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EFFECT OF BEE ATTRACTANTS AND MODE OF POLLINATION ON THE YIELD PARAMETERS OF MUSTARD USING *APIS MELLIFERA* L COLONIES

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ABSTRACT

Among the different bee attractants evaluated, the effectiveness of the treatment bee-Q @ 1.25 % was found to be superior in attracting more bees followed by, jaggery solution @ 10%. The lowest number of bees were attracted in the plots sprayed with coconut water @10%, except open pollination without any treatment spray. The highest no. of siliquae/ plant, siliquae length, no. of seeds/ siliquae, no. of seeds/ plant, seed yield/ plant and 1000 seeds weight were observed in the plot treated with bee-Q @ 1.25 % spray with 209.17 siliquae/ plant, 4.41 cm, 15.70 seeds/ siliquae, 3198.63 seeds/ plant, 13.78g/ plant and 3.35g, respectively. However, the lowest no. of siliquae/ plant, siliquae length, no. of seeds/ siliquae, no. of seeds/ plant, seed yield/ plant and 1000 seeds weight were observed in the plot treated with coconut water @ 10 % spray with 167.33 siliquae/ plant, 3.71 cm, 13.04 seeds/ siliquae, 2176.47 seeds/ plant, 10.32g/ plant and 3.10g, respectively. The highly significant results were obtained in the plots with open pollination with treatments spray which was followed by the plots with open pollination without treatment sprays, plots caged with *Apis mellifera* L. colonies and the least significant results were obtained in the plot caged without insect pollinators.

Key words: *Apis mellifera*, bee attractants, pollination, open pollination, yield parameters, sugar solution, coconut water, jaggery extract, onion extract, sugarcane juice, coriander extract, bee-Q, pomegranate juice

Brassica juncea (L.) Czern & Coss., also known as Indian mustard, belongs to Brassicaceae or Cruciferae family is generally pollinated by insects and is the most important edible oilseed. It is the world's second-largest oilseed crop after groundnut (Anonymous, 2021) with its distribution in China, Canada, India, Australia, France, Germany, etc. Honey bees are considered one of the most effective, cheapest and eco-friendly input methods for triggering crop yield both qualitatively and quantitatively. Mustard is an often-cross-pollinated and self-pollinated crop; adequate pollination is vital for the significant increase in seed production. It not only results in increasing the yield but also improves the quality. It ensures uniform maturity and early harvest of the crop (Anil, 2015). The quantitative seed production of the mustard crop is the ultimate expression of the symbiotic relationship it had with diverse floral visitors as a consequence of the pollination and fertilization process. Seed weight is a direct indicator of seed health and vigour, and it is used to assess the economic characteristics (quantitative and qualitative) characteristics of the plant. The low average yield of mustard could also be attributed to insect pests, disease damage, poor soil fertility or water stress, also there is evidence that insufficient pollination can also significantly minimize the crop yield (Free, 1999). However, there has been little research in India on the usage of bee attractants. (Patil et al., 2010). Local bee attractants, such as pomegranate juice, sugar solution, honey solution, sugarcane juice, jaggery solution, and onion solution, are commonly utilised in India to boost crop output. Mahadik et al. (2019) studied various indigenous food attractants and revealed that honey solution at 5% attracted the maximum number of bees followed by jaggery solution at 10% and molasses at 10%. The yield of rapeseed and canola can be increased by several % through pollination by insects (Manning and Wallis, 2005; Sabbahi et al., 2005; 2006). Insect pollination increased the number of pods, seeds/ pod, seed weights/ plant, and seed germination (Atmowidi et al., 2007). Goswami and Khan (2014), revealed that open-pollinated plots had the highest % pod set (83.42%) and bee-pollinated plots (75.41%), and caged-pollinated plots (62.80%). Therefore, the present investigation aimed to study the effect of bee attractants to attract *Apis mellifera* L. and also to infer the effect

of bee pollination on the yield-attributing parameters of mustard for seed production.

MATERIALS AND METHODS

The present investigations were carried out during 2021-22 in the experimental field of mustard crop and the apiary at RVSKVV- Krishi Vigyan Kendra, Morena (26°30'10.3"N & 78°0'5.87"E), Madhya Pradesh, India. The healthy seeds of mustard variety RVM- I were sown on 24/ 10/ 2021 at 5 cm depth at a row distance of 45 cm and plant to the plant of 15 cm apart with the plot size of 6.0 m x 3.0 m by following recommended package of agronomical practices. Various pests and diseases were controlled, but no pesticides were employed during the flowering time. To study the effect of different bee attractants to attract *Apis mellifera* L. in the mustard crop, an experiment was laid out in randomized block design with nine treatments replicated thrice. The treatment details are: T1: Open pollination with sugar solution @ 10%, T2: Open pollination with coconut water @ 10%, T3: Open pollination with jaggery @ 10%, T4: Open pollination with coriander @ 1.25%, T5: Open pollination with onion solution @ 10%, T6: Open pollination with sugarcane juice @ 10%, T7: Open pollination with bee-Q @ 1.25%, T8: Open pollination with pomegranate juice @ 10% and T9: Open pollination without treatment (Control). All of the treatments were applied three times at a 10-day interval at the 10% flowering stage of the crop. A one-meter square area was randomly selected and marked in each plot, and the number of *A. mellifera* bees visiting the flowers in that area every five minutes was recorded. During the flowering season, observations were obtained at five separate time slots: 0800, 1000, 1200, 1400, and 1600 hours, and the observed data was averaged daily. These observations were made one day before the spray and one, three, and five days after the spray. The data was square root transformed and statistical analysis was performed in MS Excel.

For the impact of bee pollination on the quality and quantity parameters of mustard, an experiment was laid out in Randomized Block Design with eleven treatments replicated thrice. The treatment details are T1-T9 (as mentioned above), T10: Caged with bees or bee pollination, and T11: Caged without bees or insect pollination. Plots with treatments T1 to T9 were not caged and were always exposed/open to pollination by all agencies. The treatments from T1 to T8 were sprayed three times during the flowering season starting from the 10% flowering stage at 10 days intervals. The plots with treatment T10 were caged before the beginning of flowers throughout the night to eliminate natural pollination. At the start of flowering, the crop was caged and sprayed with chlorpyriphos 20EC to kill all insects inside the cage and eliminate their contribution to pollination. Following the pesticide waiting time, the *A. mellifera* L. bee colony of determined strength at 10% flowering was placed in fine 16-mesh nylon mosquito net cages of 4x3x2 m. The bee colony was removed when all the floral bloom was exhausted. The plots with treatment T11 were caged before the beginning of flowers throughout the night to eliminate natural pollination. For the observations on qualitative and quantitative parameters, five plants (avoiding edges) were selected randomly for six different characters: number of siliquae/ plants, siliqua length (cm) (/ 10 siliquae/ plant), number of seeds/ siliquae (/ 10 siliquae/ plant), the total number of seeds/ plants, seed yield/ plant (g), 1000 seeds weight (g), and required transformation was applied followed by statistical analysis performed in MS Excel.

RESULTS AND DISCUSSION

The data presented in Table 1 indicates the number of bees attracted/ m^2/ 5 min due to different bee attractants on the day before spray and at 1, 3 and 5 days after the first, second and third sprays. According to the data analysis, the number of bees attracted/ m^2/ 5 min varied significantly with different bee attractants at 1, 3 and 5 days after the first spray. On a mean basis, bee-Q @ 1.25% was determined to be the most successful and superior treatment in attracting more bees, i.e., 34.67 bees/ m^2/ 5 min and the least successful treatment was open pollination without treatment attracting 21.89 bees/ m^2/ 5 min. Further in the second spray, the number of bees attracted / m^2/ 5 min varied significantly with different bee attractants on the day before the spray and at 1, 3 and 5 days after the spray. On a mean basis, bee-Q @ 1.25% was determined to be the most effective treatment in attracting more bees, i.e., 37.22 bees/ m^2/ 5 min and the least successful treatment was open pollination without treatment attracting 24.33 bees/ m^2/ 5 min. In the third spray, the number of bees attracted / m^2/ 5 min varied significantly with different bee attractants on the day before the spray and at 1, 3 and 5 days after the spray. On a mean basis, bee-Q @ 1.25% was determined to be the most effective treatment in attracting more bees, i.e., 37.89 bees/ m^2/ 5 min and the least successful treatment was open pollination without treatment attracting 26.22 bees/ m^2/ 5 min.

Table 1. Effect of bee attractants on *A. mellifera* in mustard (rabi 2021-22)

Treatments	Number of bee visits/ m^2/ 5 min														
	1st spray					2nd spray					3rd Spray				
	1 DBS	1 DAS	3 DAS	5 DAS	Mean	1 DBS	1 DAS	3 DAS	5 DAS	Mean	1 DBS	1 DAS	3 DAS	5 DAS	Mean
T1: Open pollination with sugar solution @ 10%	20.33 (4.56)*	35.67 (6.01)	27.67 (5.31)	25.00 (5.05)	29.44 (5.47)	22.00 (4.74)	37.67 (6.18)	34.33 (5.9)	27.67 (5.31)	33.22 (5.81)	23.00 (4.85)	42.33 (6.54)	34.33 (5.9)	29.67 (5.49)	35.44 (6.00)
T2: Open pollination with coconut water @ 10%	20.00 (4.53)	26.33 (5.18)	21.33 (4.67)	22.33 (4.78)	23.33 (4.88)	20.33 (4.56)	33.67 (5.85)	28.00 (5.34)	23.67 (4.92)	28.44 (5.38)	21.67 (4.71)	36.00 (6.04)	30.33 (5.55)	25.33 (5.08)	30.56 (5.57)
T3: Open pollination with jaggery @ 10%	20.00 (4.53)	39.00 (6.28)	31.67 (5.67)	27.33 (5.28)	32.67 (5.76)	22.67 (4.81)	41.67 (6.49)	36.67 (6.1)	29.67 (5.49)	36.00 (6.04)	24.67 (5.02)	44.33 (6.7)	36.67 (6.1)	30.33 (5.55)	37.11 (6.13)
T4: Open pollination with coriander @ 1.25%	19.67 (4.49)	29.33 (5.46)	23.00 (4.85)	23.00 (4.85)	25.11 (5.06)	20.67 (4.6)	34.33 (5.9)	29.67 (5.49)	24.67 (5.02)	29.56 (5.48)	22.33 (4.78)	37.67 (6.18)	31.00 (5.61)	26.33 (5.18)	31.67 (5.67)
T5: Open pollination with onion solution @ 10%	20.33 (4.56)	31.00 (5.61)	24.33 (4.98)	23.67 (4.92)	26.33 (5.18)	21.33 (4.67)	35.00 (5.96)	32.00 (5.7)	25.33 (5.08)	30.78 (5.59)	22.33 (4.78)	39.67 (6.34)	32.00 (5.7)	27.67 (5.31)	33.11 (5.80)
T6: Open pollination with sugarcane juice @ 10%	20.67 (4.6)	36.33 (6.07)	28.33 (5.37)	26.33 (5.18)	30.33 (5.55)	22.33 (4.78)	39.67 (6.34)	35.00 (5.96)	28.33 (5.37)	34.33 (5.90)	23.67 (4.92)	43.67 (6.65)	35.00 (5.96)	31.33 (5.64)	36.33 (6.07)
T7: Open pollination with bee-Q @ 1.25 %	20.67 (4.6)	40.33 (6.39)	35.33 (5.99)	28.33 (5.37)	34.67 (5.93)	23.33 (4.88)	43.67 (6.65)	37.67 (6.18)	30.33 (5.55)	37.22 (6.14)	25.00 (5.05)	44.67 (6.72)	37.67 (6.18)	33.33 (5.64)	37.89 (6.20)
T8: Open pollination with pomegranate juice @ 10%	19.67 (4.49)	32.67 (5.76)	26.00 (5.15)	24.33 (4.98)	27.67 (5.31)	21.67 (4.71)	36.00 (6.04)	32.67 (5.76)	26.33 (5.18)	31.67 (5.67)	22.67 (4.81)	41.67 (6.49)	32.67 (5.76)	28.33 (5.37)	34.22 (5.89)
T9: Open pollination without treatment (control)	19.67 (4.49)	23.33 (4.88)	21.67 (4.71)	20.67 (4.60)	21.89 (4.73)	20.00 (4.53)	27.67 (5.31)	24.00 (5.95)	21.33 (4.67)	24.33 (4.98)	21.33 (4.67)	29.33 (5.46)	26.33 (5.18)	23.00 (4.85)	26.22 (5.17)
C.D. p=0.05	NS	0.086	0.090	0.111	0.052	0.098	0.102	0.133	0.106	0.067	0.103	0.100	0.101	0.121	0.071
SEm ±	0.039	0.028	0.029	0.036	0.017	0.032	0.034	0.044	0.035	0.022	0.034	0.033	0.034	0.040	0.024

*Figures in parentheses square root transformed values; NS- Non significant; DBS – Day before spray; DAS – Day after spray

The present findings are in line with the findings of Manjunath (2003) who reported that spraying of bee-Q and fruit boost significantly enhanced visitation by *A. dorsata, A. cerana, A. mellifera* and other pollinators. However, attractants lost their efficacy after 5 days of spraying with sunflower. Manchare et al. (2020) stated that the bee attractants were sprayed twice, first at 10% blooming and again at 50% flowering. According to the results of bee foraging activity, the intensity of *A. dorsata* increased one day after spraying and decreased seven days later. Spraying bee attractants, such as honey solution 10%, jaggery solution 10%, and molasses 10%, attracted the greatest number of *A. dorsata* up to the fifth day after the first spray and the seventh day after the second spray. The results in the present investigation are partially in line with the findings of Venkataramegowda et al. (2013) who studied on use of bee-Q and fruit Boost as bee attractants in the pollination of niger and were observed for two weeks and estimation of seed yield was determined. Bee-Q at 12.5 gm/ lit and fruit boost at 0.75 ml/ lit was found to dramatically increase the number of bee foragers in niger plots when compared to control plots. Jayaramappa et al. (2011) reported that the studies on bee-Q @ 10, 12.5 and 15 gm/ lit, fruit boost @ 0.50, 0.75 and 1 ml/ lit, cinnamon leaf extract @ 5%, tuberose floral scented water, 10% sugar solution on ridge gourd, which is open pollinated observed that spraying of fruit boost @ 0.50 ml/ lit and bee-Q @ 12.5 gm/ lit enhanced foraging activities of Indian bees and yield by increasing yield parameters like the number of fruits per plant to 19.00 and 17.00 fruits when compared to 10.66 fruits per plant in the open-pollinated plot. The number of fruits was 21.83 and 20.83 fruits per plot when compared to 15.68 fruits per plot in open-pollinated plots. More et al. (2020) reported that there was a significant difference between bee visitation in different treatments and sprays. The bee visits on one, three and five days after the second spray of bee attractants were 13.57, 15.89 and 15.89 bees/ m^2/ 5 min, respectively and for the third spray, it was 14.11, 16.25 and 14.82 bees/ m^2/ 5 min, respectively. Thus, from the present study, it can be concluded that bee-Q @ 1.25% is the best attractant among the tested treatments in attracting a higher number of bees/ m^2/ 5 min which was followed by jaggery @ 10%. The next best treatments were sugarcane juice @ 10%, sugar solution @ 10%, pomegranate juice @ 10%, onion solution @ 10%, coriander @ 1.25%, coconut water @ 10% and the least effective treatment was open pollination without attractants application.

The data recorded on the effect of modes of bee pollination on quantity and quality parameters are presented in Table 2. Data indicated that all the bee attractants sprayed were significantly effective on seed yield and yield attributing characters. The plot treated with bee-Q @ 1.25% under open pollination conditions was found superior over all other treatments under open pollination conditions in producing the highest mean number of siliquae (209.17 siliquae/plant), highest mean siliquae length (4.55 cm/ plant), highest mean number of seeds/ siliquae (15.70 seeds/ siliquae), highest mean number of seeds/ plant (3198.63 seeds/ plant), highest mean seed yield (13.78g/ plant) and highest mean 1000 seeds weight (3.35g). However, the least no of siliquae (150.50 siliquae/ plant), lowest siliquae length (3.21 cm/plant), least number of seeds/ siliquae (12.24 seeds/ siliquae), least number of seeds/ plants (1749.58 seeds/ plant), lowest seed yield (8.79g/ plant) and lowest 1000 seeds weight (2.96g) were recorded from the crop caged without insect pollination. These results indicated that the application of attractants in open pollination conditions has a significant effect in increasing the yield of mustard crop. The present findings on the yield attributing parameters are completely in line with the findings of Mahadik et al. (2019) reported that the treatment honey solution 5% recorded 105.07 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, and net yield of 18.00 q/ha. The lowest results showed by treatments with open pollination and pollination without insects. Similarly, Subedi and Subedi (2019) reported that a significant difference was observed in the number of pods, number of seeds /pod and weight of 100 dry seeds in control and open pollination. Also, Patidar et al. (2017) studied the yield of mustard through honey bee pollinators with three pollination treatments The comparative data about modes of pollination in mustard crops revealed that the highest values of mean no. of siliqua/plant (186.44), no. of seeds/siliqua (13.82) and seed yield (20.54 q/ ha) were obtained from plants kept open to all pollinators (OP) followed by plants caged with bee hive (BP) and it was recorded lowest in plants caged pollinator exclusion (PE). Nagpal et al. (2017) conducted a field experiment on the effect of different modes of pollination on yield parameters of Indian mustard showed that the maximum number of pods/plant, pod length, pod setting (%), number of

Table 2. Effect of bee pollination on quality and quantity parameters of the mustard crop during Rabi 2021-22

Treatments	No. of siliquae / plant	Siliquae length (cm)	No. of seeds/ siliquae	Total no. of seeds/ plant	Seed yield/ plant (g)	1000 seeds weight (g)
T1: Open pollination with sugar solution @ 10%	190.50	4.21	14.19	2695.28	12.37	3.23
T2: Open pollination with coconut water @ 10%	167.33	3.71	13.04	2176.47	10.32	3.10
T3: Open pollination with jaggery @ 10%	204.33	4.41	15.48	3158.62	13.40	3.30
T4: Open pollination with coriander @ 1.25%	173.17	3.80	13.41	2323.02	10.97	3.14
T5: Open pollination with onion solution @ 10%	177.67	3.94	13.74	2431.03	11.50	3.19
T6: Open pollination with sugarcane juice @ 10%	195.00	4.30	14.47	2822.59	12.88	3.27
T7: Open pollination with bee-Q @ 1.25 %	209.17	4.55	15.70	3198.63	13.78	3.35
T8: Open pollination with pomegranate juice @ 10%	183.67	4.07	14.04	2576.46	11.99	3.19
T9: Open pollination without treatment (Control)	162.50	3.61	12.84	2086.24	9.76	3.04
T9: Caged with bees or Bee Pollination (BP)	157.33	3.50	12.61	1988.08	9.15	2.98
T10: Caged without bees or Without Insect Pollination (WIP)	150.50	3.21	12.24	1749.58	8.79	2.96
CD p=0.05	3.622	0.052	0.134	4.890	0.074	0.065
SEm±	1.227	0.017	0.045	1.657	0.025	0.022

seeds/pod, thousand seed weight, seed yield/ plot, seed germination (%), seed vigour and oil content (508.72 pods/plant, 5.69 cm, 86.32%, 15.66 seeds/pod, 6.87 g, 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, 4.92 cm, 78.33%, 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, 3.89 cm, 65.87%, 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 % in open-pollinated and *A. mellifera*-pollinated plots, respectively as compared to pollinators' exclusion. The results of the present experiment are consistent with that of Atmowidi et al. (2007), Kumari et al. (2013), Bhowmik et al. (2014), Kamel et al. (2015) and Hossain et al. (2017). Thus, the findings of the present study could have important implications for crop production and pollinator conservation efforts. However, further research is needed to investigate the specific mechanisms by which bee pollination enhances crop yields and to optimize the use of bee colonies for pollination in mustard and other crops.

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AUTHOR CONTRIBUTION STATEMENT

M.B. and A.S.Y. conceived, designed research and conducted experiments. A.S.Y. and N. contributed to analytical tools. M.B. and N. wrote the manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

REFERENCES

Anil. 2015. Role of flower visitors in pollination and seed set of mustard [*Brassica Juncea* (L.) Czern Coss] Doctoral dissertation, University of Agricultural Sciences, GKVK.

Anonymous. 2021. Ministry of Agriculture and Farmer's Welfare, Govt. of India. Available from: https://www.indiastatagri.com/table/agriculture/selected-state-wise-area-production-productivity-r/1423601 (Accessed on 25-09-2022)

Atmowidi T, Buchori D, Manuwoto S, Suryobroto B, Hidayat P. 2007. Diversity of pollinator insects in relation to a seed set of mustard, *Brassica rapa* L. (Cruciferae). Hayati Journal of Biosciences 14: 155-161.

Bhowmik B, Mitra B, Bhadra K. 2014. Diversity of insect pollinators and their effect on the crop yield of *Brassica juncea* L., NPJ-93, from southern West Bengal. International Journal of Recent Scientific Research 5: 1207-1213.

Free J B. 1999. Pollination in the tropics. Beekeeping and development 51: 6-7.

Goswami V Khan M S. 2014. Impact of honey bee pollination on pod set of mustard at Pantnagar. The Bioscan 9(1): 75-78.

Hossain I M, Rahman M M, Hossain S M, Chakraborty R, Amin R. 2017. Role of ways of insect visitors foraging for pollination in yield contributing traits of mustard. Department of Entomology; Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Jayaramappa K V, Pattabhiramaiah M, Bhargava H R. 2011. Influence of bee-attractants on yield parameters of ridge gourd (*Luffa acutangula* L.) (Cucurbitaceae). World Applied Sciences Journal 15(4): 457-462.

Kamel S M, Mahfouz H M, Blal A, El-Fatah H, Said M, Mahmoud M F. 2015. Diversity of insect pollinators with reference to their impact on yield production of canola (*Brassica napus* L.) in Ismailia, Egypt. Pesticides and Phytomedicine 30(3): 161-168.

Kumari S, Chhuneja P K, Singh J. 2013. Role of insect pollinators in seed yield augmentation of *Brassica napus*. In: Proceedings of 4th International Congress on Insect Science held on February 14-17, 2013 at Bangalore, India. 66 pp.

Mahadik P B, Kulkarni S R, Manchare R R. 2019. Impact of honey bees as a pollinator on seed production of mustard (*Brassica juncea* L.). Journal of Entomology and Zoology Studies 7(5): 1380-1383.

Manchare R R, Kulkarni S R, Mahadik P B. 2020. Effect of bee attractants on foraging activities of European bees *Apis mellifera* in Bitter gourd (*Momordicas charantia* L.). The International Journal of Engineering and Science 9(1): 50-54.

Manjunath K. 2003. Field scale evaluation of bee attractants for their efficacy in sunflower. M.Sc. Thesis. University of Agriculture Sciences, Dharwad, Karnataka, India. 120 pp.

Manning R, Wallis I R. 2005. Seed yields in canola (*Brassica napus* cv. Karoo) depend on the distance of plants from honeybee apiaries. Australian Journal of Experimental Agriculture 45: 1307-1313.

More M R, More S A, Bapurao U. 2020. Effect of bee attractants on foraging behaviour of *Apis mellifera* L. on seed onion crop (*Allium cepa* L.). Journal of Entomology and Zoology Studies 8(6): 1510-1512.

Nagpal K, Kumar S Y Y, Singh R. 2017. Effect of pollination modes on yield components in Indian mustard (*Brassica juncea* L.). Journal of Oilseed Brassica 81(2): 187-194.

Patidar, K B, Ojha, N K and Khan U I. 2017. Role of honey bee (*Apis mellifera*) in enhancing yield of mustard in humid region of Rajasthan, India. International Journal of Current Microbiology Applied Sciences 6(7): 1879-1882.

Patil J S, Mokat R B, Kamate G S, Mupade R V. 2010. Studies on the influence of bee attractants on bee visitation of *Apis dorsata* and *Trigona* sp. on onion. International Journal of Plant Protection 3(2): 174-178.

Sabbahi R. DeOliveira D. Marceau J. 2005. Influence of honey bee (Hymenoptera: Apidae) density on the production of canola (Crucifera: Brassicaceae). Journal of Economic Entomology 98(2): 367-372.

Sabbahi R. DeOliveira D. Marceau J. 2006. Does the honey bee (Hymenoptera: Apidae) reduce the blooming period of canola? Journal of Agronomy and Crop Science 192(3): 233-237.

Subedi N, Subedi P. I. 2019. Pollinator insects and their impact on crop yield of Mustard in Kusmas, Parbat, Nepal. Journal of Institute of Science and Technology 24(2): 68-75.

Venkataramegowda S, Jayaramappa K, Menon A Ceballos R. 2013. Use of bee-attractants in increasing crop productivity in Niger (*Guizotia abyssinica*. L). Brazilian Archives of Biology and Technology 56: 365-370.

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