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Impact and comparison of protected and unprotected condition to various pollinators in relation to *Apis mellifera* L. on pollination of mustard at Ambikapur (Chhattisgarh)

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Abstract
The field experiment were conducted in the Agriculture Research Farm of Raj Mohini Devi College of Agriculture and Research Station, Ambikapur (C.G.) during winter season 2020-21, to compare the protected and unprotected condition to various of pollinators in relation to *apis mellifera* l on pollination of mustard. The maximum no. of siliqua (206.6 siliqua/plant), length of per siliqua (4.72 cm), no. of seeds per siliqua (11.51 seeds/ siliqua), 1000 seed weight (5.84 g), seed yield kg/ha (1121.43 kg/ha) are obtained in T_1 (open pollination for all visitors). The minimum no. of siliqua (196.9 siliqua/plant), length of per siliqua (3.63 cm), no. of seeds per siliqua (8.77 seeds/ siliqua), 1000 seed weight) (4.04 g), seed yield kg/ha (571.43 kg/ha) were obtained in T_2 (Total closed with mosquito net without any insect) in Indian mustard.

Keywords: Agriculture, mustard, pollination, siliqua, weight, yield

1. Introduction
Indian mustard (*Brassica juncea* L. Czern) is the most important edible oilseed crops of the world after soybean and oil palm which belongs to Brassicaceae or cruciferaceae family which is mostly pollinated by insects (Bhowmik *et al*., 2014) [5]. Out of six cultivated oilseed species of genus *Brassica* more than 80% of total area occupied by indian mustard (*Brassica juncea*) alone (Chandrashekhar *et al* 2013). The oil content varies from 37 to 49% with relatively high protein content (28-36%), oleic acid (20-28%), linoleic acid (10-20%) and erucic acid (30-40%). (Sonvance and Pathak 2016) [13]. Indian mustard oil contains anti nutritional factor such as thioglucosides, glucosionate, erucic acid sinapine (cholinester), pectins and oligosaccharides. It is winter (rabi) season crop that requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Banerjee *et al*, 2010) [4].

Presently In India rapeseed and Indian mustard sown in area India is 5.96 m ha, with a production of 8.32 MT and average productivity was 1397 kg/ha (Anonymous, 2018). This crop is mainly grown in north western parts of India, Rajasthan and Uttar Pradesh are the major producing states in the country. Total area under rapseed-mustard cultivation was 47.54 thousand ha with on production of 26.99MT in Chhattisgarh and productivity was 564 kg ha (Annonymous, 2018).

Pollination is an ecological service, a role an organism plays in its ecosystem that is essential to human life. Bees are some of the most important crop pollinators. They increase production of about 75 per cent of our crop species. Research revealed that habitat fragmentation due to human activity reduces bee diversity causing shifting of bee species in another natural climate which ultimately affecting the pollination services. We can overcome by this problems by planting fallow fields and road edges with flowering plants to support wild pollinators throughout the growing season, and by reducing pesticide use, especially during crop bloom when more bees are in their fields.

Different bee species are commercial importance are found in India *viz… Apis dorsata* (Rock bee), *Apis cerana indica* (Indian hive bee), *Apis florea* (dwarf bee) and *Apis mellifera* (European or Italian bee). Rock bees are aggressive and cannot be maintained but are harvested from the wild. Honey from dwarf bees is also harvested from the wild as these are nomadic and produce very small yields. *A. cerana* indica and *A. mellifera* introduced from the temperate zone are more suitable to culturing in artificial bee boxes.

Foraging behaviour is one of the distinctive behaviours of honey bees, *Apis mellifera*. This behaviour is the link between the honey bee colony and the ambient environment. Therefore, various in-colony and out-colony factors have an impact on this behaviour, and many studies have been employed to investigate these factors. Foraging behaviour is not advantageous only for the colony and for plant pollination but also has other benefits. In contrast, some disadvantages have also been discovered to be linked with foraging activity. Practically speaking, the control over this behaviour is very important to maximize colony products as well as to increase other agricultural benefits. (Abou-Shaara 2014) [1].

Pollinators and pollination are important for crop yield. Honey bees are among the most important pollinating insects found within orchards and modern agricultural systems (Williams 1994, Morse and Calderone 2000) [15, 10]. There are many species of honeybee, but four species are common these are *A. florae, A. dorsata, A. cerana* and *A. mellifera*. Due to domestic nature, *Apis mellifera* is the most popular worldwide and can be easily reared and safely migrated from one place to other for pollination and honey production (FAO 1986) [7]. Like other honeybee species, *A. mellifera* has a high flight range for foraging (maximum 2-3 km away from its colony). Foragers take care of bringing from the environment everything that the colony needs to the hive *i.e.* pollen, nectar, water and propolis (Ameco 2012) [2]. Of the 100 crops that provide 90% of the world's food, 71 are bee pollinated, and honey bees (*A. mellifera*) are the managed pollinator conscripted to provide the necessary pollination services for most of these crops (FAO 2005) [8].

2. Materials and Methods

A field experiment was conducted during winter season 2020-21at Agriculture Research Cum Instructional Farm of Raj Mohini Devi College of Agriculture and Research Station, Ambikapur (C.G.). The experiment was laid out in randomized block design with three treatments and with seven replications.

Crop - Mustard (*Brassica juncea)*
Variety -Chhattisgarh sarson
Plot size - 7m x 4m
Date of sowing - 13-11-2021
Treatment - 3
Replication - 7
Design Randomized Block Design (RBD)

2.1 Treatment details

Three pollination studies were taken
T_1- Open pollination for all visitors.
T_2- Total closed with mosquito net without any insect.
T_3- 4 frame *Apis mellifera* colony was placed for bee pollination.

2.2 Observation to be recorded

Observation has been recorded from randomly selected and tagged per 5 plants in each plot replicated three times. The details are following:-

1. Number of siliqua per plants
2. Length of per siliqua.
3. Number of seed per siliqua.
4. 1000 seed weight.
5. Seed yield (kg/ha.)

2.3 Statistical analysis

The data obtained from the individual plant observations from RBD experiment was analyzed statistically as per the standard procedure**.**

3. Results and Discussion

3.1 Number of siliqua per plant

The impact of honey bee on pollination of mustard are sowing in table. The results revealed that maximum no. of siliqua are obtained in T_1 (open pollination for all visitors) (206.6 siliqua/plant) followed by T_3 (4 frame *Apis mellifera* colony was placed for bee pollination) (203.1 siliqua/plant). Whereas, minimum no. of siliqua are obtained in T_2 (Total closed with mosquito net without any insect) (196.9 siliqua/plant).

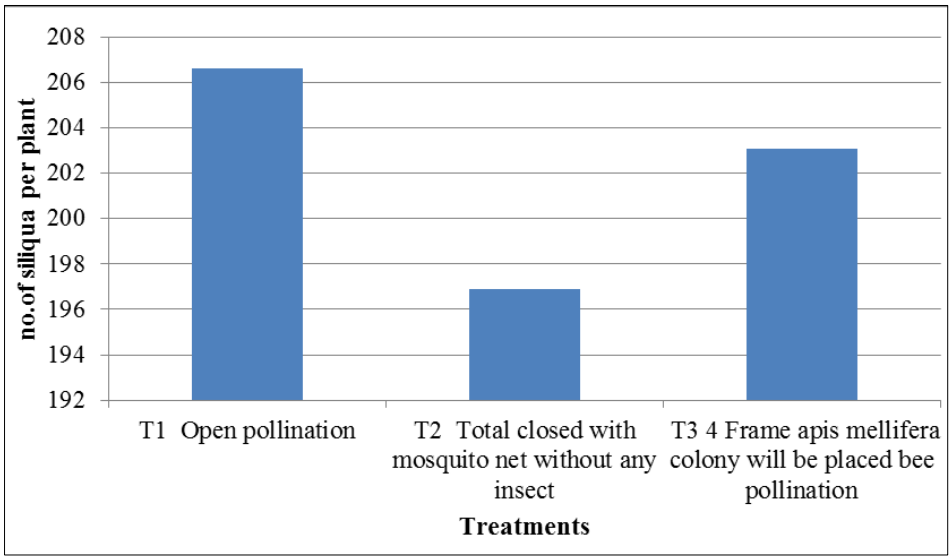

Fig 1: Number of siliqua per plant in different treatments during rabi 2021-22

3.2 Length of per siliqua.

The results revealed that maximum siliqua lengths are obtained in T_1 (open pollination for all visitors) (4.72 cm) followed by T_3 (4 frame *Apis mellifera* colony was placed for bee pollination) (4.16 cm). Whereas, minimum no. of siliqua lengths are obtained in T_2 (Total closed with mosquito net without any insect) (3.63 cm).

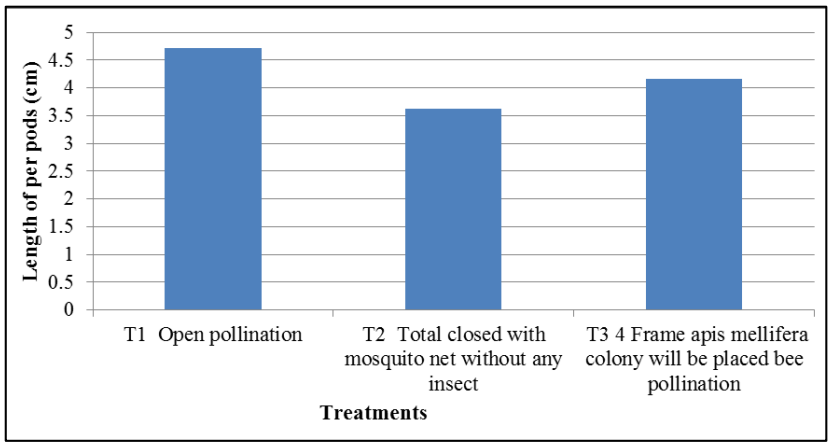

Fig 2: Length of per pods in different treatments during rabi 2021-22

3.3 No. of seeds per siliqua

The results revealed that maximum number of seeds per siliqua are obtained in T_1 (open pollination for all visitors) (11.51) followed by T_3 (4 frame *Apis mellifera* colony was placed for bee pollination) (9.49). Whereas, minimum no. of siliqua are obtained in T_2 (Total closed with mosquito net without any insect) (8.77).

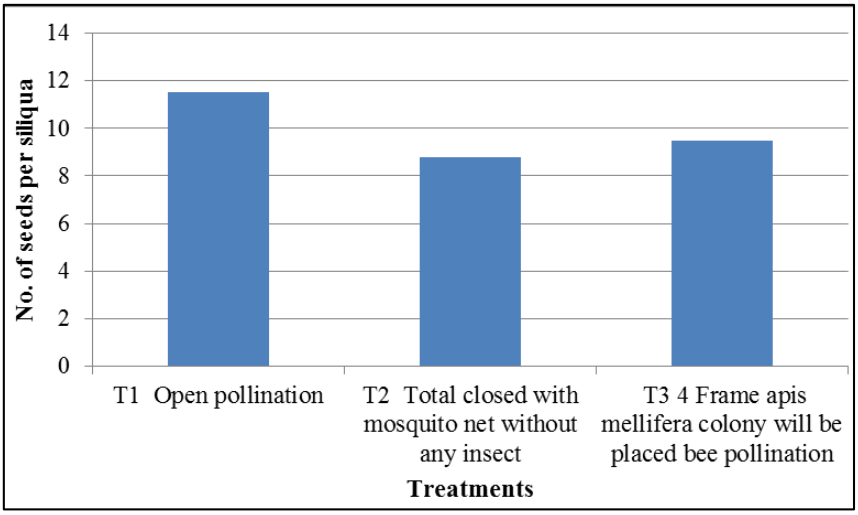

Fig 3: No. of seeds per siliqua in different treatments during rabi 2021-22

3.4 1000 seed weight in gm

The results revealed that maximum 1000 seed weight in gm are obtained in T_1 (open pollination for all visitors) (5.84 gm) followed by T_3 (4 frame *Apis mellifera* colony was placed for bee pollination) (5.50 gm). Whereas, minimum 1000 seed weight are obtained in T_2 (Total closed with mosquito net without any insect) (4.04 gm).

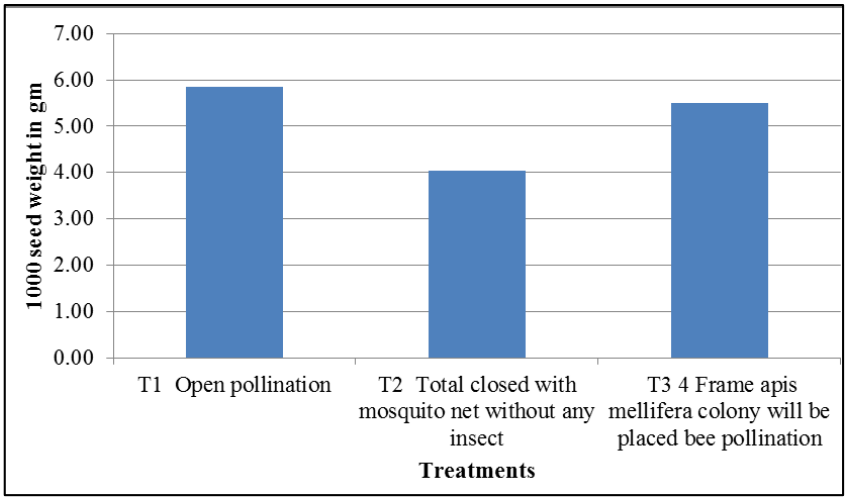

Fig 4: 1000 seed weight in gm in different treatments during rabi 2021-22

3.5 Seed yield per plot (kg)

The results revealed that maximum seed yield (kg/ha.) are obtained in T_1 (open pollination for all visitors) (1121.43 kg/ha.) followed by T_3 (4 frame *Apis mellifera* colony was placed for bee pollination) (735.72 kg/ha.). Whereas, minimum seed yield are obtained in T_2 (Total closed with mosquito net without any insect) (571.43 kg/ha.).

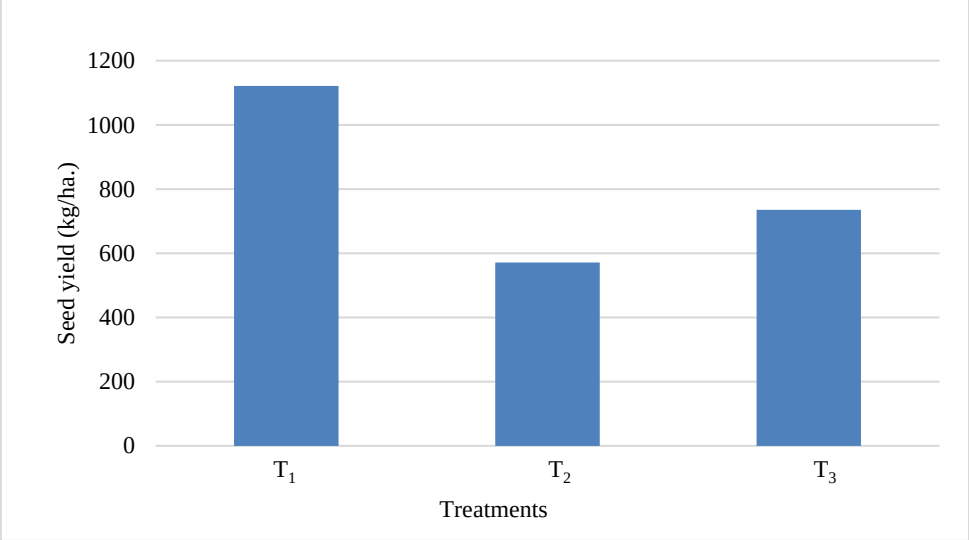

Fig 5: Seed yield (kg/ha.) in different treatments during rabi 2021-22

More or less the present findings are agreement with the findings of Patidar *et al.*, 2017 [11] who studied on role of honeybee (*Apis mellifera*) in enhancing yield of mustard and concluded that 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 Open Pollinated followed by Plants caged with bee hive (BP) and it was recorded lowest in Plants caged Pollinator Exclusion (PE). The introduction of honeybees in agricultural crops plays a vital role in pollination which in turn resulted in higher production of seed yield as well as honey production.

The present findings are agreement with the findings of Sharma and Abrol, 2014 [12] who studied on effect of insecticides on foraging behaviour and pollination role of *Apis mellifera* L. (Hymenoptera: Apidae) on toria (*Brassica campestris var. toria*) crop and concluded that open pollination resulted in 1.80 times more yield compared to caged condition and crop pollinated by bees alone. This study suggests that both protective application of insecticides and use of honeybees for pollination are essential for maximum crop yields.

More or less the present findings are agreement with the findings of Hossain *et al.*, 2020 [9] who studied role of honey bee on mustard (*Brassica spp.*) yield. Three different treatments were used, *viz.* control, netting with honey bees and netting without honey bees. Honey bees helped mustard pollination, but decreased the flowering period (6 days) of the mustard plant. Honey bees assisted the pollination of mustard and increased the number of pod per plant (14%) as well as the number of seeds per pod (11%). Honey bees enhanced the pollination of mustard plant, and netting with honey bees increased the mean seed yield (15%) per plant of mustard, however, decreased the period of flowering stage of mustard. Mustard yield was considerably higher in honey bee foraging plots.

More or less the present findings are agreement with the findings of Thakur and Rana (2008) [14] studied the effect of honey bee pollination, open pollination and hand pollination on quantity and quality of cucumber was also studied. Significant increase in fruit set was observed, highest being in hand pollination (75.68%) followed by honey bee (74.96%) and open (62.09%) pollination. Percentage of misshapen fruits was maximum in open pollination (20.05) followed by hand (14.1%) and honey bee (8.05%) pollination. Honey bee pollination resulted in significantly highest percentage of healthy fruits (92.22%) as compared to hand (85.85%) and open pollination (79.64%). Similarly weight of fruits (1184.5 g), number of seeds per fruit (472.8), fruit size (28.8 cm) and weight of 1000-seeds (29.14 g) was highest in honey bee pollination as compared to other modes of pollination.

Table 1: Impact of *Apis mellifera* pollination on Indian mustard

Treatments	No. of siliqua per plant	Length of per siliqua.	No. of seeds per siliqua	1000 seed weight (g)	Seed yield (kg/ha.)
T_1 Open pollination for all visitors (unprotected crop)	206.6	4.72	11.51	5.84	1121.43
T_2 Total closed with mosquito net without any insect	196.9	3.63	8.77	4.04	571.43
T_3 4 frame *Apis mellifera* colony was placed for bee pollination	203.1	4.16	9.49	5.50	735.72
Sem	3.657	0.178	0.128	0.141	70.486
C.D.	11.393	0.554	0.4	0.441	215.684

Apis mellifera

Apis indica

Apis dorsata

Carpenter bee

Wasp

Stingless bee

Lady bird beetle

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