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Role of honeybees in the pollination of fennel (*Foeniculum vulgare* L.)

Manoj Kumar and Ramashrit Singh

Abstract

Significant differences in different modes of pollination on fennel were found during two consecutive years. The mean number of flowers/umbel were recorded maximum in open to all insect pollinators i.e 272.30 and 265.40, respectively during the mentioned year, followed by crop caged with *Apis mellifera* (244.70 & 227.90). The number of filled seeds/umbel were recorded significantly higher in open to all insect pollinators (209.66 & 192.73) followed by *Apis mellifera* pollinated crop (171.40, 157.25). The per cent seed set was maximum (76.99 & 72.61) in open to all insect pollinators whereas *Apis mellifera* pollinated crop showed significantly higher (70.04 & 69.00) seed setting as compared to self-pollinated crop (55.52 & 48.75). The 1000-seeds weights were significantly higher in open to all insect pollinators (6.50 & 6.30 g) in comparison to *Apis mellifera* pollinated crop (5.90 & 5.80 g). The seed yield obtained from open to all insect pollinators was highest (13.75 & 12.80 q/ha) while the plots with *Apis mellifera* was (12.90 & 11.50 q/ha), statistically higher than self-pollinated crop (8.80 & 7.90 q/ha). The maximum germination (84.00 & 82.50) per cent was recorded in open to all insect pollinators followed by *Apis mellifera* pollinated crop (79.50 & 77.25) per cent whereas minimum was recorded in self-pollinated crop (57.75 & 55.50) per cent in the mentioned year, respectively.

Keywords: Pollination, *Apis mellifera*, Fennel

Introduction

The importance of beekeeping has been in practice since long back mainly for honey production and a little has till been given to the primary biological and economic role played by bees in the pollination of cultivated and wild plants. Honeybees have helped mankind in maintaining biological diversity through inducing hybrid vigour by cross-pollination and saved a number of botanical sources from extinction by providing free ecosystem services in the form of cross-pollination and propagation of many cultivated and wild plants. It has been reported that coriander (*Coriandrum sativum* L.), fennel (*Foeniculum vulgare* L.) and carrot (*Daucus carota* L.) flowers are favourably visited by honeybees more for nectar but also to obtain pollen in the absence of better flora from February to March (Mishra, 1995) [1]. The exploitation of insects for pollination is one of the strategies for enhancing crop production. It is estimated that one third of the total world food production is received from cross-pollinated crops mostly visited by the bees for obtaining pollen, nectar or both (Gatoria *et al.*1996) [2]. However, little efforts have so far been made in utilizing insect pollinators for seed production in fennel crop. Hence the present experiment was carried out and the results so obtained were presented here.

Materials and Methods

The field experiments were conducted at University Apiary at Rajendra Agricultural University, Bihar, Pusa (Samartipur) during the *Rabi* 2006 & 2007 season. There were three treatments with seven replications in randomized block design (factorial). The treatments are as below:

- T₁ = Caged without insect pollinators (SP)
- T₂ = Caged with *Apis mellifera* (BP)
- T₃ = Open to all insect pollinators (OP)

Altogether, there were 21 plots of 3 x 2 m² size. The cage of fine white nylon mosquito net of 25 mesh measuring 3 x 2 x 1.5 m³ size were raised in the treatments T₁ and T₂ in each replicate at initiation of flowering. The four corners and bottom edges of all the nets were covered with soil to prevent entrance of even the minutes insect inside. T₁ was kept free from any insect pollinators (control) and T₃ was kept open for foraging any insect pollinators including honeybees, while in treatment T₂, a three frame colony of *Apis mellifera* was placed inside the

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Net for pollination when 20 per cent plants flowered. Artificial diets were provided to supplement scarcity of food inside net. The observations with respect to number of flowers/umbel, number of filled seeds/umbel, per cent seed set and 1000-seed weight were recorded from five plants already tagged randomly from each plot at ripening. The data so obtained were statistically analysed to find out treatment effects on above noted parameters.

To determine the germinability of the seeds, obtained from different treatments, were treated with Carbendazim 50 WP (Bavistin) @ 1 g/kg of seeds and 100-seeds were sown in moist soil, in earthen pot, in three replications. The

observation on germination was recorded after three weeks and per cent germination was calculated.

Results and Discussion

To determine the effect of pollination by *Apis mellifera* (BP) in fennel as compared to other mode of pollination viz., open to all insect pollinators (OP) and self-pollination (SP) caged without insect pollinators in respect of number of flower/umbel, number of filled seed/umbel, per cent seed set, 1000-seed weight, yield and germination per cent have been presented in Table 1.

Table 1: Effect of different modes of pollination on yield attributing characters of fennel during 2006

Treatments (Modes of pollination)		Yield attributing characters			
		Mean number of flower/ umbel*	Mean number of filled seed/umbel*	Per cent seed set	1000-seed weight (g.)
T ₁ -	Caged without insect pollinators (SP)	180.50	100.23	55.52	5.10
T ₂ -	Caged with <i>Apis mellifera</i> (BP)	244.70	171.40	70.04	5.90
T ₃ -	Open to all insect pollinators (OP)	272.30	209.66	76.99	6.50
	S. Em. (+)	0.184	0.298	1.371	0.088
	C.D. (P = 0.05)	0.722	1.168	5.382	0.352

* Mean of 5 observations.

It was evident from the table that there were marked variations in mentioned parameters among different modes of pollination in fennel during 2006. It was apparent that the treatment effect differed significantly from each other in respect to number of flower/umbel. The number of flower/umbel was maximum (272.30) in case of open to all insect pollinators followed by crop caged with *Apis mellifera* (244.70) while the lowest (180.50) number of flower/umbel were observed in crop pollinated without insect. The number of filled seeds/umbel were recorded significantly higher in open to all insect pollinators (209.66 seeds/umbel) followed by *Apis mellifera* pollinated crop (171.40 seeds/umbel) and lowest in self-pollinated crop (100.23 seeds/umbel). The per cent seed set was observed maximum (76.99) in open to all insect pollinators whereas *Apis mellifera* pollinated crop

showed significantly higher (70.04%) seed setting as compared to without insect pollinators (55.52%). The observations on effect of pollination on 1000-seed weight revealed that fennel grown under open to all insect pollinators showed highest seed weight (6.50 g) followed by caged with *Apis mellifera* (5.90 g) whereas the lowest weight (5.10 g) was recorded in self-pollinated crop. The 1000-seed weight recorded due to *Apis mellifera* pollination was statistically higher than self-pollinated crop.

It was evident from table 2 that the different modes of pollination have marked variations in respect to yield. The seed yield obtained from open to all insect pollination yielded maximum (13.75 q/ha) while the yield recorded due to *Apis mellifera* pollination was (12.90 q/ha) statistically higher than self-pollinated crop (8.80 q/ha).

Table 2: Effect of different mode of pollination on seed yield and germination of fennel during 2006

Treatments (Modes of pollination)		Yield (q/ha)	Per cent increase in yield		Per cent germination
			Over SP	Over BP	
T ₁ -	Caged without insect pollinators (SP)	8.80			57.75
T ₂ -	Caged with <i>Apis mellifera</i> (BP)	12.90	46.59		79.50
T ₃ -	Open to all insect pollinators (OP)	13.75	56.25	6.58	84.00
	S. Em. (+)	0.120			1.933
	C.D. (P = 0.05)	0.472			7.588

Thus, open to all insect pollinators crop yielded 56.25 per cent more yield as compared to control (without insect pollination) and 6.58 per cent over caged *Apis mellifera*. Similarly, caged with *Apis mellifera* crop yielded 46.59 per cent more as compared to without insect pollination. Therefore, *Apis mellifera* pollinated crop, though produced less in comparison to open to all insects' pollination but proved significantly better over without insect pollinated crop. The different modes of pollination in fennel crop had marked effect on per cent germination of seed also. Highest germination percentage was observed in crop open to all insect pollinators (84.00%) followed by restricted to *Apis mellifera* (79.50%) whereas

lowest germination per cent was found in control (57.75).

Similarly, the table 3 showed that significant differences in the effect of different modes of pollination in fennel on yield attributing characters during 2007. The mean number of flowers/umbel were recorded maximum (265.40) in open to all insect pollinators followed by *Apis mellifera* pollinated crop (227.90) whereas the minimum (171.30) was recorded in self-pollinated crop. The number of filled seeds/umbel were more in open to all insect pollinators (192.73) followed by *Apis mellifera* pollinated crop (157.25) while less number of filled seeds/umbel was recorded in self-pollinated crop (101.91).

Table 3: Effect of different modes of pollination on yield attributing characters of fennel during 2007

Treatments (Modes of pollination)		Yield attributing characters			
		Mean number of flower/ umbel*	Mean number of filled seed/umbel*	Per cent seed set	1000-seed weight (g.)
T ₁ -	Caged without insect pollinators (SP)	171.30	101.91	48.75	4.90
T ₂ -	Caged with <i>Apis mellifera</i> (BP)	227.90	157.25	69.00	5.80
T ₃ -	Open to all insect pollinators (OP)	265.40	192.73	72.61	6.30
	S. Em. (±)	2.826	0.157	0.670	0.188
	C.D. (P = 0.05)	5.919	0.617	2.630	0.463

* Mean of 5 observations

Similarly, per cent seed set was more in open to all insect pollinators (72.61) followed by *Apis mellifera* (69.00) while lowest per cent seed set was recorded in self-pollinated (48.75). The 1000-seed weight was recorded significantly

higher (6.30 g) in open to all insect pollinators in comparison to *Apis mellifera* pollinated crop (5.80 g) while lower (4.90 g) in without insect pollinated crop.

Table 4: Effect of different modes of pollination on seed yield and germination of fennel during 2007

Treatments (Modes of pollination)		Yield (q/ha)	Per cent increase in yield		Per cent germination
			Over SP	Over BP	
T ₁ -	Caged without insect pollinators (SP)	7.90			55.50
T ₂ -	Caged with <i>Apis mellifera</i> (BP)	11.50	45.56		77.25
T ₃ -	Open to all insect pollinators (OP)	12.80	62.02	11.30	82.50
	S. Em. (±)	0.293			0.300
	C.D. (P = 0.05)	1.149			1.179

It was evident from table 4 that different modes of pollination have marked variations on seed yield and germination per cent similarly as 2006 season. The seed yield obtained from open to all insect pollinators yielded highest (12.80 q/ha). The yield recorded due to *Apis mellifera* pollination was (11.50 q/ha) statistically higher than without insect pollinated crop (7.90 q/ha). Thus, open to all insect pollinators crop yielded 62.02 per cent more yield as compared to without insect pollination, 11.30 per cent cover caged *Apis mellifera*. Similarly, caged with *Apis mellifera* crop yielded 45.56 per cent more as compared to self-pollination. Different modes of pollination in fennel crop have the marked effect on germination percentage of seeds also. It was observed from table that maximum (82.50%) germination was recorded in open to all insect pollinators followed by *Apis mellifera* pollinated crop (77.25%) which was statistically higher than without insect pollinated crop (55.50%).

Thus, it may be concluded that the effect of different modes of pollination on fennel crop in respect of number of flower/umbel, number of filled seed/umbel, per cent seed set, 1000-seed weight, seed yield and germination per cent was significantly higher in open to all insect pollinators followed by *Apis mellifera* pollinated crop while lowest in self-pollinated crop in both the years.

The present findings are more or less in conformity with the findings of earlier several workers also on different crops. Sagar (1981) [3] also found that weight of seed produced by 1000 umbels was 31.2 g on plants visited by insects but only 15.6 g on plants caged to exclude them. Coriander (*Coriandrum sativum* L.) and fennel (*Foeniculum vulgare* L.) flowers are favourably visited by bees. Localities were reflected according to yield potential which probably depends upon the population of insect pollinators available and weather at the time of maturity of crop. It was observed near Bombay that bee pollination increased the yield by 187 per cent and in another experiment it was found that caged plants, produced only 56 per cent of the yield recorded in open fields (Deodikar and Suryanarayana, 1977; Baswana, 1984) [4, 5]. Sagar (1981) [3] reported that the visits of insects on fennel flowers played an important role in cross pollination as the

flowers where the insects had access, yielded on an average 104.9 per cent more than those covered with cage flowers of fennel. The yield from caged plots was 15.6 g as compared with 31.2 g per 1000 umbels from the uncaged plots exposed to insect pollinators. At Hisar the caged and exposed plots yielded 392 and 1364 seeds, weighing 3.4 and 9.6 g per plant, respectively (Sagar, 1981, Sihag, 1986) [3, 6]. Baswana (1984) [5] reported that the yield per plant as well as per plot was higher in open plots as compared with the caged ones. This might be due to the fact that open plots might receive frequent visits of the insect pollinators. However, 1000-seed weight was found more in caged plots due to low seed setting which provided better chances for energy and nutrients than uncaged plots. Sihag (1986) [6] observed that in coriander, plants caged to exclude insects produced 183 seeds with a weight of 2.9 g per plant and open crop, (not caged) produced 1203 seeds weighting 15.7 g. The effectiveness of honeybees (*Apis cerana*) pollination in cages varied with varieties with increase in 21 per cent and in another 124 per cent. Kumar *et al.* (1989) [7] found that in honeybee (*A. cerana indica*) pollinated flowers of onion, the number of seeds per flower (2-36), seed set (90.47%) and seed germination (77.99%) were significantly higher than in net caged (wind/self-pollination) and muslin bagged flowers (self-pollinated) being 83.81, 29.71 and 22.23 times higher under bee pollinated, open pollinated and net caged umbels under cloth bagging. Chaudhary and Kumar (2000) [8] reported that number of capsules/10 panicles, number of seeds, number of seed/capsule, seed weight and 1000-seed weight were higher in open pollination than without insect pollination. Bee pollination resulted in better quality capsules of uniform shape and bigger size in cardamom. The yield (6.30 q/ha) in coriander was obtained from the open pollinated crop followed by bee pollination (3.82 q/ha). The percent increase in yield was highest (65.03) for OP followed by (49.86) for BP over WIP.

It was found that the open pollination yielded best results followed by bee pollination and without insect pollination. (Anonymous, 2000-01) [9]. Kumar (2001) [10] reported that among the different modes of pollination, the per cent seed set

(82.40%), number of filled seeds/capitulum (40.24), 1000-seed weight (3.52 g), yield (5.50 q/ha), germination (81.20%) and oil content (31.42%) were maximum in case of crop open to all insect pollinators followed by restricted to *A. mellifera* and *A. c. indica* whereas lowest was recorded in case of the crop without insect pollinators (control). It was observed that thousand seed weight was significantly more in case of open pollination (9.35g) followed by bee pollination (8.86 g) and WIP (7.09g), But percentage increase was highest for OP over WIP (31.91) followed by BP over WIP (24.99). The highest yield (6.30 q/ha) in coriander was obtained from the open pollinated crop followed by bee pollination (3.82 q/ha). The per cent increase in yield recorded highest (65.03) for OP followed by (49.86) for BP over WIP. It was found that the open pollination gave best results followed by bee pollination and without insect pollination, (Anonymous, 2000-01) ^[9]. Singh *et al.* (2004) ^[11] reported that the effect of bee pollination on yield attributing characters and seed yield of tori was significantly different from each other. The mean number of siliqua/plant, length of one siliqua, number of seeds/siliqua, 1000-seed weight and seed yield in g/plot and q/ha were recorded to be 88.3, 5.11, 12.7, 3.13, 2117.52 and 11.74, respectively, in open pollinated (OP) which were significantly higher over bee pollinated (BP) and self pollinated (SP) were the lowest. Chaudhary (2006) ^[12] reported that mean seed yield of fennel in caged plot was 5.2 g per plant, compared to 29.7 g per plant in open pollinated plants and 26.6 g per plant in bee pollinated plants (increase of 474.7 and 413.5%, respectively) on fennel (*F. vulgare* cv. HF-33), studied in Karnal, Haryana from 1998-99 and 1999-2000. Bee-Q-treated plots gave the highest yield of 33.8 g per plant (increase of 553.4%) & yields under bee pollination were at par with those under open pollination, suggesting the significant role of insect pollinators other than honeybees, especially *Episysplus balteatus*, *Eristalis* and *Musca* species. Chhuneja, *et al.* 2007 ^[13] reported that toria is a highly cross-pollinated crop and its seed production depends on insect pollinator. The higher value of various yield parameters of toria crop and concluded keeping one 10 bee frame strength *A. Mellifera* colony per hectare of toria crop for maximized seed yield through bee pollinations. Sharma *et al.* (2008) ^[14] reported the effects of insect pollinators on the seed yield and quality of carrot due to treatment open pollination resulted in the highest seed yield per plant (69.20 and 74.93 g, respectively), number of primary umbels (1.50 and 1.54) and secondary umbels (0.99 and 1.12), germination percentage (92.6 and 92.7 %) and vigour index (1416 and 1442). Kakar (1980) ^[15] reported that the germination of seeds harvest from bee pollinated plants was found to be extent of 92.50 per cent as against 20 per cent in plots without bee pollination and it was 96.55 per cent in open pollinated. Rao and Suryanarayan (1989) ^[16] reported that in addition to quantity, the insect pollination in general also brought about high germination in onion seeds. Kumar and Jaiswal (2012) ^[17] reported that effect of different modes of pollination on quantity and quality on coriander showed significantly higher number of flowers/umbel were recorded in open to all insect pollinators (72.60, 69.20) followed by *Apis mellifera* pollinated crops (64.30, 61.30) and lowest in self-pollinated crop (42.10, 40.50). The number of filled seeds/umbel were significantly higher in open to all insect pollinators (50.80, 46.50) followed by *Apis mellifera* pollinated crops (42.40, 39.70) and lower in self-pollinated crop (21.60, 21.50). The per cent seed set was recorded maximum (69.97, 67.19%) in open to all insect pollinators *Apis mellifera* pollinated crops showed

significantly higher seed set (65.94, 64.76%) as compared to self-pollination (51.30, 53.08%). Coriander grown under open to all insect pollinators showed highest 1000-seed weight (6.90, 6.73 gm) followed by *Apis mellifera* pollinated crops (5.41, 5.19gm) which was significantly higher over self-pollinated crop (4.10, 4.03 gm). The plots open to all insect pollinators yielded highest (14.50, 12.30 q/ha). The yield recorded in *Apis mellifera* pollinated plots was (13.25, 11.25 q/ha), statistically higher than self-pollinated crop (7.50, 7.10 q/ha). The higher germination per cent was observed in open to all insect pollinators (79.75, 76.25%) followed by *Apis mellifera* pollinated crop (72.50, 70.25%) while lowest (52.50, 51.75%) per cent in self-pollinated crop in both the years. Kumar *et al.* (2014) ^[18] reported that the seed yield of crops improve considerably by adopting proper cultural practices but insect pollinators have also been reported to play an important role in seed production of various crops. This is because most of the umbelliferous crops are cross-pollinated mainly by insects. However, little efforts have so far been made in utilizing insect pollinators for seed production. Honeybees, thus could be profitably utilized in the production of insect pollinated fruit and seed crops.

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