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Role of insect pollinators on mustard yield

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Abstract
An on farm trial was conducted at Agricultural Entomology Section, College of Agriculture, Pune to study the role of insect pollinators on mustard yield. Mustard variety-Pusa Bold was grown, following all the recommended agronomic practices except the application of insecticides. The comparative mean data pertaining to the quantitative parameters of mustard crop such as number of pods/plant, number of seeds/pod, weight of 1000 seeds (g) and seed yield (kg/ha) revealed that significantly highest values were obtained in open pollinated crop (164.40, 13.83, 4.38 and 1916.66, respectively), followed by crop covered with mosquito net (131.51, 11.57, 3.08 and 1446.68, respectively). The lowest values were recorded in the crop covered with muslin cloth (107.74, 9.89, 2.87 and 1193.49, respectively). The insect pollinators play a vital role in pollination services and hence, increase the yield of mustard crop.

Keywords: Insect pollinators, mustard, yield, field condition

1. Introduction
Indian mustard *Brassica juncea* (L.) Czern and Coss (Family: Brassicaceae and Order: Brassicales) commonly known as rai, raya or laha. It is an important oilseed crop next to sunflower. Mustard seed is rich in protein (28-36%), oil (28-32%) and essential amino acids *viz*., oleic acid (20-28%), linolenic acid (10-20%) and erucic acid (30-40%) (Solvanee and Pathak, 2016) [15]. A terminally borne, elongated corymbose raceme with a bright yellow flower makes up the inflorescence of the *B. juncea* plant (Pua and Dogulas, 2004) [9]. Pollination is a necessary process in the maintenance of a healthy and biodiverse ecosystem. In addition to increasing crop production, pollination also promotes uniform and early pod development (Abrol, 2007) [1]. The key factor in agriculture production is meeting the worlds food needs. Agricultural crops need pollination for adequate fruit setting in order to generate a sufficient amount of food. Insects are crucial pollinators (Shivanna, 2015) [12]. Pollination is the honey bees primary function in agriculture. These insects are extremely valuable economically. Since, they serve as the major pollinators (Lawal and Banjo, 2010) [6]. Bee pollination of crops is the most efficient and affordable way to boost crop yield (Singh, 2018) [14]. Several research works conducted in the field have found that honeybee pollination on mustard significantly increases pod set and productivity with hymenopteran insects accounting for 92.30 per cent of all visiting insects and *Apis mellifera* L. accounting for 99.80 per cent (Shakeel and Inayatullah, 2011) [13]. In the view of aforesaid facts and moreover considering the economic importance of insect pollinators, the present investigations were undertaken in field conditions with the following objective. To study the role of honey bees in enhancing the yield of mustard crop.

2. Materials and Methods
A field experiment was carried out during *Rabi* season 2021-2022 at Agricultural Entomology Section, College of Agriculture, Pune, Maharashtra. Two colonies of Indian honey bee were procured from CBRTI, Pune. Mustard seeds, muslin cloth, mosquito net were made available by Agricultural Entomology Section, COA, Pune. The mustard crop (Variety Pusa Bold) was raised in the plot of 16.00 m × 08.00 m area, following all the recommended agronomic practices, except application of insecticides. The experiment was laid out in Randomized Block Design with 3 treatments and 7 replications.

Table 1: Experimental details

Crop	:	Mustard
Variety	:	Pusa Bold
Design	:	Randomized Block Design
Spacing	:	60.00cm × 10.00cm
No. of treatments	:	03 (Three)
No. of replications	:	07 (Seven)
Size of the plot	:	0.50 m x 0.50 m
Date of sowing	:	31st December 2021
Date of flowering	:	4th February 2022
Date of last flowering	:	7th March 2022
Date of harvesting	:	24th March 2022
Treatment details	:	
	T_1	Open field crop
	T_2	Crop covered with white muslin cloth during flowering stage
	T_3	Crop covered with mosquito net during flowering stage

Methodology

Treatment (T_1): Open field crop: For this treatment the area of 0.50 m × 0.50 m marked by using four bamboo sticks only, so that all insect pollinators visits to flowers naturally throughout the crop growing period.

Treatment (T_2): Crop covered with white muslin cloth: The randomly selected number of spots of 0.50 m × 0.50 m size for the treatment T_2 was recorded with four bamboo sticks and the mustard crop was covered with white coloured muslin cloth before flowering. The purpose of covering with white muslin cloth was to get proper sunlight to the plants and to avoid the visiting insect pollinators on mustard flowers.

Treatment (T_3): Crop covered with mosquito net: The randomly selected number of spots of 0.5 m × 0.5 m size for the treatment T_3 was recorded with four bamboo sticks and the mustard plants was covered with mosquito net. The purpose of covering mosquito net was to facilitate partial pollination with small sized insect pollinators and to keep the crop without honey bee pollination.

Observations recorded

The research plot was kept without the application of insecticides till to pod maturity. After maturity, the muslin cloth and mosquito net were removed carefully from the plants. The crop was harvested from each plot and packed in separate bundle and were tagged. Five number of the plants were randomly selected from each bundle and all pods were carefully separated from the plants. The following observations was recorded.

a. Number of pods/plant

The pods were separated from three selected plants and was kept separately according to treatments and replications and the total number of the pods counted and expressed on a mean number of pods/plant.

b. Number of seeds/pod

The seeds removed from ten number of randomly selected pod from each treatment and counted and expressed as a mean number of seeds/pod.

c. Weight of 1000 seeds (g)

All the harvested seeds were dried under sunlight according to the treatment separately. 1000 number of seeds selected from each treatment and weight was recorded in grams.

d. Seed yield (kg/ha)

The seeds were separated from pods by threshing and yield was recorded in gram/plot and finally converted into 1kg/ha basis for statistical analysis.

Statistical analysis

The data was compiled and statistically analysed by Randomized Block Design as suggested by Panse and Sukhatme, (1985) [7].

3. Results and Discussion

The results of effect on pollinator exclusion experiments conducted to assess the role of flower visitors on pollination and are presented in the table 2. There was significant differences for all the quantitative parameters like number of pods/plant, number of seeds/pod, weight of 1000 seeds and seed yield (kg/ha) investigated among the three treatments like mustard crop allowed for open pollination, crop covered with the muslin cloth and crop covered with mosquito net.

a. Number of pods/plant

The results revealed that number of pods/plant was significantly higher in the crop allowed for open pollination (164.40) as compared to the crop which were covered with muslin cloth (107.74) and the crop which were covered with the mosquito net (131.51).

b. Number of seeds/pod

The results revealed that significantly more number of seeds/pod was recorded in the open pollination (13.83) as compared to the crop which were excluded from the pollinators such as crop covered with the muslin cloth (9.89) and the crop covered with the mosquito net (11.57).

c. Weight of 1000 seeds

The results revealed that there was considerable difference in the weight of 1000 seeds between the crop allowed for open pollination (4.38g), muslin cloth covered crop (2.87g) and mosquito net covered crop (3.08g).

d. Seed yield (kg/ha)

Significantly highest yield was obtained from open pollination (1916.66 kg/ha) followed by crop covered with mosquito net (1446.68 kg/ha) and the crop covered with muslin cloth (1193.49 kg/ha).

The present findings are in consonance with Goswami and Khan (2014) [5] who recorded maximum number of pods/plant on variety Vaibhav, Vardhan and Kranti in open pollinated

condition (164.89, 162.03 and 155.70) than in the crop caged without pollinators (79.21, 135.00 and 131.26), respectively. Atmowidi *et al*. (2007) [2] found significant increase in the yield of the mustard with more number of seeds per pod, seeds per plant in case of non-caged plants while there was increase in the number of pods/plant for two to three times when caged plants along with the honey bees and also recorded bold seeds with two to three times more weight in the presence of pollinators *i.e*. caged crop as compared to the open pollination. These results are in conformity with the results of Sekhon *et al*. (2020) [11] observed that in open pollination maximum number of pods/plant, maximum seeds/pod and highest weight of 1000 seeds was recorded during two year period (176.5 pods/plant and 179.8 pods/plant, 14.36 seeds/pod and 13 seeds/pod, 4.84g and 4.93g) when compared to the pollinators exclusion method (146.87 pods/plant and 152.39 pods/plant, 10.67 seeds/pod and 10.72 seeds/pod, 4.11g and 4.17g). Patidar *et al*. (2017) [8] findings showed that in bee pollination maximum seeds per siliqua (13.82), mean number of seeds/plant (186.44) were recorded, while the pollinator exclusion produced the lowest numbers. They also recorded maximum seed yield (kg/ha) in open pollination with 2054.38 kg/ha as compared to the pollinators exclusion with the seed yield of 1543.19 kg/ha. Sanas *et al*. (2014) [10] obtained maximum seed yield in mustard plot from open pollination and lowest seed yield in pollinators exclusion method. Devi *et al*. (2017) [4] and Devi and Sharma (2018) [3] found that the highest seed siliqua^{-1} was recorded in the open pollination method (15.54) as compared to the pollinator exclusion method (12.09).

Table 2: Effect of treatments on quantitative parameters

Tr. No.	Treatments	Number of pods/plant	Number of seeds/pod	Weight of 1000 seeds (g)	Seed yield (kg/ha)
T1	Open pollination	164.40	13.83	4.38	1916.66
T2	Crop covered with muslin cloth	107.74	9.89	2.87	1193.49
T3	Crop covered with mosquito net	131.51	11.57	3.08	1446.68
	S.E.±	3.11	0.30	0.08	53.76
	C.D @5%	9.59	0.93	0.26	165.65
	C.V	6.12	6.77	6.46	9.36

*All the observations are means of seven replications.

4. Summary and Conclusion

There was significant increase in the number of pods/plant, number of seeds/pod and weight of 1000 seeds in the crop allowed for open pollination as compared to the crop which were covered with muslin cloth and mosquito net, resulting in the dependence of the crop on pollinators for cross pollination. Number of pods/plant was in the order of open pollination (164.40) > crop covered with mosquito net (131.51) > crop covered with muslin cloth (107.74). Number of seeds/pod was in the order of open pollination (13.83) > crop covered with mosquito net (11.57) > crop covered with muslin cloth (9.89). Likewise, the weight of 1000 seeds (g) was in the order of open pollination (4.38) > crop covered with mosquito net (3.08) > crop covered with muslin cloth (2.87). Similarly, seed yield (kg/ha) was found maximum in open pollination (1916.66) followed by crop covered with mosquito net (1446.68) and crop covered with muslin cloth (1193.49).

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