

Original Research Article

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## Study of Evaluation of Pollination Efficiency of Major Insect Pollinators on Summer Squash (*Cucurbita pepo* L.)

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### ABSTRACT

#### Keywords

Pollination efficiency, Hybrids, Pollination, Summer squash, Forager

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An experiment on the insect pollinators was conducted with four summer squash hybrids viz., Parikrama, Chandra, Chamatkar and Gold Queen at the Research Farm of the Department of Entomology, CCS Haryana Agricultural University, Hisar. Based on pollination index (loose pollen grains sticking on the body  $\times$  abundance  $\times$  foraging rate), *A. mellifera* was the most efficient pollinator of *C. pepo* with pollination index of 1177360 followed by *A. dorsata* (773280) and *A. cerana* (223420) and *A. florea* with pollination index 63480 under agro-ecological conditions of Hisar (Haryana). The abundance (bees/m<sup>2</sup>/5 minutes) of *A. mellifera* (2.21) was highest followed by *A. cerana* (1.16), *A. dorsata* (1.07) and *A. florea* (0.62). Irrespective of species, the population was maximum (1.45 bees/m<sup>2</sup>/5 minutes) at 1000-1200 h of the day. Foragers of *A. dorsata*, *A. mellifera*, *A. florea* and *A. cerana* commenced their pollen collection activity at 0600, 0630, 0700 and 0700 h, with peak periods at 0600-0800, 0800-1000, 1000-1200 and 0800-1000 h respectively and all of them ceased their activity between 1700- 1800 h.

### Introduction

Pollination plays an important role in the reproduction and fruit set of flowering plants (Buchmann and Nabhan, 1996). Animal pollinators are thought to contribute 15 – 30% of the global food production (Roubik, 1995). Summer squash is an upright non-trailing bush (in contrast to climbing growth habit of most cucurbits) with 45-75 cm height. Fruits come in diverse forms from oblong or elongate to flatten but some varieties have a crook-necked fruits. The fruit surface may be smooth, scalloped, ridged, or warty and colour may

vary from white or cream to yellow to green but some are variegated or striped. Its fruits develop rapidly after flowering, and thus, they are harvested within few days before the seeds and rind become hard and the flesh becomes fibrous. The plant bears male and female flowers separately on same branch with many more male flowers usually being present. Bees are the most versatile, active and best-known pollinators. Pollination efficiency of different insect pollinators has been evaluated based on number of characteristics. Most of the workers (Atwal, 1970) considered the relative effectiveness of various species to affect

pollination in spite of their abundance (Free *et al.*, 1975; Anderson *et al.*, 1982). Therefore, the efficiency of an insect species as a pollinator has also been attributed to its size, foraging behaviour and the amount of loose pollen grains adhering to its body (Bohart and Nye, 1960; Free *et al.*, 1975). Brantjes and Leemans (1976) noticed that the large sized insects were effective in pollination of flowers due to their body contact with anthers and stigmas as compared to small sized insects, which often missed their contact with anthers and stigmas while foraging for floral rewards.

In addition, bees are faithful to one species of flower per trip (floral constancy), which greatly facilitates pollination. Various workers (Atwal, 1970; Kapil and Brar, 1971; Free, 1993) considered the relative effectiveness of insect pollinators of crops based on their abundance alone. Baker *et al.*, (1971) reported that the frequency of flower visitors, the number of flowers visited per unit time and the amount of pollen grains picked per visit helped to distinguish the pollinators as major and minor ones, however, he admitted that there were inherent differences in the ability of various species to affect pollination in spite of their abundance (Anderson *et al.*, 1982). Therefore, efficiency of an insect as a pollinator has also been attributed to its size, foraging behaviour, and the amount of loose pollen grains adhering to its body (Free *et al.*, 1975).

There are many native bee species in India. Hence, it is essential to estimate the contribution of pollinators in pollinating the summer squash flowers. Keeping this idea in view, the present investigation was carried out with the objective of studying the impact of insect pollinators and pollination methods on yield parameters, viz. Percent fruit set, fruit length, fruit diameter and fruit weight of summer squash. Lot of work had been done in India and abroad on its agronomic practices,

medicinal uses, distribution, pollen viability and pistil receptivity (Nepi and Pacini, 1993) but little research has been addressed in India on the role of insect pollinators on fruit production and efficiency of different insect pollinators on pollination of summer squash. Philippe (1991) reported occasional visit by Diptera, Lepidoptera and Coleoptera. Other insects found on the flowers included Halictids (*Pseudogochloropsis* sp.) and Xylocopids (*Xylocopa* sp.) as nectar gatherers (Couto *et al.*, 1990). Based on pollination index (loose pollen grains sticking on the body x abundance x foraging rate) pollination efficiency was calculated.

### **Materials and Methods**

The summer squash crop was raised at Research Farm of the Department of Entomology, CCS Haryana Agricultural University, Hisar. The field area (48x16 m) was first divided into 4 equal plots of 8 m width and 24 m length with irrigation channels of 50 cm width and 20 cm depth. Four hybrids viz., Parikrama, Chandra, Chamatkar and Gold Queen were sown, before sowing treated with Captan @ 3 g/kg. Per hill, two seeds were sown on single side edge of the raised bed keeping a distance of 80 cm between rows and 50 cm between plants.

For abundance by using a cone type hand net, the insects visiting the flowers of summer squash were collected by sweep method, and sweeps were made through out flowering period at different hours of the day. The collected insects were preserved as dry specimen and were identified. Counts of insect visitors were made on flowers of *Cucurbita pepo* per square metre for 5 minutes using a hand tally counter between different day hours following the methods given by Free (1993). The observations were started when 10 per cent of the plants came into bloom.

### **Foraging rate**

The foraging rate of different types of insect visitors was recorded in terms of the number of flowers visited per minute.

### **Loose pollen grains sticking on the body of insect pollinators**

For estimating the number of loose pollen grains sticking to the body of different insect

## **Results and Discussion**

### **Abundance**

Data on abundance of different bee species on summer squash flowers at different hours of the day have been presented in Table 1. Variations in abundance were recorded over time and space. No bee population was observed during 1200-1600 h. The mean number of bee species over different day hours on summer squash flowers ranged from 0.62 (*A. florea*) to 2.21 bees/m<sup>2</sup>/5 minutes (*A. mellifera*). Irrespective of species, the abundance of bees was lowest at 1600-1800 h (1.10 bees/m<sup>2</sup>/5 minutes) and highest at 1000-1200 h (1.45 bees/m<sup>2</sup>/5 minutes). The cumulative mean abundance of important bee species revealed that *A. mellifera* was the most abundant visitor with a mean population of 2.21 bees/m<sup>2</sup>/5 minutes followed by *A. cerana* (1.16 bees/m<sup>2</sup>/5 minutes), *A. dorsata* (1.07 bees/m<sup>2</sup>/5 minutes) and *A. florea* was as least frequent (0.78 bees/m<sup>2</sup>/5 minutes) visitor of summer squash flowers in the present investigations (Table 1).

All the bee species started visiting the crop from 0600 h of the day but their abundance varied during different intervals of the day. *A. dorsata* and *A. mellifera* were most abundant during 1000 to 1200 h of the day (1.63 and 2.50 bees/m<sup>2</sup>/5 minutes, respectively) while *A. florea* was most abundant during 0600 to 0800

h (0.83 bees/m<sup>2</sup>/5 minutes) and *A. cerana* during 1600 to 1800 h (1.46 bees/m<sup>2</sup>/5 minutes) of the day (Table 1).

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### **Foraging rate**

The data on number of flowers visited per minute (foraging rate) by different bee species on summer squash flowers have been presented in Table 2. The number of flowers visited by four bee species differed significantly during different times of the day.

The mean foraging rate in case of *A. mellifera* varied from 5.20 to 6.07 flowers during different hours of the day. It was 3.13 to 3.33 flowers in case of *A. cerana*, 3.90 to 5.26 flowers in case of *A. dorsata* and 1.97-2.20 flowers for *A. florea*. Among the bee species, the mean foraging rate was highest in *A. mellifera* (5.45 flowers/minute), followed by *A. dorsata* (4.38 flowers/minute) and *A. cerana* (3.21 flowers/minute), and it was lowest in *A. florea* (2.10 flowers/minute).

### Number of loose pollen grains sticking to the body of a bee

The number of loose pollen grains sticking to the body of bees while foraging on summer squash flowers has been presented in Table 3. Significant differences were found among the number of loose pollen grains sticking to the body of different foragers. *A. dorsata* had the highest loose pollen grains on their body (165000 pollen grains) followed by *A.*

*mellifera* ( 97750 pollen grains) and *A. cerana* (60,000 pollen grains), and it was lowest in case of *A. florea* (48750 pollen grains). Irrespective of four bee species, the number of loose pollen grains sticking to the body of bee did not differ significantly among different hybrids of summer squash. It was highest in cultivar Chamatkar (94500 pollen grains), followed by Chandra (93750 pollen grains), Parikrama (92500 pollen grains) and lowest in Gold Queen (90750 pollen grains) hybrid.

### Pollination efficiency

The data on pollination efficiency of different bee species foraging on summer squash flowers presented in Table 4. depict that *A. mellifera* entrapped the maximum number of pollen grains (165000 pollen grains) followed by *A. dorsata* (97750 pollen grains), *A. cerana* (60000 pollen grains) and *A. florea* (av. 48750 pollen grains).

**Table.1** Abundance of different bee species on flowers of *Cucurbita pepo* during different hours of the day

Bee species	Number of bees/m <sup>2</sup> /5 minutes during different day hours				
	0600-0800	0800-1000	1000-1200	1600-1800	Mean
<i>Apis dorsata</i>	0.66 (1.28)	1.33 (1.53)	1.63 (1.67)	0.66 (1.28)	<b>1.07 (1.44)</b>
<i>Apis mellifera</i>	2.17 (1.76)	2.33 (1.82)	2.5 (1.87)	1.83 (1.66)	<b>2.21 (1.78)</b>
<i>Apis florea</i>	0.83 (1.29)	0.67 (1.35)	0.51 (1.29)	0.46 (1.23)	<b>0.62 (1.29)</b>
<i>Apis cerana</i>	1.16 (1.52)	0.83 (1.47)	1.17 (1.34)	1.46 (1.53)	<b>1.16 (1.47)</b>
<b>Mean</b>	<b>1.21 (1.46)</b>	<b>1.29 (1.54)</b>	<b>1.45 (1.55)</b>	<b>1.10 (1.42)</b>	

Each value represents mean of 20 observations  
 Figures in parenthesis are transformed values.

	SE(m)	C.D. (p= 0.05)
<b>Bee species</b>	(0.04)	(0.13)
<b>Day hours</b>	(0.04)	(0.15)
<b>Bee species × Day hours</b>	(0.08)	(0.27)

**Table.2** Foraging rate of different bee species on flowers of *Cucurbita pepo* during different hours of the day

Bee species	Number of flowers visited per minute				
	0600-0800	0800-1000	1000-1200	1600-1800	Mean
<i>Apis dorsata</i>	4.27 (2.31)	5.26 (2.24)	4.10 (2.20)	3.90 (2.27)	<b>4.38 (2.26)</b>
<i>Apis mellifera</i>	5.21 (2.21)	6.07 (2.23)	5.31 (2.48)	5.20 (2.47)	<b>5.45 (2.35)</b>
<i>Apis florea</i>	2.20 (1.42)	2.07 (1.48)	2.17 (1.45)	1.97 (1.48)	<b>2.10 (1.46)</b>
<i>Apis cerana</i>	3.20 (2.47)	3.33 (2.51)	3.13 (2.50)	3.17 (2.45)	<b>3.21 (2.49)</b>
<b>Mean</b>	<b>3.72 (2.10)</b>	<b>4.18 (2.11)</b>	<b>3.68 (2.16)</b>	<b>3.56 (2.18)</b>	

Each value represents 20 observations  
 Figures in the parentheses are  $\sqrt{(x+1)}$  transformed values

**Table.3** Per cent abundance of different bee species on flowers of *Cucurbita pepo* during different hours of the day

Bee species	Number of bees/m <sup>2</sup> /5 minutes during different day hours				
	0600-0800	0800-1000	1000-1200	1600-1800	Mean
<i>Apis dorsata</i>	15.42 (0.66)	31.07 (1.33)	38.08 (1.63)	15.42 (0.66)	<b>21.19 (4.28)</b>
<i>Apis mellifera</i>	24.58 (2.17)	26.39 (2.33)	28.31 (2.50)	20.72 (1.83)	<b>43.71 (8.83)</b>
<i>Apis florea</i>	33.60 (0.83)	27.13 (0.67)	20.65 (0.51)	18.62 (0.46)	<b>12.23 (2.47)</b>
<i>Apis cerana</i>	25.11 (1.16)	17.97 (0.83)	25.32 (1.17)	31.60 (1.46)	<b>22.87 (4.62)</b>
<b>Mean</b>	<b>23.86 (1.21)</b>	<b>25.54 (1.29)</b>	<b>28.76 (1.45)</b>	<b>21.83 (1.10)</b>	

Each value represents mean of 20 observations

**Table.4** Pollination efficiency of different bee species on flowers of *Cucurbita pepo*

Bee species	Abundance (bees/m <sup>2</sup> /5 minutes)	Number of loose pollen grains sticking on the body of a bee	Foraging rate	Pollination index (abundance × loose pollen grains × foraging rate)	Pollination efficiency (Rank)
<i>Apis dorsata</i>	1.07	165.00	4.38	773.28	<b>2nd</b>
<i>Apis mellifera</i>	2.21	97.75	5.45	1177.36	<b>1st</b>
<i>Apis florea</i>	0.62	48.75	2.10	63.48	<b>4th</b>
<i>Apis cerana</i>	1.16	60.00	3.21	223.42	<b>3rd</b>

The abundance of *A. mellifera* (2.21 bees/m<sup>2</sup>/5 minutes) was highest followed by *A. cerana* (1.16 bees/m<sup>2</sup>/5 minutes) and *A. dorsata* (1.07 bees/m<sup>2</sup>/5 minutes), while the abundance of *A. florea* was least (0.62 bees/m<sup>2</sup>/5 minutes) and the foraging rate of *A. mellifera* (5.45 flowers visited/minutes) was highest followed by *A. cerana* (3.21 flowers visited/minutes) and *A. dorsata* (4.38 flowers visited/minutes), while the foraging

rate of *A. florea* was least (2.10 flowers visited/minutes) but the pollination index of *A. mellifera* was highest (1177360) followed by *A. dorsata* (773280), *A. cerana* (223420) and *A. florea* (63480). Hence, it was observed that *A. mellifera* was the most efficient pollinator followed by *A. dorsata*, *A. cerana* and *A. florea* on summer squash flowers under agro-ecological conditions of Hisar.



The data on foraging activity of different bee species on summer squash flowers presented in Table 4 depict that *A. dorsata* initiated foraging activity on summer squash flowers little earlier in the morning and ceased its activity little later in the evening when compared to *A. mellifera*, *A. cerana* and *A. florea*. *A. dorsata* started collecting pollens from 0600 h of the day, *A. mellifera* from 0630 h while *A. cerana* and *A. florea* from 0700 h of the day. Peak activity in pollen collection was observed during 0600-0800 h (*A. dorsata*), 0800-1000 h (*A. mellifera* and *A. cerana*) and 1000-1200 h (*A. florea*) of the day. Foraging activity for nectar by *A. dorsata* initiated from 0630 h of the day while in *A. mellifera* and *A. cerana* it started from 0730 h and in *A. florea* from 0800 h of the day. However, all the four bee species attained their peak nectar foraging activity during 1000-1200 h of the day.

It is concluded based on pollination index (loose pollen grains sticking on the body x abundance x foraging rate), *A. mellifera* was the most efficient pollinator of *C. pepo* with pollination index of 1177360 followed by *A. dorsata* (773280 ) and *A. cerana* (223420) and *A. florea* with pollination index 63480 under agro-ecological conditions of Hisar (Haryana). The abundance (bees/m<sup>2</sup>/5 minutes) of *A. mellifera* (2.21) was highest followed by *A. cerana* (1.16), *A. dorsata* (1.07) and *A. florea* (0.62). Irrespective of species, the population was maximum (1.45 bees/m<sup>2</sup>/5 minutes) at 1000-1200 h of the day. Foragers of *A. dorsata*, *A. mellifera*, *A. florea* and *A. cerana* commenced their pollen collection activity at 0600, 0630, 0700 and 0700 h, with peak periods at 0600-0800, 0800-1000, 1000-1200 and 0800-1000 h respectively and all of them ceased their activity between 1700- 1800 h. Out of the total foragers of the day for *A. mellifera*, 47.93 per cent were pollen, 19.01 per cent were nectar collectors and 33.06 per cent

were pollen+nectar collectors. *A. mellifera* spent maximum time (10.30 seconds/flower), whereas, *A. florea* spent least time (2.51 seconds/flower) while these values are 7.61 and 5.10 seconds/flower for *A. dorsata* and *A. cerana*. Based on pollination index (loose pollen grains sticking on the body x abundance x foraging rate), *A. mellifera* was the most efficient pollinator of *C. pepo* with pollination index of 1177360 followed by *A. dorsata* (773280 ) and *A. cerana* (223420) and *A. florea* with pollination index 63480 under agro-ecological conditions of Hisar (Haryana).

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