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Diversity of Insects Associated with Eggplant Flowers and their Role in Fruit Production

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ABSTRACT

Brinjal flowers attracted nineteen species of insects belonging to Hymenoptera (84.16%) and Diptera (18.16%). The most frequent flower visitors included *Apis dorsata*, *A. florea, A.cerana* and *A.mellifera bumblebee*, *Bombus haemorrhoidalis*, *carpenter bees, Xylocopa fenestrata, X.pubescens* halicted bees *Lasioglossum* species, *Halictus* spp. megachild bees *Chalicodoma cephalotes*, *Megachile lanata*, *Megachile bicolor* and ants belonging to family formicidae *Formica rubra, Camponotus compressus*, *Solenopsis geminate* and dipteran insects belonging to syrphidae *Eristalis tenax*, *Episyrphus balteatus Metasyrphus corrollae* and dipteran insects *Musca domestica*. The flower visitation rates varied among different flower visiting insects. *Chalicodoma cephalotes* had highest foraging rate (10.47 flower/min) and lowest in ants *Camponotus compressus* (4.08 flowers/min), the others being in between the two. Pollination by *B. haemorrhoidalis* increased fruit set of eggplants by 49.22% compared to the control without pollination (33.84%). The impact of pollination by bumblebees was superior as compared to pollination by *A.cerana, A.mellifera,* open pollination and control. The impact of pollination by bumblebees was superior as compared to pollination by *A. cerana, A. mellifera* and open pollination. Similarly all pollination treatments were superior over open pollination and control in terms of healthy fruit (%) crooked fruits (%) and number of seeds/ fruit.

Keywords Brinjal, *Solanum melongena* L. Flower visitors, Pollination, Fruit yield.

INTRODUCTION

Insect pollinators enhance fruit set of many vegetable and fruit crops (Klein *et al.* 2007). Eggplant is among the crops that benefits from insect pollination (Amoako and Yeboah-Gyan 1991, Free 1993). Brinjal (*Solanum melongena* L.), is an important solanaceous crop cultivated all over the world. Brinjal is usually self-pollinated, but the extent of cross-pollination has been reported as high as 48% and hence it is classified as cross-pollinated crop. The cone-like formation of anthers favors self-pollination; but since the stigma ultimately projects beyond the anthers, there is an ample opportunity for cross-pollination. The rates of natural cross-pollination may vary depending on genotype, location, and insect activity. The extent of outcrossing has been reported from 3 to7% in China and from 0 to 8.2% (with a mean of 2.7%) at Asian Vegetable Research Development Center (Chen 2000) ; however the In-

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Table 1. Insect visitors and their abundance on brinjal (*Solanum melongena* L.) flowers.

Order	Family	Genus species	Total abundance /m²/ 10min/5 plants	Percentage proportion	Foraging rate (Number of flowers visited / min)	Foraging speed (time spent / flower (in seconds)
Hymenoptera	Apidae	*A. dorsata*	5.97	5.16	9.54	6.14
		A. cerana	8.93	7.73	9.82	6.52
		A. mellifera	6.82	5.90	7.67	7.82
		A. florea	5.98	5.17	3.94	15.22
		Bombus haemorrhoidalis	4.82	4.17	6.97	5.33
		Xylocopa fenestrata	3.91	3.38	5.42	3.85
		X.pubescens	6.07	5.25	8.07	5.20
	Halictidae	*Lasioglossum species*	11.20	9.69		
		Halictus spp.	6.20	5.36	2.59	23.15
	Formicidae	*Formica rubra (Hymenoptera : Formicidae)*	7.00	6.06	4.72	12.7
		Camponotus compressus	8.52	7.37	4.08	14.7
		Solenopsis geminate	7.52	6.52	4.21	14.23
	Megachilidae	*Chalicodoma cephalotes*	3.40	2.94	10.47	5.73
		Megachile lanata	4.22	3.66	8.87	6.76
		Megachile bicolor	4.03	3.48	6.28	9.54
Diptera	Syrphidae	*Eristalis tenax*	7.02	6.11	8.29	7.23
		Episyrphus balteatus	3.04	2.66	5.87	10.22
		Metasyrphus corrollae	3.42	2.97	7.21	8.32
	Muscidae	*Musca domestica*	7.42	6.42	9.47	6.33

dian researchers have reported 2 to 48% outcrossing in brinjal varieties in India (Agrawal 1980, Choudhary1971, Sambandam1964). It is an important vegetable extensively grown in India, Bangladesh, Pakistan, China and Philippines. It is also popular in Egypt, France, Italy, many African countries and the United States. It is a popular vegetable in the Indian subcontinent and is referred as eggplant and aubergine in Europe, America and parts of Africa. India has the highest diversity of *Solanum* genotypes and hence is considered as the primary center of origin (Vavilov 1931, Isshiki *et al*. 1994). Major pests like brinjal shoot and fruit borer, ephilachna beetle, leaf roller and diseases like bacterial wilt, damping off and little leaf of brinjal are the major production constraints for brinjal (David 2001). Among several factors, pollination limitation is one of the possible factor in realizing the potential yield of the crop. Though the plant is considered as self pollinated, the presence of three types of flowers, with different style lengths is an indication that the plant could be often cross pollinated and that insect visitation to flowers might help in enhancing the fruit set. Free (1992) suggested that in the absence of pollinators, setting in brinjal could be poor. However, there has been very little information available on the floral biology of brinjal in relation to pollinators, pollination success and fruit set. A few studies have reported that the fruits are set by the long and medium styled flowers while the short styled flowers do not (Passam and Bolmatis 1997, Kowalska 2003). However, there is no comprehensive information available on the species of flower visitors of brinjal. Keeping in view the importance of insects in pollination of brinjal, effectiveness of different modes of pollination on its production and productivity were evaluated in this study.

MATERIALS AND METHODS

The present investigation was carried out in the experimental farm at Udheywalla which was located

Table 2. Impact of modes of pollination on fruit quality and production in brinjal (*Solanum melongena* L.).

Treatment	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Fruit set (%)	Healthy fruit (%)	Crooked fruits (%)	Number of seeds/ fruit	Weight of 1000 seeds (g)
Bombus haemorrhoidalis	15.20	58.52	97.20	49.22	54.43	14.23	312	5.87
A cerana pollination	15.12	56.50	96.32	48.33	53.89	13.73	306	5.79
A. mellifera pollination	14.44	55.76	90.42	47.45	51.56	15.86	224	5.32
Open pollination	13.60	52.32	82.20	39.34	40.92	25.37	166	3.10
Pollinator exclusion (control)	13.02	49.02	68.81	33.84	32.64	28.90	139	3.01
CD (P= 0.05)	1.7	0.44	0.20	0.92	0.83	0.52	0.62	0.91

20 kms from Sher-e- Kashmir University of Agricultural Sciences and Technology, Main campus Chatha, Jammu (32.68°N Longitude, 74.82 °E Altitude 327 masl). The study was made on crop raised in the month of September 2016. The crop variety Kashmiri Brinjal local was raised in a plot size of 5 × 5 m following package of practices. Visual observations on randomly selected plants were made in different locations as per the method described by Abrol (2010) with some modifications. Marked flowers were monitored regularly at peak flowering period between 06:00-8:00, 8:00-10:00, 10:00-12:00,12:00-2:00, 2:00-4:00 and 4:00-6:00 hrs for ten minutes in each square meter area from five plants during peak flowering period.

The observation on the selected plants were made at hourly intervals and the number of insect species visiting / 1 m^2 area for 10 minutes from each side of the plot were recorded by visual observation. Mean of such 5 observations were constitute reading for each hour. Time spent by insect species in seconds were also observed during the different time intervals. Rate of flower visitation were also recorded using chronometer (stop watch) to determine the foraging efficiency of insect pollinators. Foraging behavior of insects was also monitored keenly to work out plant pollinator interaction.

Role of insect pollination on quantity of fruit production

To determine, the impact of pollinators on quantity of fruit production, the studies were made under open pollination, hand pollination, bee pollination and self pollination. The experiment was carried out in RBD with four treatments replicated thrice. All the treatments were imposed at 10% flowering of the crop. In open pollination (T_1), pollinators had unrestrained access on flowers, whereas in hand pollination pollen from flowers was emasculated on other flowers (T_2). In bumblebee pollination (T_3), naturally pollinated flowers were tagged and bagged with envelop having minutes holes for aeration and in self pollination, flowers were caged with synthetic nylon netting to exclude nectarivorous insects (T_4). The cage was removed after completion of flowering. After maturity, the crop was harvested and compared for different treatments.

The fruit set in all the treatments was estimated by counting the number of fruit set out of female flowers. The mean fruit set was expressed as given below :

$$\text{Rate of fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Total number of female flower}} \times 100$$

RESULTS AND DISCUSSION

The data presented in Table 1 revealed that nineteen species of insects belonging to *Hymenoptera* (84.16%) and Diptera (18.16%) visited brinjal flowers. The most frequent flower visitors included *Apis dorsata, A. florea, A. cerana* and *A. mellifera* bumblebee, *Bombus haemorrhoidalis*, *Carpenter bees*, *Xylocopa fenestrata*, *X. pubescens* halicted bees

Lasioglossum species*, Halictus* spp. megachild bees *Chalicodoma cephalotes*, *Megachile lanata*, *Megachile bicolor* and ants belonging to family formicidae *Formica rubra, Camponotus compressus*, *Solenopsis geminate* and dipteran insects belonging to syrphidae *Eristalis tenax*, *Episyrphus balteatus*, *Metasyrphus corrollae* and dipteran insects *Musca domestica*. The flower visitation rates varied among different flower visiting insects. *Chalicodoma cephalotes* had highest foraging rate (10.47 flower/min) and lowest in ants *Camponotus compressus* (4.08 flowers/min), the others being in between the two.

In earlier studies, Nunes-silva *et al.* (2013) reported *Melipona fasciculata* is an efficient pollinator of eggplant (*Solanum melongena*. Abrol (2010) reported that Brinjal flowers (*Solanum melongena*) were attractive to 7 species of bees belonging to 4 families. Bumblebees*, Bombus asiaticus, B. albopleuralis* and *B. simillimus* were the predominant visitors to brinjal flowers, whereas honey bees (*Apis cerana, A. mellifera*), the carpenter bee *Xylocopa valga* and the halictine bee, *Lasioglossum* sp, visited less frequently and in fewer numbers. Abundance of various pollinating insects was in the order : *B asiaticus > B albopleuralis > B simillimus > X. valga >A cerana > A. mellifera > Lasioglossum* sp. Bumble bees were efficient pollinators on the basis of their field behavior, population dynamics, nectar and pollen carrying capacity and rate of flower visitation in unit time. Srinivas *et al.* (2016) reported twelve species of insects belonging to *Hymenoptera* (92%) and Diptera (8%) visiting brinjal flowers. The most frequent flower visitors included two species of *Xylocopa*, viz., *X. amethystina, X. aestuans* followed by *Apis dorsata*, *A. florea, Amegilla* sp. and *Tetragonula iridipennis*. The diversity of most frequent flower visitors was high during morning hours, which decreased by the afternoon and was lowest by the evening hours.

The effect of bee pollination on fruit setand quality

Pollination by *B. haemorrhoidalis* increased fruit set of eggplants by 49.22% compared to the control group without pollination, 33.84 % (Table 2). The impact of pollination by bumblebees was superior as compared to pollination by *A.cerana, A. mellifera* and open pollination. Similarly all pollination treatments were superior over open pollination and control in terms of *Pollination* by *B. haemorrhoidalis* increased fruit set of eggplants by 49.22% compared to the control group without pollination, 33.84%. The impact of pollination by bumblebees was superior as compared to pollination by *A. cerana, A. mellifera* and open pollination. Similarly all pollination treatments were superior over open pollination and control in terms of healthy fruit (%), crooked fruits (%) and number of seeds/ fruit. Gemmill-Herren and Ochieng (2008) studied the efficiency of different pollination ways on two eggplant varieties. For both of them, a positive influence of bumblebee pollination on the quality of eggplant fruits was confirmed. Fruits with significantly larger seed number were achieved in plants where flowers were pollinated by insects as compared to those set due to self-pollination or inflorescence vibrating.

Bumblebees are perfect to release the pollen from the anther efficiently. Brinjal flowers do not produce nectar. So bumblebees can be use with honeybees for brinjal pollination. The bumblebee pollinated eggplants gives higher yield (25%), fruit size (14% in weight and 7% in length) and four times higher number of seeds per fruit than vibration under unheated plastic houses (Abak *et al.* 2000). Al-Abbadi (2009) reported that the fruit set percentages for eggplant were 66, 59, 52 and 30%, for the two honeybees nuclei, one honeybees nuclei, bumblebees and control treatments, respectively. He found that *Bombus terrestris* L. perform as good pollinator after *Apis mellifera* L. in the fruit set, fruit weight and length parameters of brinjal.

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