



E-ISSN: 2320-7078

P-ISSN: 2349-6800

JEZS 2019; 7(5): 1380-1383

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Received: 07-07-2019

Accepted: 09-08-2019

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Impact of honey bees as a pollinators on seed production of mustard (*Brassica juncea* L.)

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Abstract

The investigation entitled “Impact of pollination of Honeybees on seed production of mustard (*Brassica juncea* L.)” was carried out during the *Rabi* 2018. The research work was conducted at research farm of Department of Agricultural Entomology, Post Graduate Institute Mahatma Phule Krishi Vidyapeeth, Rahuri. Randomized block design was used for experiment along with three replications to investigate the effect of several indigenous attractants and impact of bee pollination on yield contributing characteristics of mustard.

The treatment honey solution 5% recorded 105.07 number of pods/plant, 16.40 number of seeds/pod, 5.69 wrinkled seed/pod, fruit weight 0.35 kg/ 5 plants, net yield 19.3 q/ha and found superior among all other treatments. Followed by Jaggery solution 10% showing results of 103.8 number of pods/plants, 15.40 number of seeds/pods, 6.05 wrinkled seed/pod, 3.46, fruit weight 0.27 kg/ 5 plants, net yield of 18.00 q/ha. Lowest results showed by treatments with open pollination and pollination without insects.

Keywords: Honey bees, mustard, bee attractants, *A. florea*, *A. mellifera*, *A. cerana*, *A. dorsata*

Introduction

Brassica juncea (L.) Czern & Coss., also known as Indian mustard in Indian subcontinent belongs to the plant family Cruciferae. In the market, it is commonly referred to as Rapeseed-mustard along with four other closely related and cultivated oilseed species viz. *B. napus*, *B. rapa*, *B. carinata* and *Eruca sativa*. Over the last two to three decades, as vegetable oil demand increases with increasing population these crops has become one of the most important source of vegetable oil in the world [1]. It is cultivated in all states of India major area and production in Rajasthan, Haryana, Madhya Pradesh, Uttar Pradesh and West Bengal. Rajasthan ranked first position in production of mustard. It produced annually about 3270 MT followed by 810 MT in Haryana and 700 MT in Madhya Pradesh respectively [2].

Mustard is an often-cross-pollinated crop that is it has both type of pollination but cross pollination is about 80-85%, that's why adequate pollination is vital for significant increase in seed production. Utilization of insect pollinators, especially honeybees are considered as one of the cheapest and eco-friendly inputs in maximizing the yields [3]. Cross pollinated with insects knows as entomophilous crops and especially by honeybees is considered as one of the effective and cheapest method for triggering the crop yield both qualitatively and quantitatively. Primarily two honey bee species viz., *Apis cerana indica* and *Apis mellifera* have been successfully domesticated and practices for their well management for pollination of crops have been standardized for many crops [4]. Out of 19 insect visitors, 15 Hymenopteran and 4 Dipteran insects were found to visit the mustard blossoms. The abundance of Hymenopteran was highest followed by the Dipterans and others. In Hymenopterans, the honeybees were the most effective pollinator followed by non *Apis* bees and the *scolid* wasp [5].

The bee attractants that means material to increase the honey bee visit to specific crops would be of great practical value to harvest the benefits of cross pollination. Commercial and local bee attractants are bee line, Bee scent plus, Bee here, Bee scent, fruit boost and Bee – Q are being used to boost the yield of pea, watermelon, peach, blue berries and apple in the United States, Canada and Spain [6]. But in India local bee attractants viz. sugar solution, Jaggery solution, Sugarcane juice and honey solution are used to increase yield of the crop. However, the related studies on use of bee attractants in India are very less. In this regard, studies on effect of different bee attractants were studied with effect on yield, was studied in the present investigation.

Materials and Methods

The investigation entitled "Impact of pollination of honey bees on seed production of mustard (*Brassica juncea* L.)" was carried out during the Rabi 2018. The research work was conducted at research farm of department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri. The bee attractants viz., Sugar solution 5%, Sugar solution 10%, Sugarcane juice 5%, Sugarcane juice 10%, Jaggery solution 5%, Jaggery solution 10%, Molasses 5%, Molasses 10% and Honey solution 5% were sprayed two times, first at 10 percent flowering and second at 50 percent flowering. The experiment was laid out in randomized block design with eleven treatments and three replications with view to find out the effect of bee attractants on activities of honey bees and effect of honey bee visits on seed yield and yield contributing characters of mustard. The following yield contributing parameters were recorded to know the impact of bee pollination in enhancing the productivity of mustard.

Number of pods per plant

In every plot of treatment five plants were selected randomly and number of pods on these plants were counted. Average pods per plant were recorded.

Number of seeds per pod

This observation was recorded by selecting ten pods from each replication of treatment during harvesting. The number of seeds was counted and average seeds per pod were calculated.

Percentage of wrinkled seeds

Similarly, from selected ten pods, number of developed seeds and wrinkled seeds were counted separately and percentage of wrinkled seeds was calculated by using formula:

$$\text{Percentage of wrinkled seeds} = \frac{\text{Number of wrinkled seeds / pod}}{\text{Number of seeds / pod}} \times 100$$

Test weight (weight of 1000 seeds)

This observation was recorded by weighing 1000 dried seeds sample from each plot by using electronic weighing balance.

Yield of five plant in kg

Five plants were harvested from each replication of treatment and yield was determined in kg as harvested weighted separately and the yield per plot was later converted into yield per hectare.

Seed yield in q/ ha

Each plot was harvested weighted separately and the yield per plot was later converted into yield per hectare.

Results

The results of the present investigation showed in table 1 which shows that, all the bee attractants sprayed were significantly effect on seed yield and yield attributing characters. They proved superior in recorded parameters over control i.e., unsprayed and without pollinators.

Number of pods per plant

In case of all the treatments, honey solution 5 percent recorded 105.07 pods per plant and found superior over all other treatments such as jaggery solution 10 percent, molasses

10 percent, sugarcane juice 10 percent and sugar solution 10 percent which recorded 103.8, 97.80 and 91.53 86.33 pods per plant, respectively. The treatment open pollination recorded lowest i.e. 76.07 pods/plant followed by pollination without insect (68.53 pods/plant).

Number of seeds per pod

The plot sprayed with honey solution 5 percent recorded highest number of seeds/pod (16.10 seeds/ pod) followed by jaggery solution 10 percent (15.40 seeds/ pod).

The next treatments viz. molasses 10 percent, sugarcane juice 10 percent and sugar solution 10 percent were found superior over open pollination without spray and pollination without insects which recorded 15.00, 14.53 and 14.13 seeds/ pod respectively.

The remaining treatments viz., open pollination without spray and pollination without insects recorded 12.80 and 11.33 seeds/pod respectively.

These results clearly indicated that application of attractants has significant effect in increasing the number of seeds/pods. This was possible due to maximum visits of different species of honey bees that increased impact of pollination. Thus, it resulted in the effective cross pollination and better seed setting in mustard.

Percent wrinkled seeds/pod

The treatment honey solution 5 percent noticed least number of wrinkled seed (5.69 wrinkled seed/ pod) and proved significant over rest of treatments. The next better treatments were jaggery solution 10 percent (6.05 wrinkled seeds/ pod) and molasses 10 percent (7.56 wrinkled seeds/ pod) over open pollination without spray and pollination without insects respectively. Remaining treatments such as sugarcane juice 10 percent, sugar solution 10 percent and jaggery solution 5 percent were noticed 7.75, 8.01 and 8.04 wrinkled seeds/ pod. The treatment PWI noticed maximum number of wrinkled seeds/pod (15.87) and was significantly inferior to all the treatments. The treatment open pollination without spray recorded 11.48 wrinkled seeds/ pod.

Test weight (weight of 1000 seeds)

The average test weight of treatment honey solution 5 percent was 3.55 g. Jaggery solution 10 percent was the next better treatment which recorded 3.46 g. test weight followed by molasses 10 percent (3.44 g.). The lowest test weight of seed was observed in pollination without insects (2.91) and open pollination without spray (3.06 g.).

Yield of five plant in kg

The highest seed yield per 5 plants was recorded in treatment with honey solution 5 percent (0.35 kg). Jaggery solution 10 percent (0.27 kg) was next best treatment followed by molasses 10 percent (0.25 kg). Sugarcane juice 10 percent (0.21 kg) and sugar solution 10 percent (0.20 kg) were independently superior among other treatment. The lowest seed yield of 5 plants 0.11 kg and 0.15 kg were recorded in treatment pollination without insects and open pollination without spray respectively which were found not significant among all other treatments. These observations indicated that spraying of attractant could increase the activity of honey bees as well as yield of mustard.

Seed Yield/ha

The results concluded that about 19.33 q. seed yield per ha

was recorded in plot which received honey solution 5 percent and found significant among the rest of treatment. Jaggery solution 10 percent (18.00 q/ha) was next better treatment

followed by molasses 10 percent (16.60 q/ha). The lowest seed yield recorded in treatment pollination without insects (7.33) and open pollination (10.00) respectively.

Table 1: Effect of bee pollination on seed yield and yield contributing characters of mustard

Sr. No.	Treatment	No. of pods per plant	No. of seeds/pod	Percent wrinkled seeds	Test weight (gm)	Yield of 5 plants (kg)	Yield (Q/ha)
1.	Open Pollination	76.00	12.80	11.48	3.06	0.15	10.00
2.	Pollination Without Insects	68.50	11.33	15.87	2.91	0.11	7.33
3.	Sugar Solution 5%	78.40	12.83	10.94	3.11	0.16	10.67
4.	Sugar Solution 10%	86.33	14.13	8.01	3.18	0.20	13.33
5.	Sugarcane Juice 5%	79.00	13.00	10.26	3.21	0.17	11.33
6.	Sugarcane Juice 10%	91.50	14.53	7.75	3.26	0.21	14.00
7.	Jaggery solution 5%	82.00	14.07	8.04	3.19	0.19	12.67
8.	Jaggery solution 10%	103.80	15.40	6.05	3.46	0.27	18.00
9.	Molasses Solution 5%	81.80	13.40	8.96	3.18	0.18	12.00
10.	Molasses Solution 10%	97.8	15.00	7.56	3.44	0.25	16.60
11.	Honey Solution 5%	105.07	16.10	5.69	3.49	0.29	19.33
	SE +	1.09	0.41	0.60	0.02	0.006	0.27
	CD 5%	3.23	1.20	1.78	0.06	0.018	0.79

Discussion

Effects of pollination on fruit set of sarson; number of seeds per siliqua and mean weight of 100 seeds in controlled and open pollinated plants. Percent fruit set, number of seeds per siliqua and mean seed weight of 100 seeds compared each other and were significantly ($P < 0.01$) higher in open pollinated viz., 8.09, 9.37 and 141.86 than in controlled treatments [7]. When the honeybees were supplemented to the open pollination in sunflower, the seed setting percentage and seed yield were significantly increased and the yields were drastically reduced when the crop was covered with insect proof net that is pollination without insects [8]. Significant differences were observed between pollinated and covered plants for three yield parameters i.e., total yield, number of seeds per silique, and weight of 100 seeds. Average yields were 189.3 pods/plant in the pollinated plot and 142.2 pods/plant in the covered plots. There was an average of 150 seeds/silique in pollinated plot and in covered plots 11 seeds/silique. The weight of 100 seeds was 0.55 gm in pollinated plots and 0.37 gm in covered plots [9].

Field experiment on quantitative and qualitative effects of honeybees pollination on apple crop conducted at different fields which showed that there was no significant difference ($P > 0.01$) in the fruit set in different experimental designs in self-compatible varieties of apple (Golden Delicious and Red Gold), but the differences in these experimental designs were significant ($P < 0.01$) in self-incompatible varieties like Red Delicious and Royal Delicious [10]. Qualitative and quantitative effects of pollination on the percent fruit set; number of seeds per siliqua and mean weight of 100 seeds were compared in controlled and open pollinated plants and were recorded as significantly different ($P < 0.01$) and showed as higher in open pollinated viz., 6.41, 52.80 and 240, respectively [11]. A field experiment on the pollination efficiency of honey bees in sunflower and results recorded as the seeds/capitulum (1278), one thousand seeds weight (47.3) and% crinkled seeds (8.2) were maximum in six framed *Apis mellifera* pollinated crop followed by one colony of *Apis florea* pollinated crop. The six framed *Apis mellifera* yield in (16.4 q/ha), one colony of *Apis florea* (15.0 q/ha), and% seed setting in *Apis mellifera* (86.9%) crop was significantly higher over the crops which was in insect proof net pollination without insects [12]. A field experiment on the effect of

different modes of pollination on quantitative and qualitative parameters of Egyptian clover, *Trifolium alexandrinum* L. resulted that maximum seed setting (81.5%) was recorded in *A. mellifera* pollination with an 8 frame colony (BP-8F) followed by 4 frame colony (BP-4F) (75.1%), open pollination (OP) (73.8%) and 2 frame colony (BP-2F) (71.5%). Maximum seed yield (2662.3 seeds) was observed in treatment BP-8F followed by BP-4F (2373.8), OP (2316.3) and BP-2F (2235.5). Minimum one thousand seeds weight was observed in WIP (2.64 g) [13].

The highest germination percent were observed on *Apis cerana* F. pollinated plot seeds (90.50% germination) followed by *Apis mellifera* L. pollinated plots (87.25%) and lowest on control plots (42.00% germination) seeds. Similarly, seed test weight of 1000 seeds of *Apis cerana* F. pollinated plots (3.22 gm/1000 seeds) and *Apis mellifera* L. pollinated plots (2.93 gm/1000 seeds) were and lowest on control plots (2.26 gm/1000 seeds) recorded [14]. The niger crops to three different modes of pollination viz. caged without insects which naturally pollinate the crops, caged with *Apis mellifera* and open to all insect pollinators. observed that the best mode of pollination is when crop is caged with *Apis mellifera* which resulted into highest percent of seed set, number of filled seed/capitulum, 1000 seed weight and oil content per cent etc. as compared to crop caged without insect pollinators [15]. Significant differences reported among the tested pollination patterns regarding the different measured parameters. Among these highest fruit yield/ plant (1037.9 g), highest fruit weight (583.8±317.3 g), and greatest fruit size (546.5±278.6 cm³) were obtained in the honeybee pollination system as compared with the other two pollination patterns. The fruit yield (11.42 tons/ Fadden) was highest in honeybee pollination system and equal to 148% and 200% of that of the open and closed pollination systems respectively [16]. A field experiment on effect of different modes of pollination on yield parameters of Indian mustard showed that the maximum number of pods/plant, pod setting (%), pod length, number of seeds/pod, thousand seed weight, seed yield/ plot, seed germination (%), seed vigor and oil content (508.72 pods/plant, 86.32%, 5.69 cm, 15.66 seeds/pod, 6.87 gm, 17.63 q/ha, 89.20%, 628.12 and 39.42%, respectively) were in open pollination followed by that in bee pollination (404.56 pods/plant, 78.33%, 4.92 cm, 14.26 seeds/pod, 6.39 g,

15.57 q/ha, 85.20%, 542.54 and 38.36%, respectively) and pollinators' exclusion (287.56 pods/plant, 65.87%, 3.89 cm, 12.24 seeds/pod, 5.30 g, 13.01 q/ha, 78.40%, 385.54 and 37.04%, respectively). Seed yield increased by 35.50 and 19.66 percent in open pollinated and *Apis mellifera* pollinated plots, respectively as compared to pollinators' exclusion [17]. A laboratory reared bumble bee colony for pollination of tomato cultivar grown inside Polly house resulted in increased number of fruits per cluster (6.76 fruits/cluster), number of fruits (75.80 fruits/plant), fruit length (5.16cm), fruit breadth (5.75cm), fruit weight (93.87g), fruit yield (12.7kg/m²) and healthy fruits (90.33%). This studies also showed reduction in number of misshapen fruits (9.8%), and increased in number of seeds (102.95 seeds/fruit), 1000 seed weight (6.32gm) over control crop [18]. Pollination had no impact on number of umbels produced/plant. Both honey bee pollination and open pollination resulted in 77.45% and 87.68% increase, respectively, in seed yield of onion. The numbers of pods / umbel, number of seeds /umbels, thousand seed weight and seed germination were also increased significantly due to pollination [19].

Conclusion

With reference to above results, it could be concluded that:

- Among the all the indigenous food attractants honey solution 5 percent attracted maximum number of bees followed by jaggery solution 10 percent and molasses 10 percent.
- Better results in case of number of pods (pod/plant), number of seeds (seeds/ pod), test weight (g/1000 seeds) and total yield (q/ha) were observed in honey solution 5 percent treated plot.
- The differences in pollination without insect and open pollination without spray were non significant with regard to almost all aspect. Natural pollination contributed 36.42% yield over pollination without insect treatments.

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