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APICULTURE FOR SUSTAINABLE AGRICULTURE: BANGLADESH PERSPECTIVE

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ABSTRACT

The paper is targeted to trace out the role of apiculture in improving crop yield leading to the betterment of human livelihood in Bangladesh. Different cultivated crops in Bangladesh such as cabbage, cauliflower, mango, litchi, mustard, cotton, onion, coriander and chili are highly dependent on honey bee pollination. Adequate pollination results in higher seed yield, quality and germination capacity. Besides, honey and beeswax are the casual output of apiculture which acts as a good income generating source. Other bee producing products like pollen, propolis and royal jelly are very much useful to make secondary products of human use. Considering the benefits, some organizations of the country have shown their interest on commercial rearing of honey bee. But making profit from this business has been very difficult due to lack of related information, institutional research, sufficient machinery and equipment. Farmers are involved in indiscriminate application of pesticides which kills the natural pollinators as well as deteriorates the environmental condition. DAE (Department of Agricultural Extension) has taken initiatives for training on apiculture and dissemination of necessary technologies to improve the situation. Attention on apiculture will ultimately lead to the maximization of crop yield, improvement of livelihood and conservation of biodiversity.

Keywords: Honey bee, crop yield, biodiversity, rural livelihood.

Introduction

Bangladesh ranks 94th in terms of land area and 8th in terms of population among the 182 countries in the world, and there is an average of 1291 people per km^2 area **(**Bangladesh Population 2019**).** Agriculture is an important economic sector in Bangladesh, contributing 14.2% of the country's GDP (BER 2019). About 160 crop species grow in Bangladesh, where rice, maize, wheat, sugarcane, jute, tea, pulses, oilseeds, potatoes, vegetables and fruits are the main crops. Agriculture in Bangladesh is commercialized day by day and the farmers are showing interest in producing valuable crops like vegetable, fruit, oilseeds and pulses in parallel with traditional cereal crops. Pollination acts as the key driver for better production of these commercial crops, and the relationship between flowering plants and flower-visiting insects is of great importance in Bangladesh. Here, honeybees play vital role in the agricultural ecosystem as natural pollinators of various plant species, however due to injudicious application of fertilizers, pesticides and flower induction hormones, their population is going down gradually. So, there is growing interests in apiculture and uses of honey bees for crop pollination to maximize yield and quality of crops through biodiversity conservation.

Apiculture and honey bee species

Rearing of honey bees on a commercial scale for crop pollination and production of honey is called apiculture. There are 10 species of honey bees namely *Apis dorsata, A. florae, A. cerana, A. koschevnikovi, A. nigrocincta, A. mellifera, A. andreniformis, A. armbrusteri, A. lithohermaea* and *A. nearctica.* Among the species giant honey bee *A. dorsata,* little honeybee *A. florae,* Asian honey bee *A. cerana,* and Western honey bee *A. mellifera* are well known (Bandgar *et al.* 2018). The Western honey bee species is mostly domesticated and widely used for production of honey and simultaneously crop pollination. *A. armbrusteri, A. lithohermaea* and *A. nearctica* have gone extinct.

Impact of honey bee pollination on crop

In the world, 30 % human diet is directly or indirectly dependent on bee pollination, and many farmers in the

globe rely on managed bee pollination (Hoopingarner and Waller 1992, Amin *et al.* 2012). In addition, many forages for cattle are grown from seeds of insect-pollinated plants and bees contribute 70-80% pollination among the insects. In 146 countries of the world, 90% food comes from 115 crop species of which 71 are pollinated by bees (Amin *et al*. 2012). The total economic value of insect pollination in the globe amounted to $210 billion in 2005, which represented 9.5% of the total value of agricultural production used for human consumption (Allsopp *et al.* 2008). Through their pollination services and honey production, honey bees are estimated to be worth $15 billion to the US, $19 billion to the EU and over $69 billion to East Asia (Allsopp *et al.* 2008). Insect pollination is thought to be the main reproductive mechanism in 78% of temperate flowering plants, and is essential to maintain plant genetic diversity. Some crops such as blue berries and cherries are 90% dependent on honey bee pollination. Another crop namely almond depends entirely on insect pollination. There are 620,000 beekeepers in the EU, producing 220,000 tons of honey every year (Zoccali *et al.* 2017).

Managed honey bee pollination exerted higher percentage of pod formation (12-28%), seed set (21-35%) and seed weight (9-40%) of different vegetable crops like cabbage, cauliflower, radish and lettuce (Table 1). Installing honey bee colonies increase yield up to 12-78% in different fruits, oil seeds and cash crops (Figure 1). The great value of bees as pollinator has been known to farmers in Bangladesh for many years, but this knowledge is not widely appreciated and practiced. The value of bee pollination in Western Europe is 30-50 times higher than the value of honey and wax (Vinod *et al.* 2016). In Africa, bee pollination is 100 times higher than the value of harvested honey, depending on the type of crops (Vinod *et al.* 2016). However, there is no comprehensive study so far in Bangladesh regarding the value of bee pollination on various agricultural crop species.

Table 1. Impact of honeybee pollination on vegetable seed production

Crop	Increase in (%)		
	Pod formation	Seed set	Seed weight
Cabbage	28	35	40
Cauliflower	24	34	37
Radish	23	24	34
Lettuce	12	21	9

(Verma and Partap 1994)

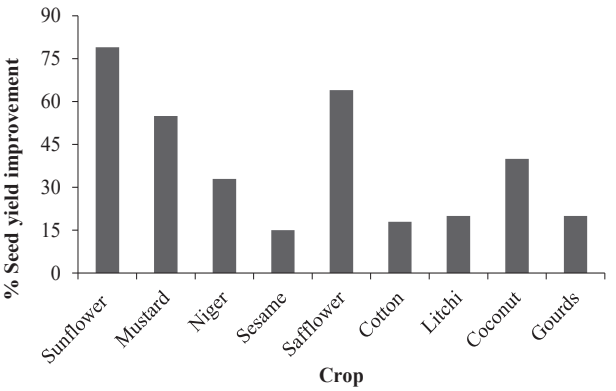

Figure 1. Seed yield improvement of some crops by installing honey bee colonies (Klatt 2014).

The attributed honeybee pollination increased yield and quality of crops US$14.6 billion in the US in the year 2000 (Alemberhe and Gebremeskel 2016). In Western Cape (South Africa), honey bee pollinated deciduous fruit industry generates one billion per year and creates job opportunities for 80,000 people (Alemberhe and Gebremeskel 2016).

Crops that get benefit out of honey bee pollination

Honey bee workers forage from flower to flower and they travel incredible distances to collect pollen and nectar. Their foraging activity insures pollination of the following plants and thus increases fruit size at yield, hastens maturity and produces a more symmetrical fruit shape. Various crops such as vegetables- cabbage, cauliflower, broccoli, Brussels sprout, Chinese cabbage, carrot, cucumber, pumpkin, gourd, squash, radish, okra, turnip, canola, peas and beans; fruits- mango, litchi, citrus, papaya, strawberry, melon, almond, apple, apricot and peach; oil seed crops- mustard, sunflower, niger, rape seed and safflower; spices- onion, coriander and chili; forage-lucerne, clover; and cash crop like cotton get benefit out of honey bee pollination (Abrol 2011).

Importance of honey bee for higher yield and quality seed production

Honeybee pollination is one of the most important factors affecting seed production of crops. It increases crop yield and improves seed quality. Inadequate pollination not only reduces the yields but also deteriorates seed quality. More than 5% consumable fats and oil in the world come from oilseeds such as mustard, sunflower, coconut, cotton,

groundnut and oil palm species. Though some of these plant species have pollinators belonging to insect species other than honeybees, but these plants depend on, or get benefit from bee pollination to some extent. Managed honeybees increase number of seeds, weight of seed, germination rate and oil content of sunflower (Table 2). Pires *et al*. (2014) reported higher yield, seed germination and oil content in cotton with honeybee pollination however, the crop is self-pollinated (Bommarco *et al.* 2012).

Contribution of apiculture towards biodiversity conservation, food security and rural livelihood

Beekeeping activities are integrated with crop pollination and crop productivity, soil conservation and soil fertility, environment conservation and maintenance of biodiversity, income generation and food security, and livelihood of rural people (Figure 2). The beekeeping plays a significant role in contributing food production through increased pollination of food crops, and can conserve forests and foster sustainable environmental management practices (Agera 2011).

In terms of apiculture, the least visible livelihood outcome is the pollination of both wild and cultivated flowering plants. Honey is also traditional medicine or food in nearly all societies. The beekeepers and other people in rural communities use honey and beeswax to make candles and get better return by selling this secondary product. Bees also generate other products (pollen, propolis and royal jelly) that can in some situations be harvested, marketed and made into secondary products thereby strengthening people's livelihood (Chazovachii *et al*. 2013).

Scenario of apiculture, crop pollination and honey production

Apiculture in Bangladesh is going to be a fascinating industry for production of honey through pollination of different crops namely mustard, black cumin, coriander, litchi, sweet gourd, melon, mango, onion etc. In the fiscal year 2015-16 and 2016-17, the highest amount of honey (522.6 and 770.2 Mt, respectively) was gathered from mustard (Table 3). Commercial rearing of honey bee colonies and honey production is increasing in Bangladesh (Table 4). In the fiscal year 2015-16, the amount of honey production in Bangladesh was 1110.8 Mt from 110254 colonies and it reached 1528.8 Mt from 136365 colonies in the fiscal year 2016-17. Different government and non-government organizations are patronizing farmers and rural people for their involvement in apiculture. Bangladesh Small and Cottage Industries Corporation (BSCIC), a state-owned organization, and the non-government organizations viz. Bangladesh Rural Advancement Committee (BRAC), Proshika, and Palli Karma-Sahayak

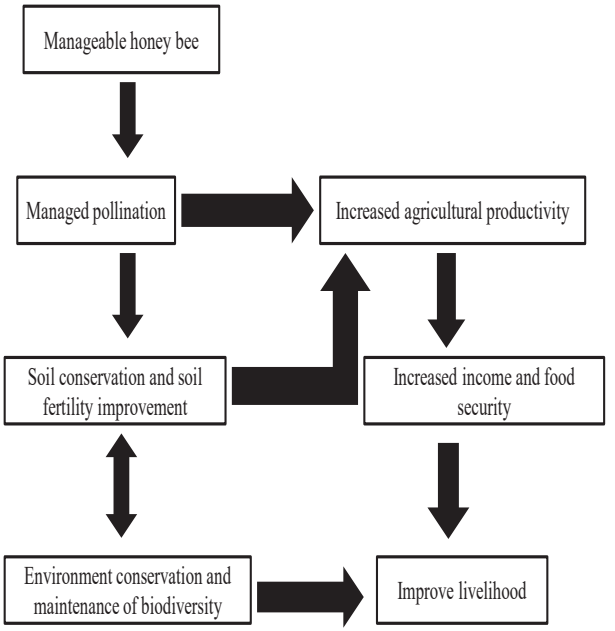

Figure 2. Contribution of honey bee pollination to agricultural productivity, improving livelihood and biodiversity conservation (Minja et al. 2016).

Table 2. Effect of honey bee pollination on seed yield and seed quality of sunflower

Parameters	Pollinators		
	Honeybees	Without	Honeybees and other insects
Number of seeds capitulum^{-1}	503	81	557
Number of empty seeds capitulum^{-1}	84	446	70
Weight of 100 normal seeds(g)	7	4	8
Yield	Standard	Reduced by 87%	Increased by 17%
Germination (%)	82	71	89
Oil content (%)	42	29	44

(Verma and Partap 1994)

Table 3. Amount of honey production in Bangladesh during July 2015 to June 2017 by cultivated honey bees on different agricultural crops

Crops	Honey production (Mt)		Increased honey (Mt)
	2015-16	2016-17	
Mustard	522.6	770.3	247.6
Black cumin	125.5	174.6	49.0
Coriander	267.1	317.2	50.1
Litchi	106.4	171.7	65.3
Sesame	85.0	90.5	5.5
Jujube	4.1	4.5	0.4

(DAE 2018)

Table 4. Increment of honey production in Bangladesh during July 2015 to June 2017

Fiscal year	2015-16	2016-17	Increment
Number of bee colonies	110254	136365	26111
Produced honey (Mt)	1110.8	1528.8	418.0

(DAE 2018)

Table 5. Return from a colony of *Apis mellifera* and benefit cost ratio

Colony	Cost (TK.)	Return items			Return (TK.)		Benefit cost ratio
		Honey (kg)	Wax (kg)	Colony (TK.)	Gross	Net	
Small	10800	52.5	2.0	5200	16100	5300	1.49
Medium	14500	63.2	3.0	8500	21740	7240	1.50
Large	18000	91.3	5.5	9800	29160	11160	1.62

Price of raw honey and wax is 200 TK. Kg^{-1} (Islam *et al.* 2016).

Foundation (PKSF) are currently producing honeybee colonies for production of honey and crop pollination.

Return from honey bee colonies and benefit cost ratio

Most of the costs in bee keeping are fixed and costs involved in purchasing wooden box, hive, honey extractor, bee veil, hand gloves, knife, feed, transportation and labor. The average cost for small, medium and large size hive $year^{-1}$ is TK. 10800, 14500 and 18000, respectively. The keepers in Bangladesh can produce on an average 52.5, 63.3 and 91.3 kg honey, 2.0, 3.0 and 5.5 kg wax $year^{-1}$ from a small, medium and large size hive, respectively and they could earn TK. 16100-29160 $hive^{-1}$ $year^{-1}$. Net return and benefit cost ratio ranged from 5300-11160 TK. $hive^{-1}$ year-1 and 1.49-1.62, respectively. Benefit cost ratio was higher for large size hive which is more profitable.

Constraints in using honey bees for pollination of crops

In Bangladesh, most of the farmers are illiterate and unaware of pollination. Due to this ignorance, farmers use pesticides in improper, unplanned and unscientific ways. The utilization of honey bee pollination is not a focus due to insufficient communication and coordination with government authorities or institutions. Meanwhile, the commercial rearing of honey bee is not developing due to a lack of related information, institutional research, sufficient machinery and equipment. In addition, there is limited scope of training for beekeeping personnel.

Activities of the Department of Agricultural Extension (DAE) regarding apiculture

Department of Agricultural Extension has put utmost effort to disseminate the honeybee cultivation at farmers' level. It facilitates the honeybee farmers to increase their honey production by providing necessary technologies. DAE provides training for its personnel and farmers with a view to improving their knowledge for increasing honey production in the country. It has provided a training program on 'Apiculture for crop and honey through ecofriendly management' for 600 officers for a period of 5 days. In Bandarban district, 40 amloki (*Phyllanthus*

emblica) producers were given a training program to learn about bee cultivation for increasing crop yield simultaneously collecting and storing honey. In addition, 150 persons of Nomads community were trained on bee culture so that they could adopt 'bee cultivation' as a means of leading their life. For the last two years there is a significant increment of honey production across the country through DAE's initiative and activities which have been shown in table 3.

Future action plan of the DAE regarding honey bee pollination

- Existing cropping pattern will be revised (without disturbing food security of the country) for accommodating honey producing crops and for sustaining year round apiculture. This will improve soil health, crop production, and maintain biodiversity.
- Encourage social forestry to accommodate honey producing plant like mango, litchi etc.
- To create awareness on apiculture and medicinal use of honey.
- Facilitate demonstration on apiculture to promote pollination for increasing crop yield.
- Development of local groups to sustain year round apiculture.
- To encourage establishment of honey processing factories.
- Strengthening/ developing local/ indigenous method of honey processing/ preservation.
- Provide more training to officers, staffs and farmers for up scaling efficiencies of DAE.
- Provide support to Nomads and other backwards societies so that they can take apiculture as a means of their livelihood.
- To involve waste labor of rural community to reduce cost of honey production for competing with the international market.
- Ensuring quality of honey to international standard for exporting in advanced countries.
- DAE personnel will make linkage with the buyers/ honey processing factories/ honey exporters to create opportunity for getting higher price of honey. This kind of linkage strategies will also be applicable for crop involved in honey production.
- To create consciousness regarding use of honey.
- To involve women in apiculture to generate employment.
- To create awareness among farming communities for apiculture as a means of increasing crop yield.

Conclusion

The bee-keeping is a proven technology for profitable venture requiring small investment. For development of agriculture and rural economy, bee-keeping may play a vital role as one of the economic activities. Moreover, for strengthening high-value cash crop production, proper pollination could be ensured through apiculture. So, agricultural policies need to be adopted for developing awareness among the farmers to insure appropriate pollination of their crops and particular attention should be given to develop the beekeeping industry.

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