

Pollinator community of sunflower (*Helianthus annus L.*) and its role in crop reproductive success

Wali Muhammad^{1,2*}, Shafqat Saeed³, Ammad Ahmad⁴, Muhammad Yasir Ishfaq⁵, Muhammad Mahtab Anjum⁶

¹Pest Warning and Quality Control of Pesticides, Agriculture Department, Government of Punjab, Pakistan

²Department of Entomology, Faculty of Crop and Food Sciences, PMAS Arid Agriculture University, Rawalpindi, Pakistan

³Institute of Plant Protection, Muhammad Nawaz Shareef (MNS) University of Agriculture, Multan, Pakistan

⁴Department of Entomology, University College of Agriculture and Environmental Sciences, The Islamia University of Bahawalpur, Pakistan

⁵Department of Entomology, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan

⁶Department of Entomology, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan

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Abstract

A study was carried out to identify the pollinator community and its role in pollination of sunflower at the research farm of Bahauddin Zakariya University, Multan, Pakistan. The community of pollinators was composed of 14 insect species including eight bee species (Hymenoptera), four fly species (Diptera) and two butterfly species (Lepidoptera). Bees were the most abundant floral visitors. *Apis dorsata* Fabricius, *Xylocopa* sp and *Megachile* sp. were the most abundant among the bees with the highest visitation frequencies i.e. 1.33, 0.07 and 0.06 individuals per head per minute, respectively. The abundant flies included *Eristalinus aeneus* Scopoli and *E. arvorum* Linnaeus. The peak visitation activity of pollinators was recorded between 08:00 to 10:00 hrs. Although there was no significant difference in number of seeds per head produced in insect pollinated (open) as compared with, without insect pollinated (caged) heads. However, insect pollination significantly increased the number of healthy seeds, 100 seed weight and germination percentage. As *A. dorsata* Fabricius was the major pollinator of sunflower, future studies should focus on its conservation for better crop production.

Keywords: Sunflower, Pollination, Pollinator community, Reproductive success

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*Corresponding author email:
walientomologist@gmail.com

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Introduction

Terrestrial ecosystems are mainly maintained by mutualistic interactions between animal pollinators and the flowering plants (Nicolson and Wright, 2017).

Pollination is a critical ecosystem service in natural and agricultural systems delivered by animals as 75 percent of flowering plants species require animal mediated pollination (Cayenne and Rebecca, 2003). Pollination is often carried out by animals such as



insects, birds and bats. Insect are commonly known as the best functioning elements in terms of pollination in terrestrial ecosystem of the world (Klein et al., 2007). By facilitating sexual reproduction, they put positive impact on the yield, quality and genetic stabilization of majority of crop species (Muhammad et al., 2020). Under the worst-case scenario of rapid climate change events, there is a threat of food shortage and economic insecurity especially in the developing countries (Ali et al., 2011). Pollinators, especially the wild and managed bees can contribute significantly in this regard as they contribute 62 percent of the total global food supply (Stein et al., 2017).

Sunflower (*Helianthus annuus* L.) is an economically important oilseed crop (contributes 32% of domestic edible oil production) and is cultivated under variety of environmental conditions due to its resistance to adverse weather conditions, crop rotation, intercropping options and succession in seed-producing regions (Porto et al., 2007). There are several species of wild bees helping sunflower pollination but *Bombus haemorrhoidalis* Smith is most reported specie helping sunflower pollination (Sheikh et al., 2014). Honeybees have been reported as very important pollinators of sunflowers across the world (Andrada et al., 2004; Mehmood et al., 2018). They support better seed and oil content production by supporting fertilization process (Morgado et al., 2002; Nderitu et al., 2008). Studies conducted in Pothwar area of Pakistan have shown that wild bees and honeybees are helpful in quality seed development in canola crop (Razzaq et al., 2019). However, widespread application of insecticides and destruction of nesting sites of honeybees is leading to decline in their populations and ultimately hampering sunflower yield (DeGrandi-Hoffman and Martin, 1995; Santana et al., 2002). Pollinator community is attracted towards flowering plants based on numerous factors including nectar sugars, corolla length and pollen quality. Studies have shown that sunflower pollinators are attracted to the cultivars having higher amounts of nectar sugar (Mallinger and Prasifka, 2017).

Foraging activity of pollinators is very important in determining reproductive performance of various plants (Wubie et al., 2014; Yao et al., 2006; Said et al., 2017). Foraging activity including visitation rate, visitation frequency and stay time on flower is greatly influenced with the weather conditions. Wild bees are the most abundant group of flower visitors than flies in the areas having natural vegetation (Saeed et al., 2017; Liu et al., 2019; Bartual et al., 2018). Honeybees

are most dominant pollinators in Pothwar region of Pakistan comprising of 78 % pollinator community in sunflower season. Among the honeybee's group of pollinators, *Apis mellifera* was reported as most abundant specie (Rasheed et al., 2015; Aslam and Awan, 2000; Mehmood et al., 2018; Razzaq et al., 2019; Perrot et al., 2019). Sajjad et al. (2017) have reported *Apis dorsata* and *A. florea* as the most abundant pollinators of sunflower in Multan, Pakistan. Present study was planned to evaluate the role of pollinators' community in sunflower pollination in terms of different yield attributing components and seed germination. The diurnal pollination activity was also recorded.

Material and Methods

The study was carried out at the research farm of Bahauddin Zakariya University, Multan, Pakistan from March to June, 2015. The study area was an intensively managed agricultural landscape with a small tree plantation at distance of one kilometer in East. Data recording was started when 20% sunflower plants were at flowering stage. Data was recorded continuously until about 80% seed setting occurred. At 50% flowering stage, ten plants were randomly tagged to see the effect of open pollination. Other 10 plants were covered before the opening of flowers with mesh bags to exclude insect pollinators for insects. Biweekly observations of flower-visiting insects were made from 15th of April to 15th of May. In each census, 20 plants were randomly selected and each plant was observed for 15 minutes for number of individuals of different floral visitors.

Two parameters of floral visitor assemblage were derived from the data i.e. overall abundance (total number of individuals of each floral visitor in all the censuses) and visitation frequency (mean number of individuals of each floral visitor on single plant during one minute of interval). Some of morphologically distinct floral visitors were also caught by aerial net for later identification. Insects were identified to the lowest possible taxonomic level. The data were recorded six times in each observation day i.e. 8:00, 10:00, 12:00, 14:00, 16:00 and 18:00 hrs.

The heads of open and caged plants were harvested upon maturity. The yield attributing components were recorded as the weight of heads, diameter of head (cm), number of healthy and unhealthy (wrinkled) seeds per head, seed weight per head and germination percentage.



The weight of head and weight of seeds per head was measured using electronic balance. The diameter of head was recorded by using simple scale. Number of unhealthy seeds per head was measured manually. Germination percentage was determined by selection of 100 healthy seeds each from open and caged heads. These seeds were soaked for 6 hours and then sown in moist sand containing petri dishes. These petri dishes were placed under shade showered on daily bases with tap water using a hand sprayer. Germinating plants were counted on daily basis for a week until germination process stopped. The data regarding yield attributing components were compared between open and caged treatments using T-test at alpha 0.05.

Results

The generated data revealed that the floral visitors of sunflower observed were belonged to five families in three orders i.e. Syrphidae in Diptera, Danaidae in Lepidoptera and Apidae, Halictidae and Megachilidae in Hymenoptera.

Overall, insects belonging to Hymenoptera were the most abundant pollinators of sunflower crop. Among Hymenoptera, the giant wild honeybee (*Apis dorsata*) was the most abundant floral visitor with 839 individuals (Table 1). The maximum visitation frequency of 1.33 individuals /flower/minute was also observed for *A. dorsata* (Table 1).

Foraging behavior was seemed to be greatly affected by the weather factors along the day. The peak abundance of pollinators was observed at the start of the day (8:00 hrs.) which declined gradually up to 4:00 hrs. Again, it got an increase at 6:00 hrs. but less than half of the morning abundance (Figure 1).

There was no significant difference between head weight, head diameter and number of seeds per head in open and caged pollinated treatments. However, open pollinated heads (insect pollinated) showed

significantly less number of unhealthy seeds (169.6±48.5), higher 100 seed weight (6.61±0.57 g) and higher germination percentage (42.8±1.52%).

Table-1. Insect species visiting sunflower flowers along with their total abundance, visitation frequency and foraging behavior

Order	Family	Genus/Species	Overall abundance	Visitation frequency (Individuals /flower/minute)	
Diptera	Syrphidae	<i>Eupeodes corollae</i>	4	0.006	
		<i>Ischiodon scutellaris</i>	8	0.01	
		<i>Eristalinus arvorum</i>	6	0.009	
		<i>Eristalinus aeneus</i>	11	0.02	
Lepidoptera	Danaidae	<i>Danaus chrysippus</i>	10	0.02	
		<i>Eurema hecabe</i>	8	0.01	
Hymenoptera	Apidae	<i>Apis dorsata</i>	839	1.33	
		<i>Apis florea</i>	4	0.006	
		<i>Xylocopa</i> sp.	45	0.08	
		<i>Amegilla</i> sp.	13	0.02	
	Halictidae	<i>Lasioglossum</i> sp.1	13	0.02	
		<i>Lasioglossum</i> sp.2	26	0.04	
		<i>Halictus</i> sp.	20	0.03	
	Megachilidae		<i>Megachile</i> sp.	44	0.06

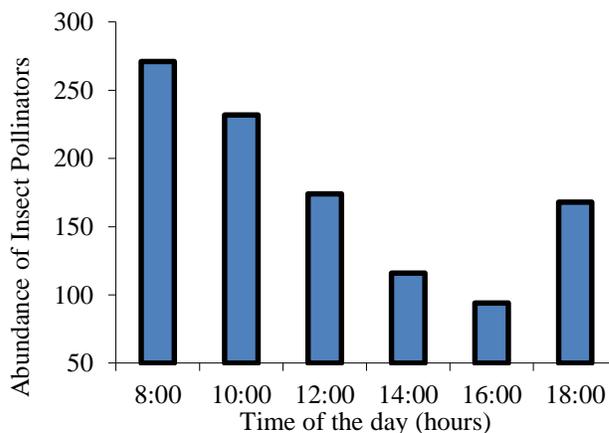


Figure-1. Diurnal abundance trend of floral visitors in sunflower

Table-2. Comparison of yield components resulted from insect pollinated and covered sunflower heads.

Yield components	Head weight (g)	Head diameter (cm)	No. of Seeds/head	No. of unhealthy seeds/head	100 Grain Wt. (g).	Germination (%)	
Insect pollinated	144±24.24	18.6±1.25	1501.4±19.42	169.6±48.5	6.61±0.57	42.8±1.52	
Self-pollinated	141.3±30.33	16.8±1.72	1479.1±121.32	364.4±36.2	5.1±0.31	21.4±3.12	
T-test result	Difference	2.746	1.873	-22.310	-194.807	1.905	21.433
	t (Observed)	0.071	0.877	-0.182	-3.218	2.907	6.169
	t (Critical)	2.306	2.306	2.306	2.306	2.306	2.306
	p-value	0.945	0.406	0.860	0.012	0.020	0.000

Discussion

Among the assorted flower visitors of sunflower in current study, *Apis dorsata* was recorded as the most abundant pollinator. In the sub-tropical climatic conditions of south Punjab, Pakistan, *A. dorsata* plays a significant role in successful seed production of sunflower, which not only improves the quality of grains but also results in higher yield (Said et al., 2018; Said et al., 2017). The arrangement of flowerets in the sunflower i.e. layer of non-productive zygomorphic ray florets at the edge of the capitulum and several productive actinomorphic disk flowerets in the center, serves as a visual signal that entices honeybees (Wojtaszek and Maier, 2014).

Native bees including wild honeybees have also been reported as important pollinators of many other crops in the study region (Muhammad et al., 2020; Bartual et al., 2018; Mehmood et al., 2018). Although other solitary bees were not as abundant as honeybees but they supplement the overall pollination of sunflower by creating interspecific behavioral interaction which ultimately increase the per-visit efficacy of honeybees (Fründ et al., 2013; Greenleaf and Kremen, 2006; Liu et al., 2019). Pollination efficiency of honeybees can increase five times when they pollinate in aggregation with wild bees, thus a little diversity and abundance of wild bees can increase the crop pollination as well as crop yield (Greenleaf and Kremen, 2006). The similar results were presented by Mehmood et al. (2018), who reported that maximum activity was observed in morning hours as shown in figure 01.

There was no significant difference observed in head weight, diameter and number of seeds per head among open and caged flowers. Head weight and its diameter are independent of the pollinators' visitation as these are mainly the varietal characters and some agronomic practices (Balalić et al., 2016; Liu et al., 2019). Moreover, sunflower also exhibits some degree of wind and self-pollination, but their role has never been quantified (Degrandi-Hoffman and Chambers, 2006; Perrot et al., 2019).

In the present study, less number of unhealthy seeds, higher seed weight and seed germination was recorded in open pollinated heads. This finding is comparable with the result of Chambó et al. (2011) who recorded 43% higher seed yield from sunflower plants that were visited by insects' pollinators compared with plants circumscribed to pollinators. Similar experiment was also performed by Nderitu et al. (2008) who also recorded 53% more seed yield from sunflower plots

which were visited by insects' pollinators as compared to plots from where pollinators were excluded.

Conclusion

Based on results of current study it was concluded that sunflower attracts a rich fauna of insects which is mostly comprises of honeybees. Insect pollination does not increase the number of seeds per head; however it increases number of healthy seeds, seed weight and germination percentage. Therefore pollinators (honeybees), not only improve the yield of sunflower but also improve the quality of seeds. Future studies should be focused on conservation of honeybees for better crop production.

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Contribution of Authors

Muhammad W: Planned and conducted the trials

Saeed S: Approved and provided funding and research area

Ahmad A: Planned the data sheets and conducted statistical analysis

Ishfaq MY: Recoded data and write up

Anjum MM: Recoded data and write up