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Original Research Article

Effect of Honey Bee (*A. mellifera*) Pollination on Yield and Yield Attributing Parameters of Onion (*Allium cepa* L.)

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A B S T R A C T

Investigations were carried out at the Raninagar village of Chakdaha block in Nadia district of West Bengal during 2015-16 to study the effects of managed honeybee pollination on yield and quality of onion seeds with three treatments viz., Plants caged in nets without any pollinator (T1), plants caged in nets with only honey bee (*Apis mellifera*) as pollinator (T2), and plants open to all pollinators (T3). 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 / umbel, thousand seed weight and seed germination were also increased significantly due to pollination. Open pollination showed better performance than honey bee pollination under net, though not at a significant level, in all these aspects except seed germination.

Keywords

Pollination, onion, honey bee

Introduction

Pollination is the process by which pollen is transferred to the female reproductive organs of a plant, thereby enabling fertilization to take place. Insect pollinators play an important functional role in increasing not only quantity but also the quality of fruit, thus increasing the yield of a crop.

Honeybees are primary pollinators for the majority of the world's angiosperms (Ollerton *et al.*, 2012), pollinating one or more cultivars of 66% of the world's 1500 crop species which is accounting for 15-30% of food production. About 80% of crop insect pollination is accomplished by honeybees (Singh and Singh, 2006). The European or western honey bee *Apis mellifera* L. (Hymenoptera: Apidae) is the most commonly managed pollinator worldwide.

Onion (*Allium cepa* L.) is an extremely important vegetable crop. A global review of major vegetables shows that onion ranks second after tomato in area. Approximately, 36 million tons of onions are produced on 2-5 million ha globally. India is the 2nd largest producer of onion in the world next only to China, with 19.90% share in world total production, but the productivity of onion in India is very low, i.e., 16.29 tones/ ha as compared to China and other countries like Egypt, Netherlands, and Iran etc. In India 187.36 lakh MT onion is produced over 11.50 lakh ha area (Anon., 2015). The major

onion producing states of India are Maharashtra, Gujarat, Orissa, Karnataka, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Bihar, Punjab and Rajasthan, with Maharashtra as the leading onion producing state contributing 33%, followed by Karnataka 17% and Gujarat with 10% of onion production of India.

Seed is the basic unit of crop production and in case of some plants where seed are the principle mode of propagation, seed set and subsequent seed development are the obvious basic and vital phenomena in any seed production program. Onion is a biennial crop for the purpose of seed production. In one season bulbs are produced from seeds and in second season bulbs are replanted to produce seeds. Inadequate pollination of the onion flower results in deformed and smaller seeds with low germination capacity (McGregor, 1976). Insufficient pollination cause difficulties in onion hybrid seed production because of poor quality seeds (Free 1993). Both the seed industry and onion seed producers are increasingly confronted by the serious economic problem of disappointing seed yields in commercial onion fields. This is because the onion flowers are not capable of self-pollinating as the pollens usually sheds before the female part is receptive (protandry) (Lema 1998). So, the out-crossing becomes more critical due to the protandrous nature of the onion plant (Muller, 1983). The amount of out-crossing may vary from 8 to 71% under different conditions (Van Der Meer and Bennken, 1972).

According to Banik, (1990), the pollination activity of wind has little effect (10%) on onion pollination because of its sticky pollen, other pollinators were 3% and honey bees were 87% in onion pollination. The honeybees were effective pollinators on onion because both pollen and nectar are available from the plant (McGregor, 1976).

From the above, it emerges out that to increase or retain higher productivity of onion, effective pollination by various insect pollinators, particularly honeybees, needs to be ensured and its impact be analyzed. And here lies the immense scope of exploiting honeybees in enhancing crop productivity. Keeping this view in mind, the present investigation has been designed aimed at identifying and finding out the efficiency of honeybees (*A. mellifera* Linn.) in pollinating onion and to examine the role of managed honeybee pollinators in increasing seed yield and germination percentage of the onion plant.

Materials and Methods

Raising the crop - Medium sized (4.5-6.5 cm), single centered bulbs of onion (cv. Sukhsagar) weighing about 50-60g, were planted at spacing of 30x30cm in area measuring 14x18sq.m. The crop was manured with FYM @ 25 tons/ha, mustard oil cake @ 300kg/ha and NPK @ 100:60:50kg/ha. The entire amount of FYM and mustard oil cake was applied prior to first ploughing. The full dose of P_2O_5 and K_2O along with half of Nitrogen was applied as basal dose whereas rest of half dose of Nitrogen was top-dressed in two splits at 30 and 45 days after planting. Before planting the bulbs were treated with Bavistin 50%WP @ 2g/lit. Three hand-weeding were done at 30, 45 and 60 days after planting. Irrigation was given as per requirement. The crop received two sprays with Mancozeb 75%WP @ 0.4% at 45 and 55 days after planting. Moreover, one spraying with Fipronil 5%SC @ 0.01% was given at 65 days to control onion thrips. After seed maturity, the umbels were hand-picked and brought to the threshing floor.

The experimental plot was designed in three large plots measuring 14 X 6 m. Each of the large plots was considered as a treatment. These large plots were then divided into seven small plots of 2 X 6 m along the length, each represented a replication.

The treatments were: T_1 – Without any pollinator, T_2 – Honey bee (*A. mellifera*) as pollinator, and T_3 – Open pollination. In T_1, $1m^2$ area in each replication was covered by mosquito nets measuring 1m X 1m X 2m before the opening of ray florets to prevent the entry of pollinators. To ensure absence of pollinators within these nets, these were further sprayed with Fipronil 5% SC @ 0.01% along with the entire crop. This treatment also helped in controlling onion thrips, *Thrips tabaci*.

In T_2, the entire plot was covered by a large net measuring 14m X 6m X 4m and one 2-frame colony of *A. mellifera* with sufficient amount of stored food, and a viable queen and sufficient numbers of workers contained in a nucleus hive was placed inside the net at a height above crop canopy when about 5% of the plants came into bloom.

Soon after placement of the colony the bees were provided with a single supplementary feeding (sugar syrup), whereas, water was provided during the entire period. When the flowering was over, all the nets and the honey bee colony was removed to ensure uniform post-pollination condition in all the treatments. In T_3, pollinating insects were allowed to visit the flowers.

After seed maturity, the umbels of one square meter area from each replication were harvested and sun dried. Observations were taken on, Number of umbels per plant, Number of pods per umbel, Number of seeds per umbel, 1000 seed weight (g) and Seed yield (kg / ha).

The number of umbels per plant was recorded from10 plants/replication. To record the number of pods per umbel, two umbels from each of these plants were examined. The seeds formed in these umbels were extracted and counted.

Thousand seed weight was recorded in each of the replications. The seed yield was recorded from 1 sq.m area of each replication which was later converted into q / ha. An increase in seed yield due to managed honeybee pollination was calculated using the formula as follows-

$$\text{Yield increment (\%)} = \frac{\text{(Yield from honeybee pollinated plot – Yield from insect excluded plot)}}{\text{Yield from open pollinated plot}} \times 100$$

Observations were also taken on germination percentage of the seeds of all three treatments.

One hundred seeds of onion were sprinkled on a 10cm diameter petri plate which was covered with moist filter paper.

Moisture was maintained by spraying water. The filter paper was removed after the germination was over and the number of seeds germinated out of hundred was counted. The experiment was replicated thrice. Finally germination percentage of seeds was determined by using the formula-

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds in petri dishes}}{\text{Total number of seeds used for germination}} \times 100$$

To study the effect of honey bee pollination on yield and yield attributing parameters, 'F' test was done following square root transformation and angular transformation of the data, wherever required, following Randomized Block Design (RBD).

Results and Discussion

Under field condition the effect of honey bee pollination on seed yield and various yield attributing parameters of onion were studied as compared to open pollination and without any pollination

Quantitative characters

The observations taken were no. of umbels /plant, no. of pods/umbel, no. of seeds/umbel, 1000 seed weight and seed yield.

No. of umbels / sq.m

Data presented in table 4.3 shows that no. of umbel produced per plant in honey bee pollinated and open pollinated crops and those without any pollinators was 47.14, 47.43 and 46.14 respectively which indicates that pollination had no impact on no. of umbels produced by plants.

No. of pods / umbel

The average no. of pods set/umbel was 220.78 in honey bee pollinated crop as compared to 232.14 in open pollinated crop. On the contrary, it was only 6.33 in crops where no pollination was allowed to visit the flower.

No significant difference was however recorded in respect of average no. of pods/umbel between honey bee pollinated and open pollinated crop.

No. of seeds / umbel

The number of seeds produced per umbel was much higher in honey bee and open pollinated field (802.21 and 851.29, respectively) as compared to that without pollinators (18.72). The number of seeds produced in open pollination was statistically at par with honey bee pollination.

1000 Seed weight (g)

Both honey bee and open pollination significantly increased 1000 seed weight of onion (3.23 and 3.65, respectively) as compared to without any pollinator (2.67).

No significant difference was, however, observed between honey bee pollination and open pollination in respect of 1000 seed weight.

Seed yield (kg/ha)

Among the three treatments, open pollination gave highest yield of onion seeds (518.22 kg / ha) followed by honey bee pollination (457.72 kg / ha). Only 5.91 kg of seeds / ha was obtained in plots without any pollinator.

Both honey bee pollination and open pollination were on a par in respect of seed yield.

Qualitative characters

Yield increment percentage

The analysis of investigation performed on onion crop with the three different treatments *viz.*, without pollination, honeybee pollination and open pollination clearly reveals an increment in seed yield of onion from treatment with honeybee (*Apis mellifera*) pollination with a percentage yield increment of about 7745% in comparison to treatment without any pollinator, whereas in open pollination the increment was 8768%. The yield increment of honey bee pollination using formula was found to be 87%.

Table.1 Effect of Honeybee Pollination on Yield & Yield Attributing Parameters of Onion

Parameters → / Treatments ↓	No. of Umbels / Sq.m	Average No. Of Pods / Umbel	Average No. Of Seeds / umbel	1000 seed wt. (gm)	Seeds yield (kg/ha)	Germination (%)
Without any pollinator	46.14 (6.83)	6.33 (2.69)	18.72 (4.37)	2.67 (1.91)	5.91	14.00 (21.84)
With honeybee as pollinator	47.14 (6.93)	220.78 (14.86)	802.21 (28.32)	3.23 (2.05)	457.72	76.00 (60.75)
With open pollination	47.43 (6.95)	232.14 (15.19)	851.29 (29.11)	3.65 (2.16)	518.22	71.00 (57.49)
SE(m)	2.91 (0.22)	13.52 (0.45)	32.94 (0.63)	0.22 (0.06)	12.97	(1.39)
CD5%	N/A	42.12 (1.42)	102.61 (1.95)	0.69 (0.17)	40.41	(4.35)

Germination percentage

Insect pollination had immense impact on seed germination. It was highest (76.00%) in honey bee pollinated crop closely followed by open pollination (71.00%), while it was very low (14.00%) in plots without any pollinator. The two former treatments, however, showed no significant difference among them in respect of seed germination.

The results of the present investigation clearly show that, honey bee pollination is a must for commercial production of onion seeds. Honey bee pollination resulted in many fold increase in the average number of pods / umbel, average number of seeds / umbel, weight of seed / umbel and seed yield as compared to without any pollinator.

Moreover, higher proportion of viable seeds was produced in honey bee pollination as was evident from higher germination percentage of harvested seeds. A perusal of available literature shows the importance of bee pollination in enhancing the yield and other yield attributing parameters of onion seeds.

In the present investigation, it is further evident that, open pollination performed better than honey bee pollination under net in all these parameters except seed germination percentage, though not at a significant level. The better performance of open pollination may be due to inconvenience caused to the forager bees by confining them inside the net, relatively fewer foragers inside the net (only two frame colony was placed), presence of large number of *A. dorsata* in open field, greater foraging efficiency of *A. dorsata* and presence of dipteran flies in open pollination.

Among the three treatments, open pollination gave highest yield of onion seeds (518.22 kg / ha) followed by honey bee pollination (457.72 kg / ha). Only 5.91 kg of seeds / ha was obtained in plots without any pollinator. Both honey bee pollination and open pollination were on a par in respect of seed yield.

An increment of 77.45% in seed yield of onion was obtained by placing honeybee (*Apis mellifera*) colonies in onion fields in

comparison to that without any pollinator, whereas, in open pollination the increment was 87.68%.

Seed germination was highest (76.00%) in honey bee pollinated crop closely followed by open pollination (71.00%), while it was very low (14.00%) in plots without any pollinator. The two former treatments, however, showed no significant difference among them in respect of seed germination.

It is concluded that, being highly cross pollinated, onion requires the help of insect pollinators particularly honeybees for pollination and seed setting. Among the pollinators, honey bees are most efficient, though others, especially the flies also play some role in pollination. As the wild honey bee population is reducing day by day due to human activities, hive bees like *A. mellifera* should be placed in onion fields to ensure commercial seed production of onion.

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