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Augmentation of *Apis mellifera* for Fruit Yield Enhancement in *Capparis decidua* (Forssk.) Edgew (Kair)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Capparis decidua (Family: Capparidaceae) is a very nutritious shrub of arid region. Its fruits are utilized in famous Rajasthani Panchkutta and Tricutta vegetable and pickle making. The present paper deals with the effect of augmentation of *Apis mellifera* beehives on the fruit setting and fruit quality parameters. It was found that the average numbers of fruit setting raceme^{-1} were found 4.36, 3.77 and 2.2 in natural pollination with augmentation of honey bees, pollination by honey bees only and natural pollination respectively. Germination percentages, total sugar, average fruit weight, shoot length and seedling length was higher in case of natural pollination with augmentation of honey bees among all the treatments.

Keywords: Capparis decidua; pollination; augmentation; fruit setting; germination; fruit weight.

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1. INTRODUCTION

There are many food-value plant species in forests that produce edible leaves, fruits, seeds, roots, and rhizomes, among other things. Many of these plants are directly useful to humans. Most foods obtained from forests have excellent nutritional contents, even though the nutritional value of the majority of these items is not precisely recognized. One of the many edible fruit-bearing and food-producing species found in Rajasthan's dry and semi-arid zones is *Capparis decidua*.

Children's nutrition, both in rural and urban places, is significantly influenced by native fruits. The fruit *C. decidua* is one of the key components of the well-known Marwari vegetables Panchkuta and Trikuta, which are made from five and three different types of dried fruits or seeds, respectively. These dishes are considered to be staples of the Marwari diet. 'Kair' is the common name for *C. decidua*, a member of the Capparidaceae family. It also goes by the name *Capparis aphylla*. The Capparidaceae family has between 700 and 900 species spread across 40 to 45 genera. Its members exhibit a wide range of fruit and floral characteristics [1, 2]. It has several branches that are either leafless or have extremely small leaves. It rarely rises higher than five meters. It rarely rises higher than 5 meters. It blossoms in March to April and August to September and fruit get ripen in May and October. It can withstand moderate frost and is exceptionally drought-resistant [3]. *C. decidua* can be utilized in semi-arid and desert environments for landscape gardening, afforestation, and reforestation since it helps prevent soil erosion [4,5].

Kair is a caducous plant and found all throughout the desert areas of India and other nations. In general, the species has a wide ecological range, and in India, it is particularly common in arid and semi-arid regions of the states of Gujarat, Punjab, Uttar Pradesh, Madhya Pradesh, and Andhra Pradesh, western Rajasthan and parts of Haryana. Being xerophytic, the plant is typically found in desert regions and is a draught-resistant plant with a long lifespan. It is the perfect plant for preventing soil erosion, notably wind erosion, and stabilizing sand dunes. Also, as *Capparis* contains high levels of nutrients like proteins, carbohydrates, minerals, and vitamins, its fruits are utilized as vegetables and the fruits are used to make pickles [6].According to Mishra et al. [7]; Singh and Mishra [8], Verma et al., [9]; Dangi and Mishra [10], the entire plant, especially its fruit, has therapeutic benefit for treating cough, asthma, heart issues, and many other conditions.

According to Chouhan et al. [11], mature fruits are very nutrient rich. Also, it was found that the fruits were high in dietary fiber [12]. The fruits and flower buds produced 14% surface wax (w/w), which was found to consist of a mixture of compounds, primarily straight chain saturated hydrocarbons and ketones with C-28 and C-32 chain length, associated with oils that contained nitrogen and sulphur [13]. Additionally, fifteen natural substances have been extracted and identified from Kair fruit [14].

Four bee species, three wasp species, and two species of butterflies have been identified by Latif et al. [15] visiting the blooms of *C. aphylla*. Reviewing the above it was found that record of pollination by *A. mellifera* and its effect on fruit quality and quantity was missing. Therefore, present study was conducted deals to evaluate the effects of augmentation of *A. mellifera* on fruit production and fruit quality of *C. decidua (*Forssk.) Edgew(Kair),

2. METHODOLOGY

A. mellifera hives boxes containing eight frames were augmented in *C. decidua* under caged condition. Bamboo-Net structures were installed in the *C. decidua* field to conduct pollinator exclusion experiment by keeping honey beehives boxes. A Randomized block design (RBD) with 3 treatments was applied and replicated thrice. Three different trees of almost equal size and canopy were selected for pollination by honey bees only. These plants were caged within Bamboo-Net structures (T2). An eight framed hives with *A. mellifera* L. bee colony were placed in each cage. The trees were caged restricting the entry of insects (Pic1).

Three trees were randomly chosen for natural pollination with the introduction of honey bees (T1), allowing free visits from all pollinators and the placement of a honey bee colony with eight fra-mes of adult bees in the research area according to general recommendation by Steel et al. [16]. Natural pollination (T3) was observed on three randomly selected trees/shrubs tagged for control treatment away from rest of the experimental area. In each experimental area treatment, a sampling unit consisted of a set of 50 racemes that had been marked with tags. The average fruit weight was obtained by dividing the total fruit weight by the total number of fruits, and the mean number of fruit per raceme was computed by counting all the fruits in the sampling unit and dividing that number by 50. The data was analysed statistically [17]. Size of the fruit, fruit weight and total sugar were also calculated. For germination percentage and vigour index following formula were used.

Percent germination was calculated by using formula:

> Germination %= Seeds germinated/total seeds x 100

Vigor index was calculated by using formula:

> Vigor index (VI) = [seedling length (cm) × germination percentage]
> [18]

3. RESULTS

Pollination effect of honey bees (*A. mellifera* L.) on average number of fruit setting per raceme and quality parameters like average fruit weight (in kg) and size (mm) of *C. decidua* are summarized in Table 1 & 3; Fig. 1, 2 & 3. Significant differences (P>0.05) were observed among the treatments in terms of average number of fruit raceme^{-1} (Pic 2, 3). The average numbers of fruit setting raceme^{-1} were 4.36, 3.77 and 2.2 in natural pollination with augmentation of *A. mellifera*, pollination by *A. mellifera* only and natural pollination respectively. With the addition of *A. mellifera* and pollination by *A. mellifera* alone, there was an increase of 98.18% and 71.36% in the number of fruit raceme^{-1} over the control, respectively.

Our findings are consistent with those of Sujitratanunth [19], who estimated that *Citrus maxima* fruit percentage was 66.9%, which represented a 274.5% increase in fruit production over the cage without bees. In a different study done by Chaudhry [20], peach trees that were given access to honey bee colonies produced an optimal harvest of 6.5 peaches per branch. According to Cayuela et al. [21], plants that were not pollinated by honey bees (the control) had a much lower number of fruits per panicle than those that were.

The pollination effect of honey bees (*A. mellifera* L.) on average fruit weight (in gm) is indicated in Table 1. Significant differences (P>0.05) were found among the treatments. Average fruit weight was found to be 0.81 g and 0.79 g in treatments with pollination by *A. mellifera* alone and natural pollination, respectively. These values were relatively lower than natural pollination with *A. mellifera* augmentation, i.e. 0.91 g. Volz et al. [22] also reported similar findings stating the maximum apple weight of variety 'Braeburn' (170 g) in trees that had treatment of pollination.

Total sugars was found to be maximum (1.8%) in the case of natural pollination *A. mellifera* augmentation, followed by pollination by honeybees alone (1.6%), and least (1.5%) in the control.

Pic 1. *Apis mellifera* augmentation in Kair (*C. decidua*)

Pic 2. Fruits setting of *C. decidua*

Pic 3. Fruits of *C. decidua*

Germination percentage (Table 4; Fig. 3) in natural pollination with augmentation of honey bees was 55.33% in comparison to pollination by honey bees (50.33%) and natural pollination (49.33%). Similar results were reported by Sabir et al. [23] indicating *A. mellifera*, as a good source of pollination of *Brassica campestris* resulting in maximum seed yield (19.9 q/ha), 1000 seed weight (3.8 g) and seed germination (95.8%).In the present study root length (3.03cm), Shoot length (4.05cm) and Seedling length (7.08cm) were found to be highest in natural pollination with augmentation of honey bees among all the treatments. Seedling Vigour index (Table 2) natural pollination with augmentation of honey bees was higher (392.28) in comparison to pollination by honey bees (332.00) and natural pollination (322.61).

4. DISCUSSION

Chaturvedi [24] revealed that insects were the primary pollinators of litchi. The Dehradun cultivar of litchi had the highest yield when pollinated by bees, as opposed to tree which are not pollinated by bees, according to Badiyala and Awasthi [25]. Similar findings were observed by Kumari et al. [26] stating that percentage fruit set/fruit weight was higher in natural pollination with *A. mellifera* and other pollination modes than without pollination by insect pollinators. Pareek et al. [27] showed how important pollination and pollinators are for fruit setting in ber. Insufficient pollination reduces oil tree peony fruit set, according to Zhang et al. [28] research. Augmenting appropriate bee density to the field for pollination is a key tactic to increase fruit yield.

Verma and Dulta [29] reported similar findings that there wasn't any fruit set in absence of insect pollinators in self-incompatible apple cultivars like Royal and Red Delicious, and it was 10.12 and 8.27% greater in honeybee-pollinated blooms in comparison to open pollinated flowers. Without any insect pollinators, the fruit loss in Golden Delicious and Red Gold was considerably higher (P 0.01) than in open and honeybee-pollinated flowers. In regards to weight, length, width, volume, and other fruit quality measures, honeybee cross-pollination considerably improved the fruit.

This demonstrates honeybees' capacity for pollination in agricultural settings and their high adaptation to both crops and trees [30]. Our results imply that to reduce the danger of pollination deficiencies influencing food production, management measures for managed bees and wild insect populations should be increased as they provide pollination services for the development of agro-forestry systems.

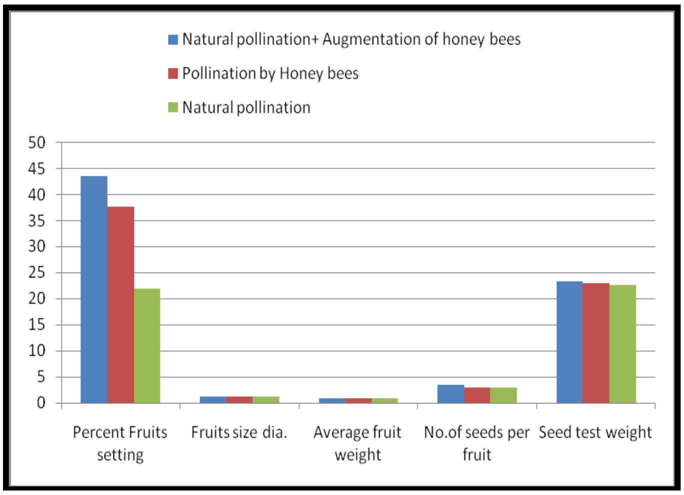

Fig. 1. Studies on effect of *A. mellifera* augmentation on fruit size, percent fruit setting, fruit weight, No. of seeds per fruit and seed weight in *C. decidua*

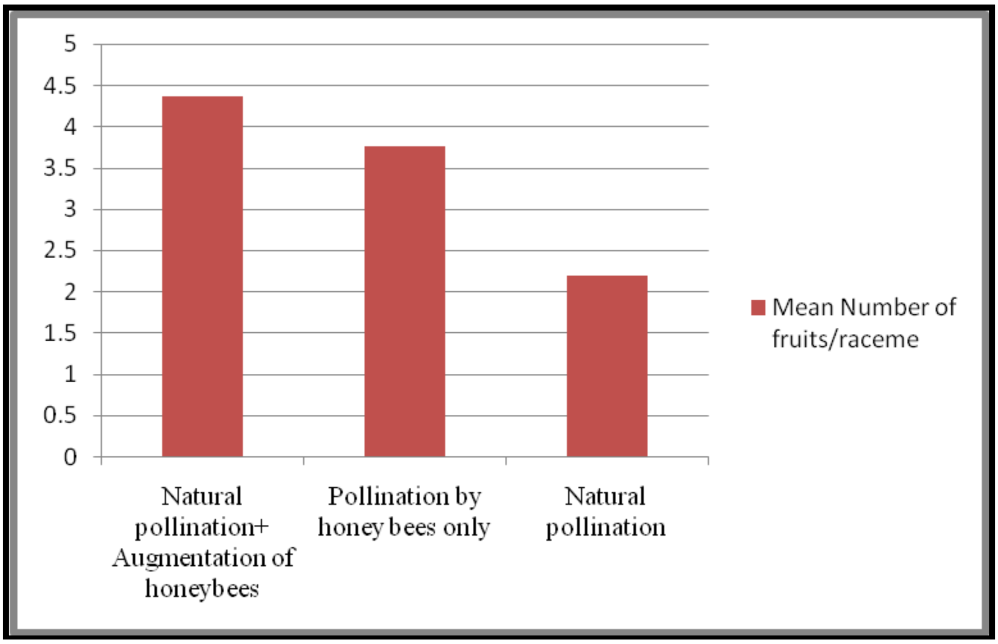

Fig. 2. Pollination effect of *A. mellifera* L. augmentation on average number of fruit setting in *C. decidua*

Table 1. Studies on effect of *A. mellifera* augmentation on fruit setting, fruit dia., average fruit weight, no. of seeds per fruit, seed weight and total in Kair (*C. decidua*)

Treatment	Parameters					
	Fruits setting (%)	Fruits size Diameter(cm)	Average fruit weight (gm)	No.of seeds per fruit	Seed test weight (gm)	Total sugars %
T1(Natural pollination+ Augmentation of honey bees)	43.6	1.23	0.91	3.4	23.40	1.8
T2(Pollination by Honey bees)	37.67	1.21	0.81	3.0	23.00	1.6
T3(Natural pollination)	22.0	1.19	0.79	2.96	22.73	1.5
Grand mean	34.42	1.21	0.84	3.13	23.04	1.6
SE	0.61	0.011	0.035	0.112	0.136	0.03
CD @5%	2.39	0.027	0.086	0.274	0.332	0.11
CV	3.06	1.132	5.173	4.386	0.723	3.46
Significance @5%	S					

Table 2. Studies on effect of *A. mellifera* augmentation on seedling fresh weight, seedling dry weight and seedling vigour in Kair (*C. decidua*)

Treatment	Seedling fresh weight (gm)	Seedling dry weight (gm)	Seedling Vigour index (Mass)	Seedling Vigour index (length)
T1(Natural pollination+ Augmentation of honey bees)	0.56	0.07	3.87	392.28
T2(Pollination by Honey bees only)	0.53	0.06	3.00	332.00
T3 Control (Natural pollination)	0.52	0.06	3.02	322.61
Grand mean	0.54	0.06	3.30	348.96
SE	0.011	0.006	0.190	16.75
CD@5%	0.027	0.014	0.464	40.99
CV	2.55	11.37	6.74	5.88
Significance @5%	S	Ns	S	S

Table 3. Pollination effect of *A. mellifera* L. augmentation on average number of fruit setting in *C. decidua*

Treatment	Mean number of fruits/raceme	Percentage increase over natural pollination
Natural pollination+ Augmentation of honeybees	4.36	98.18
Pollination by honey bees only	3.77	71.36
Natural pollination	2.2	-

Table 4. Studies on effect of *A. mellifera* augmentation on germination %, root length, shoot length and seedling length in Kair (*C. decidua*)

Treatment	Germination%	Root length (cm)	Shoot length (cm)	Seedling length (cm)
T1(Natural pollination+ Augmentation of honey bees)	55.33	3.03	4.05	7.08
T2(Pollination by Honey bees only)	50.33	2.84	3.89	6.73
T3 Control (Natural pollination)	49.33	2.68	3.72	6.41
Grand mean	51.66	2.85	3.89	6.74
SE	1.825	0.100	0.103	0.187
CD@5%	4.467	0.246	0.253	0.459
CV	4.327	4.319	3.257	3.412
Significance at 5%	S	S	S	S

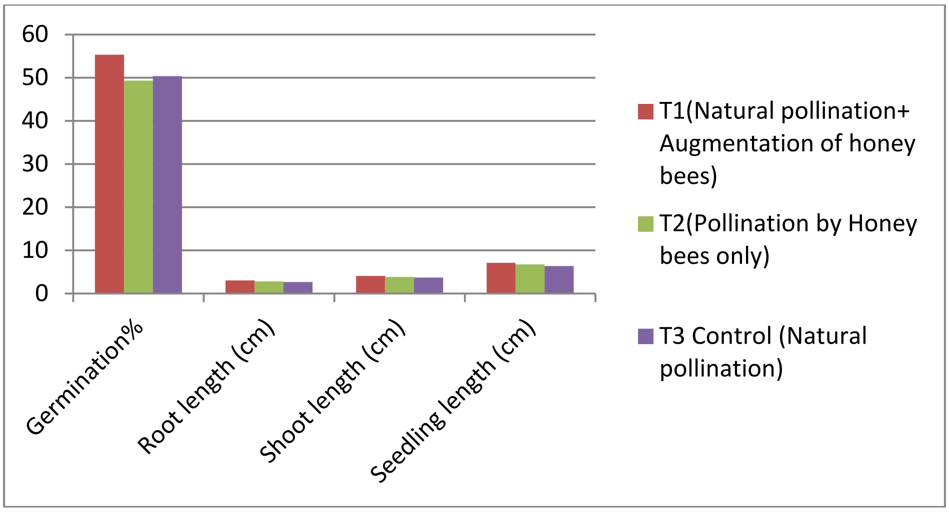

Fig. 3. Effect of *A. mellifera* augmentation in Kair (*C. decidua*)

5. CONCLUSION

Pollination is an essential ecosystem service that is accountable for better yield in plants. Different trees/shrub species have different requirements for effective pollination. Despite the fact that pollination is an unbound service provided by bees together with several wild bees, they need to be conserved and protected. In conclusion, our observation on insect visitors reveals that there is a large and varied assemblage of potential pollinators. However, the irregular arrival and departure of the various insect species portend that most wild pollinators can only be relied upon secondarily.

In this study, the pollination impact of honeybee *A. mellifera* L. on fruit weight and development was examined. When natural pollination was supplemented with honeybees (*A. mellifera* L.), we observed a significant increase in the quantity of fruit raceme^{-1} and fruit weight. Therefore, for optimal fruit output, farmers are thus suggested to put in colonies of honeybees in their farms during blossom of tree/shrub. Our research is intended to help raise community knowledge of the value of honeybees in forestry, agro-forestry, and agriculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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