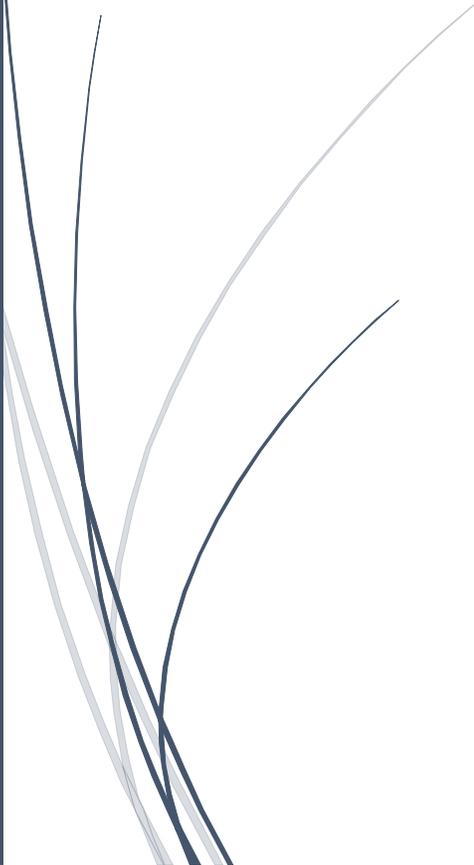


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*Impact of Beekeeping with
Indigenous Bees (*Apis cerana* &
Trigona) on Mango and Cashew
Production in India*

A series of thin, curved lines in shades of blue and grey originate from the bottom left corner and sweep upwards and to the right, creating a decorative, organic shape.

Dr. Debika Chatterjee

Under the Mango Tree (UTMT) Society, INDIA

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INTRODUCTION

Under The Mango Tree (UTMT) Society is an award winning not-for-profit organisation that promotes beekeeping with indigenous bees *Apis cerana indica* and *Trigona iridipennis* for increasing agricultural productivity, enhancing incomes and improving livelihoods of smallholders in **India**. The income earned from enhanced productivity and sale of agriculture commodities can be as much as fourteen times the income through sale of honey. ***Bees for Poverty Reduction (BPR)*** is the strategy by which UTMT Society targets rural poverty through beekeeping, by offering training and handholding programme in beekeeping for farmers, and setting up a beekeeping ecosystem that generates employment centered around beekeeping in rural areas. This innovative and unique framework supports livelihood diversification as well as increased agricultural productivity, increased employment through the UTMT beekeeping ecosystem, enhanced sustainable environment and reliable incomes for farmers as a result of direct market access.

This study assesses the impact of bees on pollination of Mango, Cashew and Cluster Bean flowers in two locations – Valsad (Gujarat) and Palghar (Maharashtra) – in western India.

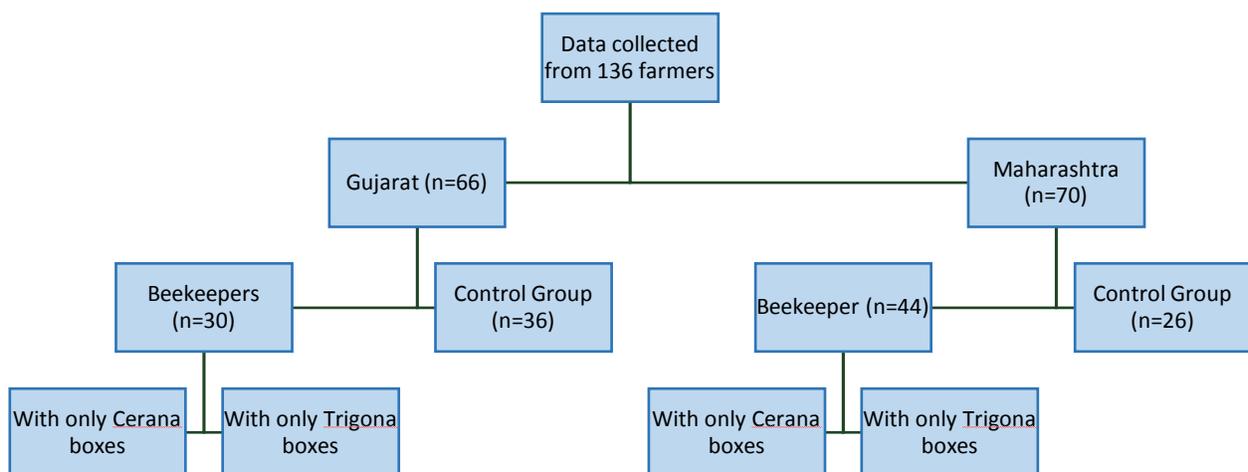
METHODOLOGY

Sample Selection:

Data was collected for 136 farmers from two neighbouring states in Western India – Gujarat and Maharashtra. For the past several years, UTMT Society has been training farmers to do beekeeping in the Valsad district in Gujarat, and in the Palghar district in Maharashtra. While selecting the sample it was ensured that:

- 1) All the Beekeepers included in the study had healthy beehives – either Cerana or Trigona hives.
- 2) All the participants (Beekeepers and Control Group farmers) had Mango and Cashew trees in their farm or orchard.
- 3) All the participants belonged to similar agro-climatic zone.
- 4) All the participants followed the same agricultural practices.
- 5) The Control Group villages were at least 10 km away from the beekeeping villages.
- 6) The Control farmers did not have any beehive (Cerana or Trigona) in their villages.

A total of 136 farmers – 74 Beekeepers and 62 Control Group - participated in the study. The sample distribution is given in the following chart.



As we wanted to include Cluster bean in the current study, the farmers were given Cluster bean seeds as part of the bee-flora initiative, so that they can also grow the vegetable between November 2018 and March 2019. Unfortunately, due to scarcity of rains in Maharashtra (Hindustan Times 2018), the farmers there could not cultivate any extra crop during that period.

Data Collection:

Data was collected from the selected farmers through interviews in their local language. The participants were asked questions about:

- Number of Trees for Mango and Cashew / Quantity of Seed sown for Cluster Bean
- Usage of Fertilizers and Pesticides
- Total Production in Kilograms
- Income generated by selling the crops
- Improvement in the quality of the fruit
- Number of beehives for beekeepers



Figure 1- Cashew nuts ready to be processed (©M.Kunz)



Figure 2- Weighing the freshly picked Mangoes in the orchard (©M.Kunz)



Figure 3- Harvested Cluster bean (©M.Kunz)



Figure 4-Collecting Cluster bean harvest data (©M.Kunz)

RESULTS

1. Average per unit production

Since the farmers who were included in the study are small and marginal farmers, their land sizes varied between 1 to 2.5 Acres, and the farmers owned between 5 to 50 Mango and Cashew Trees. Comparisons were made between Beekeepers and Control Group farmers based on average per unit production (for Mango & Cashew – Kgs produced per Tree, and for Cluster Beans – Kgs produced per Kg of seed).

Average Per unit production = $\frac{\text{Total Production in Kgs}}{\text{Total Area in Guntha}^1 \text{ OR No. of Trees}}$

Total Area in Guntha¹ OR No. of Trees

Average per unit production was calculated for the Beekeepers and was compared to that of the Control Group farmers. This gave us the average percentage of increase in the production due to the presence of beehives in the farm or orchard. (Findings are shown in Table 1)

Table 1: Percentage of Difference in Average Per Unit Production between Beekeepers & Control farmers

	Mango	Cashew	Cluster Bean
Gujarat	55%	267%	181%
Maharashtra	18%	45%	433%

¹ Guntha is a measure of area. 40 Gunthas = 1 Acre

As the data shows, in both the states, all the crops showed a positive increase in production, indicating that the Beekeepers had higher production than the Control Group farmers. For Mango and Cashew, the increase in per unit production was higher for Beekeepers from Gujarat than that of Maharashtra. The Gujarat farmers who had beehives in their farms or orchards, produced 55% more Mangoes per tree than the farmers who didn't have beehives in the vicinity. The Maharashtra beekeepers showed a modest increase of 18% for Mango production. Although there is a huge difference in the per tree production for Gujarat and Maharashtra beekeepers, it clearly indicates that beekeeping did positively impact on the crop yield.

Compared to the Gujarat beekeepers, the Maharashtra beekeepers are small farmers with fewer number of trees.

Table 2: Comparison on average number of trees per farmer in the two states

	Gujarat	Maharashtra
No. of Mango Trees	22.68	11.68
No. of Cashew Trees	18.08	7.91

As shown in Table 2, on an average, the Maharashtra beekeepers had less than 12 Mango trees, whereas Gujarat beekeepers had around 22 Mango trees. Been small scale farmers, the Maharashtra beekeepers primarily used the produce for self-consumption and hence they probably took less care of the trees during fruition. Whereas the Gujarat farmers with larger orchards, grew Mangoes and Cashews primarily for commercial purpose, hence it can be assumed that they would give extra attention to their trees.

As Table 1 indicates, the Gujarat Beekeepers produced 267% more Cashew per tree than the Control Group farmers, and Maharashtra showed only 45% increase.

But for Cluster Beans, the Maharashtra beekeepers showed a huge increase of 433% per unit production as compared to the Control farmers in their state, whereas Gujarat beekeepers showed 181% increase.

2. Average per farmer production

Average number of trees (or quantity of seed sown) that the Beekeepers and Control Group farmers had were calculated by dividing the total number of trees (or quantity of seeds) by total no. of farmers.

Average per farmer production = Average no. of trees (or quantity of seed sown) x Average per unit production

The average per farmer production for farmers from Gujarat and Maharashtra were calculated for each of the three crops, and the findings are shown in Table 3.

Table 3: Average per farmer production for Beekeepers and Control Group

	Mango		Cashew		Cluster Bean	
	<i>Beekeeper</i>	<i>Control</i>	<i>Beekeeper</i>	<i>Control</i>	<i>Beekeeper</i>	<i>Control</i>
Gujarat	654.5 Kg	599.8 Kg	80.5 Kg	23.8 Kg	472.6 Kg	259.5 Kg
Maharashtra	144 Kg	122.6 Kg	42.7 Kg	29.4 Kg	30.8 Kg	5.8 Kg

From the above table it is quite evident that the Maharashtra farmers had smaller lands and fewer trees as compared to the Gujarat farmers. Also, in 2018-19, quite a few districts (including Palghar) in Maharashtra suffered from drought which in turn impacted the crop production in that state (Hindustan Times 2018). But even with smaller farms and less water for irrigation, the Beekeepers did comparatively better than the Control Group farmers in the same agro-climatic area.

3. Economic value of the produce

It is fairly obvious that increase in crop yield will lead to economic well-being of the farmers, whether they sell their produce in the local market or used it for self-consumption. Since the data indicated that majority of the farmers used their produce for self-consumption, we decided to calculate the imputed economic value of the produce rather than just focusing on the actual income earned by selling the crops.

The economic value of the produce was calculated by first arriving at the average price per kg of fruits/vegetables sold. The total income from sale of Mango, Cashew and Cluster beans respectively was divided by the total quantity of each sold, thereby arriving at the average price at which they are sold. The average price was then multiplied by the average produce per farmer to calculate the economic value of the produce.

Hence additional economic value of the produce due to introduction of beehive was calculated by multiplying difference between with-beehive production and without-beehive production with Average price per kg of fruits sold. Findings are shown in Table 4.

Additional Economic Value of the produce = (with-beehive production – without-beehive production) x Average price per kg of fruits sold

Table 4: Increase in Economic Value (imputed) of Produce due to Beekeeping

	Mango	Cashew	Cluster Bean
Gujarat	Rs.9062	Rs. 6419	12909
Maharashtra	Rs.1015	Rs.1520	Rs.997

On an average Rs.71 (INR) = \$1 (USD)

4. Income from sale of each crop for beekeepers and control farmers

Since some of the farmers did sell their produce, a comparison of the income from sale of each crop for Beekeepers and Control Group farmers were also calculated.

$$\text{Average income earned by each farmer} = \frac{\text{Total Income}}{\text{No. of people selling}}$$

A difference in the average income of Beekeepers and Control Group farmers were calculated, and consequently the percentage of difference of average income earned was also calculated.

(Findings are shown in Table 5)

Table 5: Average difference in income generated (per farmer) between Beekeepers and Control Group

	Mango		Cashew		Cluster Bean	
	Difference in average income earned (Rs.)	Percentage	Difference in average income earned (Rs.)	Percentage	Difference in average income earned (Rs.)	Percentage
Gujarat	Rs. 1522	7%	Rs. 6012	250%	Rs. 8823	91%
Maharashtra	Rs. 5959	98%	Rs. -254	-4%	Rs. -417	-28%

On an average Rs.71 (INR) = \$1 (USD)

The data shows that highest percentage of difference in average income between beekeepers and Control Group farmers were for Cashew in Gujarat. This was followed by Mango in Maharashtra (98% increase for beekeepers) and Cluster Bean in Gujarat (91% increase for beekeepers). Even though for all the three crops in Gujarat, there has been a positive increase for the beekeepers, the percentages ranged between a high of 250% for Cashew and a low of 7% for Mango. But for Maharashtra, the findings were drastically different, where only for Mango the beekeepers on an average earned more than the Control Group farmers. For both Cashew and Cluster Bean the Control Group farmers on earned more than the Beekeepers. This could be

because that the Control Group farmers had more Cashew trees (13 trees on an average per farmer) than Beekeepers (8 trees on an average per farmer), hence their total production was more which meant they were able to sell more consequently leading to a higher income generation per farmer. Similarly, the Control Group farmers in Maharashtra sowed Cluster Bean in larger quantities than the Beekeepers.

So even when the per unit production had increased for all the Beekeepers compared to the Control Group farmers for all the three crops studied, the actual income generated by selling the produce depended on the total production and total quantity sold.

5. Evaluating the impact of beekeeping with only 2 Cerana boxes or only 2 Trigona boxes

The Beekeepers included in the current study had beehives ranging from 1 to 38, but majority of the farmers had two beehives in their farms or orchards. Since pollinator density can directly impact the crop yield, we decided to analyse the production data only of those farmers who had only two Cerana boxes or only two Trigona boxes.

Per unit production for these selected farmers were calculated by

$$\text{Average Per unit production} = \frac{\text{Total Production in Kgs}}{\text{Total Area in Guntha OR No. of Trees}}$$

The average per unit production of the Cerana beekeepers and Trigona beekeepers were compared with the Control Group farmers. The following table (Table 6) shows the difference in per unit production for Mango, Cashew and Cluster Bean between Beekeepers and Control Group farmers. This analysis was only done for the Gujarat farmers since the number of beehives varied greatly for Maharashtra farmers, and only few farmers had exactly two beehives in their farms.

Table 6: Per unit increase in crop yield for the Beekeepers (as compared to the Control Group) in GUJARAT due to the presence of either 2 Cerana boxes or 2 Trigona boxes in their farms or orchards

	Mango		Cashew		Cluster Bean	
	Increase in per unit production for Beekeepers	Percentage of increase compared to the Control Group	Increase in per unit production for Beekeepers	Percentage of increase compared to the Control Group	Increase in per unit production for Beekeepers	Percentage of increase compared to the Control Group
Beekeepers with only 2 Cerana boxes	13Kg	71%	3.5Kg	284%	574Kg	301%
Beekeepers with only 2 Trigona boxes	11.1 Kg	60%	1.1Kg	92%	No impact	--

As the table indicates, per-unit increase in yield was highest for those who had Cerana boxes and grew Cluster Bean, and on the contrary presence of Trigona boxes in the Cluster Bean farms didn't have any impact on the production. Cerana also worked quite well on Cashew flowers, which was followed by Trigona on Cashew flowers. For Mango, it seems both Cerana and Trigona had similar pollination impact.

Based on the percentage of increase in per unit production of the Beekeepers (as compared to the Control Group) we can list pollination impact of Cerana and Trigona on the crops following way (refer to Table 7).

(Please note: that this table is only based on the data of the current study.)

Table 7: Impact of Cerana and Trigona Beekeeping on Mango, Cashew and Cluster Bean in Gujarat

Crops	Bee species	Percentage of increase in crop production of the beekeepers as compared to the Control Group
Cluster Bean	Cerana	301%
Cashew	Cerana	284%
Cashew	Trigona	92%
Mango	Cerana	71%
Mango	Trigona	60%
Cluster Bean	Trigona	No impact

6. Improvement in the quality of the produce

It is widely known that pollination by honeybees not only increases the yield quantity, but also significantly improve the quality of the produce. There have been many studies on various different fruits and vegetables on the impact of bee pollination on the quality of various different fruits and vegetables (Dulta, 1987; Partap, 2000).

To measure whether presence of beehives in the farm or in the orchard actually did change the quality of the produce, we asked the Beekeepers if the fruits were any different from the fruits grown before the presence of beehives. The responses of the beekeepers in the two states are delineated in Table 8.

Table 8: Improvement in the quality of the fruit

	Mango	Cashew	Cluster Bean
Gujarat	97%	95%	92%
Maharashtra	65%	64%	55%

It was found that in majority (92% to 97%) of the beekeepers in Gujarat of the beekeepers said that their current produce was of better quality than that of the pre-beekeeping yield. Whereas

in Maharashtra, the impact on the quality of the fruit was only 55% to 65% of the Beekeepers felt that there was some improvement in the overall quality of the fruits and vegetables.

With respect to the general quality of the fruit, the beekeepers mentioned that their fruits were brighter in colour, bigger in size, juicier in consistency, and tastier on the palette.

Table 9: Quality changes noticed by the Gujarat beekeepers after beekeeping

	Mango	Cashew	Cluster Bean
Change in Colour	58%	65%	45%
Bigger in Size	95%	95%	76%
Jucier than before	3%	0%	8%
Tastier	13%	3%	34%

7. Pesticide usage

Information related to the use of pesticide and fertilizer was also collected from the Beekeepers and Control Group farmers. All the beekeepers from Gujarat, and 77% of the beekeepers from Maharashtra said that after beekeeping, they reduced the usage of pesticides on their crops.

DISCUSSION

In the current study it was found that the average per tree production of Mango and Cashew was higher for Beekeepers as compared to Control Group farmers for both Gujarat and Maharashtra. These findings are in accordance with some of the previous research publications by (Badiyala 1991) and (Vasanthakumar S. 2018) who also studied the impact of indigenous bees on Mango. Even though we couldn't find any studies on impact of *Apis cerana* on cashew production in India, we did come across studies done in Brazil (Frietas 1996) and in Ghana (Aidoo 2013) indicating that Cashew production increases significantly when there are beehives in the neighborhood. Consequently, beekeeping also led to an increase in the average economic value of produce for farmers.

In this research we also observed that both *Cerana* and *Trigona* pollinated Mango flowers equally well. Whereas in some past studies in India (Singh 1989), Brazil (Cortopassi-Laurino 1991) and Australia (Anderson 1982) it has been mentioned that *Trigona* is the most common bee visiting the mango flowers. They are considered as the most efficient pollinator for Mangoes mainly because of their size which help them to come in close contact with the stigma of the Mango flower. They also observed that *Trigona* bees moved more frequently from tree to tree and thus were probably the most effective cross pollinators (Anderson 1982).

Most of the beekeepers interviewed in the current study observed improvement in quality of their produce in terms of colour, size and taste. We came across similar studies noting the impact of *Apis cerana* on quality of produce for Apple, Peach, Plum, Citrus and Strawberry. They indicated increase in fruit set, fruit weight, fruit length and diameter for Apple (Verma 1986), Peach (Partap 2000), Plum (Partap 2000), Citrus (Partap 2000) and Strawberry (Partap 2000). For Citrus fruit presence of *Apis cerana* also reduced premature fruit drop, increased juice and also increased sugar content in juice (Partap 2000). Even though the current study pointed to a similar direction, but the percentages varied widely, which could be because of the multitude of variables that might have impacted the fruit set.

CONCLUSION

There has been clear indication of impact of beekeeping on agricultural productivity of Mango, Cashew and Cluster Bean in Gujarat and Maharashtra. Although some of the statistics match with previous research reports, but not all the findings are consistent with them.

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