved in visiting bitter gourd *Momordica charantia* and cucumber crops (Schultz, 2006). Shah *et al* (2015) has also reported *Apis mellifera* and *Apisflorea* as efficient pollinators of cucurbits. Table 2 shows that the mean population of carpenter bees was noted highest in morning on variety Sonam (0.98 bees plant^{-1}) followed by Gudka (0.88 bees plant^{-1}), Paracha (0.85 bees plant^{-1}), Anmol (0.84 bees plant^{-1}) and Malawi (0.81 bees plant^{-1}) while lowest population of carpenter bees was recorded in evening on variety Sonam (0.37 bees plant^{-1}), followed by Gudka (0.38 bees plant^{-1}), Anmol (0.39 bees plant^{-1}) Malawi (0.40 bees plant^{-1}) and Paracha (0.44 bees plant^{-1}). Oronje, *et al.,* (2012) have also reported honey bees (*Apismillifera*), *Lasioglossum* sp., *Xylocopa* sp. and *Plebienahildebrandti*as the major insect pollinators of bitter gourd (*Momordica charanta*). Bodlah and Waqar (2013) have reported *Xylocopa* species of carpenter bees visiting bitter gourd (*Momordica charanta*) crop. Subhakar*et al*., (2011) have reported *Amegilla* species pollinating bitter gourd flowers. Several species of butterflies were recorded visiting bitter gourd (*Momordica charanta*) crop. Butterflies visit flowers during daytime and these insects are comparatively less effective regarding pollinating the flowers. Mean population of butterflies is presented in table 3 which was recorded highest in morning time on variety Sonam (0.74 butterflies plant^{-1}) followed by Anmol (0.73 butterflies plant^{-1}), Gudka (0.65 butterflies plant^{-1}), Paracha (0.64 butterflies plant^{-1}) and Malawi (0.62 butterflies plant^{-1}) while lowest mean population of butterflies was recorded in evening time on variety Sonam (0.38 butterflies plant^{-1}) followed by Gudka (0.42 butterflies plant^{-1}), Malawi (0.45 butterflies plant^{-1}), Anmol (0.48 butterflies plant^{-1}) and Paracha (0.49 butterflies plant^{-1}). Saed, (2012) has reported butterflies and moths as frequent visitors of bitter gourd (*Momordica charantia*) flowers. Shah *et al.,* (2015) have reported cabbage butterfly and lemon butterfly as good pollinators of cucurbitacae family. Subhakar*et al.,* (2011) have reported 4 species of butterflies visiting bitter gourd flowers including cabbage butterfly and lemon butterfly. Deyto and Cervancia (2009) have stated that lepidopterans were the most frequent visitors among different insect pollinators on *Momordica charantia*in Philippines.

Moreover, one species of Syrphid fly *Eristalistenax* was found visiting bitter gourd (*Momordica charanta*) varieties. Table 4 shows that highest mean population of syrphid fly was recorded in morning on variety Paracha (0.82 flies plant^{-1}) followed by Malawi and Gudka (0.78 flies plant^{-1}), Anmol (0.77 flies plant^{-1}) and Sonam (0.70 flies plant^{-1}) while lowest population of Syrphid flies was recorded in evening on variety Anmol (0.22 flies plant^{-1}) followed by Sonam and Malawi (0.26 flies plant^{-1}), and Paracha and Gudka (0.33 flies plant^{-1}). A Syrphid fly, *E. laetus,* also showed good potential for bitter gourd pollination (Sajjad and Saeed, 2009). Saed*et al.,* (2012) has reported two *Erastilinus* species visiting bitter gourd crop. Subhakar*et al*., (2011) has also reported *Erastilinus* species visiting bitter gourd (*Momordica charantia*) flowers.

The current data shows that all insect pollinators have maximum population at morning (09am-12pm) as compared to evening (03-06pm). Subhakar*et al*., (2011) has reported maximum foraging activity of insect pollinators of bitter gourd during morning. Saed*et al*., (2012) have reported morning as peak foraging timing of bitter gourd pollinators. Other researchers also found that the peak foraging time of pollinators is in morning during hot weather (Ahmad and Aslam, 2002).

Similarly yield of bitter gourd (*Momordica charantia*) was recorded from both covered and uncovered plots. figure 1 shows that more yield was obtained from uncovered plots. The analysed

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data showed that the yield is usually frequently and considerably larger inside insect pollinated plots through the entire growing time. Highest mean yield of all varieties was obtained from open plots; having access to insect pollinators [Anmol (9140 Kg ha^{-1}), Malawi (6924 Kg ha^{-1}), Gudka (6751 Kg ha^{-1}), Sonam (6560 Kg ha^{-1}) and Paracha (6198 Kg ha^{-1})] while lowest mean yield of all varieties was obtained from nylon covered plots; having no access to insect pollinators [Anmol (1007 Kg ha^{-1}), Malawi (1288 Kg ha^{-1}), Gudka (976 Kg ha^{-1}), Sonam (891 Kg ha^{-1}) and Paracha (1097 Kg ha^{-1})]. Gingras *et al.*, (1997) has reported that fruits were produced from all plots, but plots that were open to insect pollinators produced significantly more fruits, with superior weight and pollination rates. Furthermore, an increase of 85.21% was recorded in yield of bitter gourd (*Momordica charantia*) in insect pollinated plots when compared with covered plots (having no access to insect pollinators) yield. Laberge *et al*., (2006) have recorded 60% increase in yield of cucumber achieved by utilization of pollinators.Subhakar*et al*., (2011) has also recorded highest weight, number of seeds and seed weight of bitter gourd (*Momordica charantia*) in unrestricted open pollinated plots. Moreover, Parker (2006) observed that plants openly accessible to pollinators generated 25% more yield in comparison to other plants which were denied pollinators access.

Figure 1. Mean yield of bitter gourd (*Momordica charantia*) varieties.

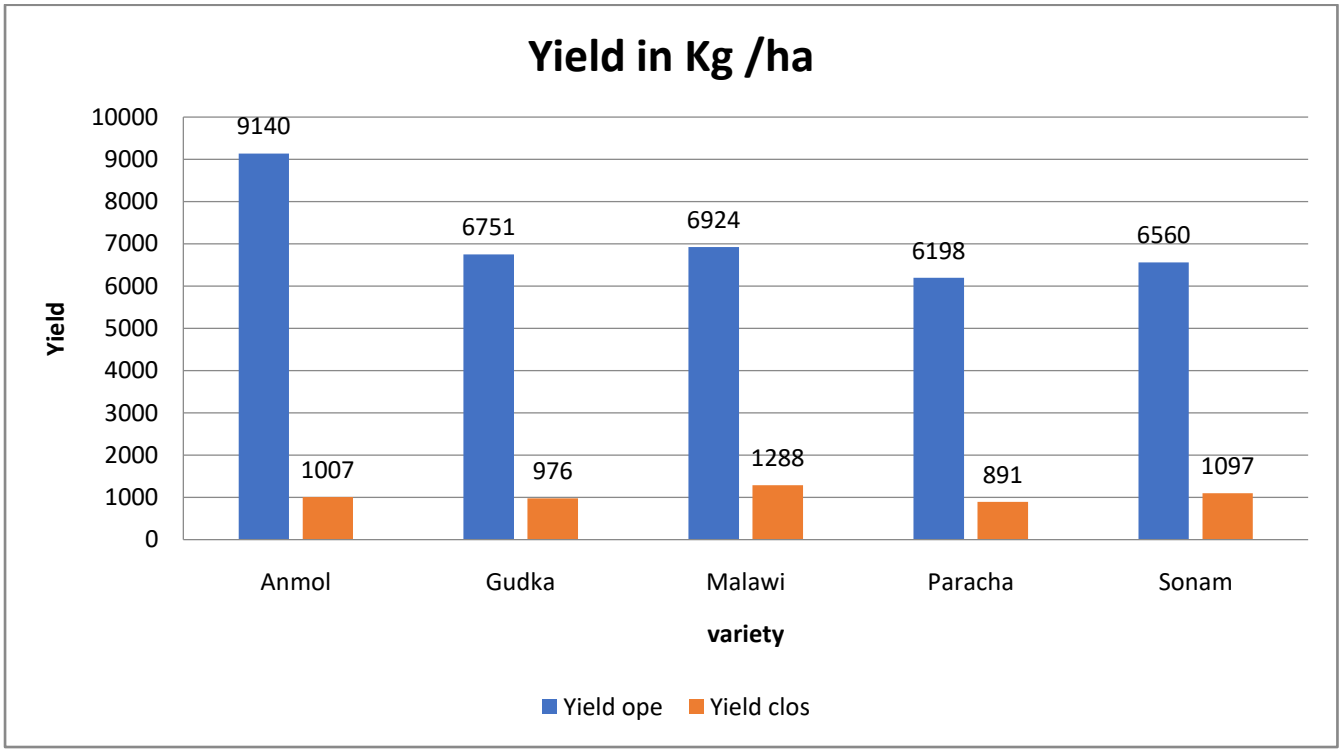

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Table 1. Mean population of Honey bees plant^{-1} on five varieties of bitter gourd from June to August 2017.

v x t × i														
Variety (V)	**Time (t)**	**Week (i)**												Mean
		1	2	3	4	5	6	7	8	9	10	11	12	
Anmol	**Morning**	0.68	1.47	1.99	2.8	1.77	2.88	2.36	1.1	0.084	0.88	0.66	0.4	1.42 a
	Evening	0.79	0.7	0.74	0.96	1.18	1.18	0.96	0.73	0.77	0.29	0.44	0.22	0.75 b
Gudka	**Morning**	0.69	1.25	2.17	1.95	1.62	2.84	2.4	0.92	1.1	0.84	0.55	0.25	1.38 a
	Evening	0.77	0.55	0.89	1	1.36	1.1	1.22	0.95	0.77	0.18	0.44	0.14	0.78 b
Malawi	**Morning**	0.52	1.14	1.66	2.21	1.62	2.84	2.43	0.92	0.95	0.68	0.58	0.25	1.32 a
	Evening	1.25	0.7	0.88	0.84	0.85	1.03	1.21	1.03	0.62	0.36	0.47	0.14	0.78 b
Paracha	**Morning**	0.58	1.83	2.32	2.51	2.03	2.83	2.13	0.77	0.44	0.55	0.4	0.44	1.40 a
	Evening	0.69	0.58	1.03	0.92	0.91	1.07	0.95	0.77	0.51	0.36	0.47	0	0.69 b
Sonam	**Morning**	0.77	1.55	2.06	2.51	1.99	2.73	2.51	0.77	0.77	0.73	0.55	0.4	1.45 a
	Evening	0.84	0.47	0.77	0.99	0.96	1.14	1.14	0.92	0.92	0.51	0.47	0.07	0.77 b
Mean		0.75 e	1.02 d	1.45 c	1.66 b	1.42 c	1.96 a	1.73 b	0.88 de	0.69 e	0.53f	0.50f	0.23 g	

Values followed by different letters are significantly different at 5% level of significance by using LSD test.

LSD for week0.14, LSD for variety 0.09, LSD for time 0.05

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Table 2. Mean population of carpenter bees plant^{-1} on five varieties of bitter gourd From June to August 2017.

Varieties (v)	Timing(t)	v × i× t												Mean
		Week (i)												
		1	2	3	4	5	6	7	8	9	10	11	12	
Anmol	**Morning**	0.75	0.95	0.88	1	1.03	1.69	1.1	0.44	0.25	0.33	0.25	0.14	0.73a
	Evening	0.33	0.44	0.55	0.7	0.51	1.25	0.97	0.29	0.11	0.4	0.14	0.14	0.48b
Gudka	**Morning**	0.8	0.58	0.8	0.58	0.88	1.95	0.95	0.4	0.18	0.29	0.18	0.18	0.65a
	Evening	0.18	0.4	0.73	0.62	0.58	0.73	0.69	0.29	0.18	0.4	0.14	0.14	0.42b
Malawi	**Morning**	0.73	0.77	0.58	0.91	0.84	1.4	0.88	0.29	0.36	0.29	0.21	0.22	0.62a
	Evening	0.29	0.33	0.65	0.51	0.58	0.66	0.83	0.44	0.29	0.36	0.22	0.25	0.45b
Paracha	**Morning**	1.32	0.88	1.06	0.62	0.73	1.4	0.84	0.14	0.11	0.29	0.22	0.14	0.64a
	Evening	0.4	0.18	0.84	0.33	0.62	1.4	0.73	0.14	0.11	0.51	0.36	0.11	0.49b
Sonam	**Morning**	1.03	0.69	1.1	0.95	1.35	1.95	0.66	0.36	0.29	0.22	0.22	0.11	0.74a
	Evening	0.55	0.07	0.51	0.66	0.58	0.62	0.4	0.29	0.14	0.44	0.22	0.14	0.38b
Mean		0.64cd	0.53d	0.77b	0.69bc	0.77b	1.30a	0.80b	0.33ef	0.20g	0.35e	0.21fg	0.16g	

Values followed by different letters are significantly different at 5% level of significance by using LSD test.

LSD variety 0.08, LSD time 0.05, LSD week0.12

Table 3. Mean population of butterflies plant^{-1} on five varieties of bitter gourd from June to August 2017.

Varieties (v)	Timing(t)	v × i× t												Mean
		Week (i)												
		1	2	3	4	5	6	7	8	9	10	11	12	
Anmol	**Morning**	0.75	0.95	0.88	1	1.03	1.69	1.1	0.44	0.25	0.33	0.25	0.14	0.73a
	Evening	0.33	0.44	0.55	0.7	0.51	1.25	0.97	0.29	0.11	0.4	0.14	0.14	0.48b
Gudka	**Morning**	0.8	0.58	0.8	0.58	0.88	1.95	0.95	0.4	0.18	0.29	0.18	0.18	0.65a
	Evening	0.18	0.4	0.73	0.62	0.58	0.73	0.69	0.29	0.18	0.4	0.14	0.14	0.42b
Malawi	**Morning**	0.73	0.77	0.58	0.91	0.84	1.4	0.88	0.29	0.36	0.29	0.21	0.22	0.62a
	Evening	0.29	0.33	0.65	0.51	0.58	0.66	0.83	0.44	0.29	0.36	0.22	0.25	0.45b
Paracha	**Morning**	1.32	0.88	1.06	0.62	0.73	1.4	0.84	0.14	0.11	0.29	0.22	0.14	0.64a
	Evening	0.4	0.18	0.84	0.33	0.62	1.4	0.73	0.14	0.11	0.51	0.36	0.11	0.49b
Sonam	**Morning**	1.03	0.69	1.1	0.95	1.35	1.95	0.66	0.36	0.29	0.22	0.22	0.11	0.74a
	Evening	0.55	0.07	0.51	0.66	0.58	0.62	0.4	0.29	0.14	0.44	0.22	0.14	0.38b
Mean		0.64cd	0.53d	0.77b	0.69bc	0.77b	1.30a	0.80b	0.33ef	0.20g	0.35e	0.21fg	0.16g	

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Values followed by different letters are significantly different at 5% level of significance by using LSD test.
LSD variety 0.07, LSD time 0.04, LSD week 0.12

Table 4. Mean population of Syrphid flies plant^{-1} on five varieties of bitter gourd at two different timings from June to August 2017.

Varieties (v)	Timing(t)	v × t × i												Mean
		Week (i)												
		1	2	3	4	5	6	7	8	9	10	11	12	
Anmol	**Morning**	0.28	0.81	1.14	1.7	1.07	1.14	1.22	0.66	0.59	0.29	0.25	0.14	0.77a
	Evening	0.26	0.4	0.4	0.33	0.14	0.33	0.18	0.22	0.14	0.18	0.07	0	0.22b
Gudka	**Morning**	0.22	0.66	1.18	1.62	1.14	1.03	1.11	0.7	0.66	0.4	0.55	0.18	0.78a
	Evening	0.47	0.36	0.4	0.36	0.25	0.47	0.81	0.14	0.22	0.11	0.11	0.25	0.33b
Malawi	**Morning**	0.36	0.77	1.29	1.62	1.18	1.1	0.74	0.66	0.51	0.51	0.55	0.14	0.78a
	Evening	0.11	0.4	0.66	0.25	0.29	0.66	0.4	0.22	0.07	0.07	0.07	0	0.26b
Paracha	**Morning**	0.33	0.7	1.18	1.88	1.26	0.6	1.03	0.95	0.59	0.7	0.62	0.07	0.82a
	Evening	0.22	0.73	0.7	0.58	0.25	0.51	0.47	0.18	0.14	0.03	0.18	0	0.33b
Sonam	**Morning**	0.33	0.7	0.88	1.77	1.36	0.36	1.03	0.66	0.36	0.36	0.44	0.11	0.70a
	Evening	0.22	0.33	0.58	0.36	0.33	0.36	0.36	0.14	0.14	0.11	0.25	0	0.26b
Mean		0.28f	0.58d	0.84b	1.05a	0.73bc	0.66cd	0.73bc	0.45e	0.34ef	0.27f	0.31f	0.09g	

Values followed by different letters are significantly different at 5% level of significance by using LSD test.
LSD for time 0.04, LSD for week 0.11, LSD for varieties 0.07

Conclusion

It is concluded from the current study that maximum insect pollinators of bitter gourd (*Momordica charantia*) belong to order Hymenoptera. Among Hymenopteran insects, Honey bees are the major pollinators of bitter gourd (*Momordica charantia*) and Peak foraging time of all pollinators is morning (09am-12pm) as compared to evening (03-06pm). Most of the pollinators had highest population in week 6 in second week of July due to high flowering. Maximum yield was obtained from uncovered plots as compared to covered plots which show that insect pollinators have high impact on yield of bitter gourd (*Momordica charantia*).

Recommendations

According to current study insect pollinators population remains low at the initial weeks of bitter gourd flowering hence, it is recommended to keep bee colonies in field to achieve high yield. Moreover, further research is needed to compare foraging ability of different insect pollinators of bitter gourd (*Momordica charantia*).

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