Original Article

Journal of Apiculture 33(1) : 25~32 (2018)
DOI: 10.17519/apiculture.2018.04.33.1.25

Supplement Feeding to Honeybee Colony for Field Crop Pollination; Pumpkin and Honey Production in Sandbar Cropping System

M.H. Rashid[1], H. F. El Taj[1]*, Nazmul Islam Chowdhury[2], Nirmal Chandra Bepary[2] and Chuleui Jung[3]

[1]Dept. of Entomology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
[2]Head, Extreme Poverty Programme, Practical Action Bangladesh
[2]Manager-Agriculture, Extreme Poverty Programme, Practical Action Bangladesh
[3]Department of plant medicals, Andong National University, Korea

(Received 15 March 2018; Revised 12 April 2018; Accepted 24 April 2018)

Abstract

An experiment was conducted in pumpkin fields fully composed of sandy soil at sandbar area of Brahmaputra River flowing near the Kurigram district of Bangladesh during winter of 2017 to investigate the role of supplementary feeding on bee population and pollination by honeybee, *Apis mellifera* L. Honeybee colonies were provided with 4 different supplementary feeds: syrup-1; syrup-2; syrup-3 and syrup-4 and no food was provided to the control colonies. The highest increase of brood cells was observed in the syrup-1 colonies and brood cells increased 385.0% and 351.6% but only 94.2% and 58.9% in control after 15 and 30 days of experimentation, respectively. The highest amount of honey was stored from the colonies fed with syrup-1 but the least quantity from the control colonies. The pollen collection was the highest (2.61g) in syrup-2 but syrup-3 provided the least. Bee°Øs visitation frequency to pumpkin flowers were varied by supplementary foods. The highest visitation frequency 0.26 and 0.57 were found at 15 and 30 DAT in control and syrup-3 colonies while the lowest visitation rate 0.18 and 0.26 were observed in syrup?3 and syrup-2, respectively. The highest fruiting rate (45.7%) was found in the field adjacent to the syrup-2 colonies while the lowest (18.3%) yielded from the control fields. The results clearly demonstrated that supplementary feeding could enhance proper pollination via increased bee population for the field crop such as pumpkins.

Key words: *Apis mellifera*, Supplementary feeds, Pollination, Flower visit frequency, Fruiting rate

INTRODUCTION

Bangladesh is a deltaic country formed by the floodplains of the three foremost rivers: the Ganges, Brahmaputra, and Meghna. These rivers ditch into the Bay of Bengal, although only 7% of the catchment area lies within the country's precincts. Across the river banks on the southern coastlines, and north of the basin, are *sandbars*, accumulations of coarse sands. The northwestern corner, at the confluence of the Teesta River and the Brahmaputra River, is especially exposed to flooding and erosion. After each rainy season consequently with flood, large sand islands appear in the main rivers of northwest Bangladesh. These innumerable vast sandbars emerge in the riverbeds during

*Corresponding author. E-mail: H .F. El Taj.fuad_eltaj@yahoo.com

the dry season (November-April). Most of these sandbars remain unused and barren because of their unfertile sandy traits (Rahman and Reza, 2011). In spite of this intricacy, the sandbar inhabitants have been growing pumpkins with technological assistance from an NGO, Practical Action Bangladesh (PAB). As pumpkin (*Cucurbita pepo* L.) is a monoecious, obligate cross-pollinated crop, so, transfer of pollen to the pistil of the female flower is essential (Delaplane and Mayer, 2000). Any pollinating agent or hand pollination is crucial for those crops. Commonly, very few pollinating agents are found in the sandbar areas due to lack of flora and pumpkin growers are usually fertilize the female pumpkin flowers by hand pollination. But it is cumbersome, laborious, sensitive and could not achieve 100% pollination success. While the insects ,especially bees are important pollinating agent and can be efficiently fertilize the flowers of the sandbar cropping system as well produce honey which can alleviate the poverty of the sandbar inhabitants. The seed set of pumpkin also depends on insect pollination (Fuch and Muller, 2004; Nicodemo *et al*., 2009). Although squash bee and carpenter bees are known efficient pollinators of pumpkin, honey bee, *Apis mellifera* L., is also a particu-larly important pollinator, especially in sandbar areas where other bees are absent (Hurd, 1964). For commercial production of pumpkins, honey bees are the only effective pollinator that can provide in sufficient numbers for adequate pollination (Free, 1993). Walters and Taylor (2006) reported that addition of a honey bee hive to a field of pumpkin increased the quantity of set-fruit by 62% and total fruit weight by 100% under field conditions where sufficient natural pollinators freely visited pumpkin flowers. Consequently, honey bee colonies are rented in large numbers by pumpkin growers for the elevation of pumpkin pollination. Farmers routinely supplement pumpkin fields with honey bee hives (Free, 1993) which is assumed to increase the visitation frequency to pumpkin flowers, and increase fruit yield.

Honeybees need several nutrients, like carbohydrates, proteins, lipids, vitamins, and minerals for their growth and development. They take carbohydrates from nectar and proteins from pollen (Javaheri *et al*., 2000). The pumpkin flowers are rich of pollen content but the amount of nectar is not sufficient due to hot and dry conditions of sandbar for meet up the food requirement of honeybee as well as honey production. As sandbar area does not have diversified crops so there is no way to meet up the nectar requirement from any other resources to increase the honey production. Supplementary foods can be fed to honey bees to supply the nutritive requirements of colonies as well honey flow in sandbar areas and at times when natural food sources (pollen, nectar, or honey) are inadequate or not available. Feeding bees with pollen substitute and sugar syrup increase the number of bees and frames covered by bees, brood area and colony weight (Sahinler *et al*., 2003).

Bee pollen is the food of the young bee containing high protein contents (Ghosh and Jung, 2017). It is considered one of nature's most completely nourishing foods. It contains almost all the essential components of proteins, free amino acids, and vitamins, including B-complex and folic acid for the diet of human which acts to enhance high-density lipoproteins (HDL), reduce low-density lipoproteins (LDL), and standardize blood serum cholesterol and triglyceride levels (Mercola, 2016). Generally pumpkin flowers are large and contain enormous pollen and sufficient amount of nectar. But the nectar dried up quickly due to hot sandy soil of the cropping area. Sugar is the main commodity to feed honeybees when availability of natural nectar becomes scarce. During the pumpkin growing season in sandbar, other natural nectar sources are also scarce. Thus, supplementary feeding of honeybee may be necessitated for proper colony development and pollination. Supplementary foods could meet up the shortage of nectar and encourages the bees to increase the population and pollen collection. This paper reports the experiment done in pumpkin cultivation system while feeding supple-mentary foods to the bee colonies.

MATERIALS AND METHODS

Study Site and System

This study was conducted in pumpkin field at sandbar area beside the river Brahmaputra, Kurigram district at 2,100m above sea level from January to March 2017. The site was characterized by heavy rainfall during the month of May to September and scanty rainfall during the rest of the year. During experimentation average daily temperature and humidity was 32~37°C and 33~39% respectively. The soil of the experimental area was sandy in texture and acidic in pH (around 5.8) with very poor fertility status. Pits of dimensions one meter in diameter and in depth were dug. These were placed approximately two meters apart. Then, the bottom of the pit was filled with about 5~10kg of compost/cow dung mixed with pit soil. This was left for 15 days. Next, 4~6 seed of pumpkin, *Cucurbita pepo* L. were planted in each pit and the pits were soaked with water. Irrigation was done twice a week. All management practices were done by the workers of an NGO named Practical Action Bangladesh (PAB).

Experimental beehives

Ten bee hive box with removal tops contents honey bees *Apis mellifera* were examined. Each hive box containing of 6 frames was treated as a replication and two replications were maintained for each feeding treatment.

Tested supplementary food

Five different feeding treatments were implemented for the experiment. Bees were fed with: syrup-1 (White sugar: water=2:1), syrup-2 (White sugar: water=1.5:1), syrup- 3 (White sugar: water=1:1), syrup-4 (Brown sugar: water=2:1) and Control (without food). White refined household-quality sugar from cane (refined sucrose) or brown unrefined sugar from cane were used. Sugar syrups were providedinside each hive box in a division board feeder with the amount of 1 L. at an interval of 15 days. Total 3 litre of sugar syrup was supplied to each box during the experimental period. The feeding started from the first week of February and lasted until the end of March.An existing frame was removed to place the division board feeder into the hive. Straws were placed in the feeder to prevent bees being drowned while taking up the sugar syrup.

Bee population

The number of sealed brood cells of 2 frames located at the center was counted for estimation of bee population. This investigation was carried out every 15 days through the winter season from February to March. Each colony was monitored by taking photos of both sides of the two selected frames using digital camera. After printing the photos, number of brood cells was counted by naked eyes (Abd-Elmawgood *et al*., 2015).

Amount of honey (g)

Honey stored in the cells of the tested comb was harvested. All frames from the each box were taken and honey was harvested using a honey extractor. Honey was collected at 30 days after treatment.

Amount of pollen (g)

Pollen traps were installed and all forager bees are forced to enter through a plastic ribbon with holes. Those holes (Ø 5mm) cause pollen to fall off and the pollens are collected after falling through a grid. The grid prevents the bee to have access to the fallen pollen Collection of pollen was done at 15th day for 1 hour with clear weather and between 9:00 am and 12:00 pm as this time pumpkin flower remain at blooming and dew is dried up. The collected pollen were kept in vial and weighed by digital balance.

Assessment of flower visiting rate

Four pits each contain 3 to 5 pumpkin plant at different distance nearest to the boxes of five treatments were

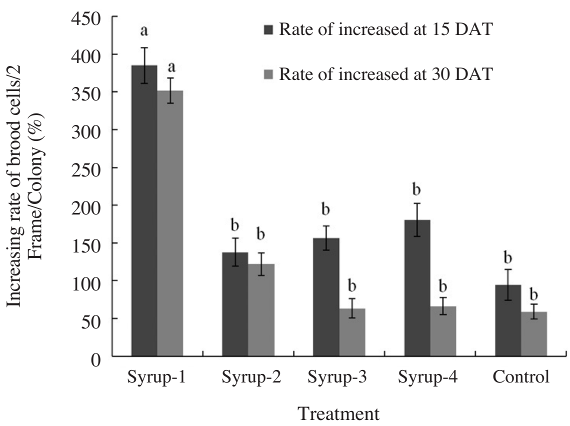

Fig. 1. Increasing rate of brood cells per colony at 15 and 30 DATs while fed different supplementary feeds.

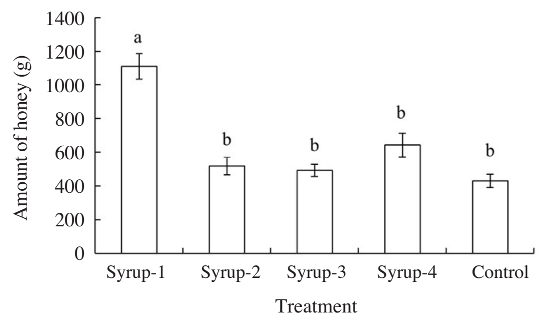

Fig. 2. Amount of honey (g) produced from the colonies provided by different supplementary feeds.

selected to observe the visit rate to the pumpkin flowers by honeybees. All bees visiting to the pumpkin flowers along the pits were surveyed visually for a total of 10 minutes each by slowly walking down the row. Scoring of the number of bee visits to each flower was repeated in the selected pits. A flower "visit" was recorded when the bee came in contact with the reproductive parts. Observation of visit rate was conducted with clear weather and between 9:00 am and 12:00 pm. Assessment of visit rates (the numbers of visited honey bees by the number of flowers) was conducted twice just after 15 days of first and second feeding supplement.

Estimation of fruiting rate (%)

Numbers of male and female flowers of each pit were tagged and recorded. After 15 days total number of fruit per pit was counted and fruiting rate (%) was calculated.

Statistical analysis

Treatment effect on the traits ofbee population, honey production , amount of pollen (g), bee visit rate and fruiting rate were determined by using one way ANOVA, and means were separated by using Tukey Honest Significant Difference test (Tukey HSD test) using SPSS statistical program version 20.0.

RESULTS

Bee population

Bee population was estimated by counting only the brood cells. Increasing rate of brood cells per colony after 15 and 30 DAT were significantly influenced by the supplementary feeds (Fig. 1). The syrup-1 helps to increase the brood cells 385.03% and 351.54% but only 94.17% and 58.88% brood cell increased in control after 15 and 30days of experimentation, respectively. It has been found from the experiment that the honeybee colony was viable when fed with sugar syrup-1, which increased the production of broods.

Honey production

The production of honey differed significantly while treated the bee colonies (F=23.463; df=4; P<0.05) with different supplementary feeds (Fig. 2). Deposited honey was harvested and weighted after 30 days of supplied supplementary food. The highest amount of honey (1,110g/colony) harvested from the colonies fed with white syrup-1 but the least (430g/colony) quantity of honey collected from the control colonies (without supplemented). The colonies provided with brown sugar syrup also yielded the significant amount of honey (642 g/colony) in comparison with control colonies.

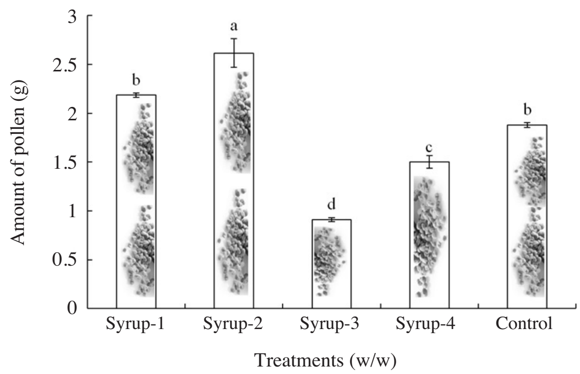

Fig. 3. Amount of pollen (g) collected from the colonies supplied with different supplementary feeding.

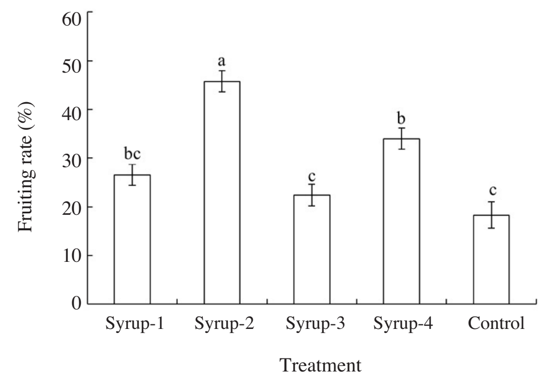

Fig. 5. Percentage of pumpkin fruiting along the areas treated with different supplementary feeding.

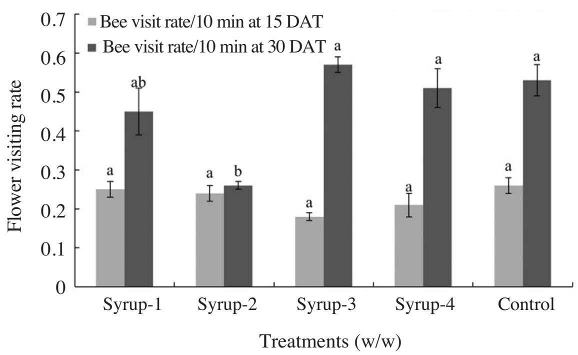

Fig. 4. Bee visiting rates to the pumpkin flowers along the areas treated with different supplementary feeding.

Amount of pollen (g)

The pollen flow is also observed after applying different supplementary feeding (Fig. 3). Significantly variations in pollen production were observed among the tested colonies (F=75.863; df=4; P<0.05). The colonies fed with white syrup-2 yielded the highest amount of pollen (2.61g) followed by syrup-1 (2.18g) but syrup-3 provided the least amount of pollen (0.91g).

Flower visiting rate

Honey bees visitation frequency to pumpkin flowers in sandbars were significantly varied by the different supplemented food only at 30 days after treatment (15 DAT: F=1.376, df=4; P>0.05; 30 DAT: F=7.763, df=4; P<0.05) (Fig. 4). At 15 DAT, there was no difference of flower visiting rates among treatments. On the other hand, at 30 DAT, flower visiting rates were higher than at 15 DAT and different among treatments showing higher in syrup-3, syrup-4, and control and lowest in syrup-2 treatment.

Fruiting rate

Fruiting rate differed significantly among the supplementary feeds (F=22.168; df=4; P<0.05) (Fig. 5). The fruit succession rate was highest (45.75) in the field treated with the colonies by syrup-2 followed by syrup-4 while the lowest number (18.28) of fruits was yielded from the control treatment where no supplementary feeding was provided.

DISCUSSION

Generally, supplementary feeding is required when bees are moved into flowering orchards, deficient bloom or during cloudy or bad weather or during package bee installation on undrawn comb, to overwinter and to promote colony extension for future colony divisions (Herbert 1992).Supplement artificial diets can also be effective in stimulating honey bee colonies to rear brood (Mattila and Otis, 2006; Nabors, 2000 and Standifer *et al*., 1973). The present experiment conducted at sandbar which is very hot during the day and so that the nectar of the pumpkin flowers usually dries very fast. Hence, the extra feeding to the bees can be enhancing the bee's activities. However, supplied all the tested diets to the bees in the sandbar pumpkin fields were effective in stimulating brood rearing or number of combs covered with bees. Bee colonies provided with syrup-1 induced the highest amount of worker brood cells followed by syrup-4 and syrup-2 in the months of February and March. As the sugar quality and content of syrup-1 are high, so, it performs well than control and even any other syrup. Bees fed with various sugars helped to survive better, produced the same amount of wax per bee, and capped more honeycomb cells (Barker and Lehner, 1978). Sugar syrup has long been recognized as having a stimulatory effect, such as an increase in bee population, pollen-collecting activities (Barker, 1971). Free and Spencer-Booth (1961) observed bees switching their foraging strategy after sugar feeding to support colony brood rearing. However, sugar syrup has become more widely used to feed bee colonies because of it lower expense and ease of handling.

After March the sandy soil of the riverside area turned into hot very fast and the total environment became harsh for the pumpkin plants and bees. At that time the number of pumpkin flowers and bee activities reduced gradually which affected the bee population. Comparatively cooler temperature of February was better for increase the bee population and bees can produce much honey and pollen. Tested diets were differed in their consumption by bees;syrup-1 was completely consumed in comparison with other diets. Even though same amount of sugar and water was mixed for syrup -1 and 4 but the brown sugar used in syrup -4 did not perform as white sugar. Degrandi - Hoffman *et al*. (2008) suggested that differences in the nutritional quality of the supplementary foods and perhaps the digestibility and accessibility of their nutrients to worker bees influence the amount of brood that can be reared even when consumption rates are similar.

Colonies receiving syrup-1 had maximal bee strength and produced more honey than the other colonies. Somerville (1999 and 2000) used the thick sugar syrup (2/1 sugar/water ratio) to produce enough honey for winter and thin syrup (1/1 sugar /water ratio) to stimulate the colony to expand the brood area. Abdellatif *et al*. (1971) have reported the increased honey production from colonies feeding pollen substitute during dearth period. Chhuneja *et al*. (1992) reported that higher consumption of pollen substitute diet resulted in higher production of brood and more populous colonies produced significantly more honey. It is contented that stronger colonies store more honey as compared to the weak colonies (Kumar *et al*., 1995).

The pollen collection varied after providing supplementary foods. The colonies supplied with syrup-2 yielded the highest amount of pollen (2.615g). Actually pollen is used for bee brood rearingand bees preferred to mixing syrup-2 with pollen for brood food.

Honey bees have high search ability for flower resources, foraging optimally in terms of energy and time efficiency (Seeley, 1995). As only pumpkin flowers are available in sandbar so honey bees actively visit one species of flower in a bout. Floral visitation rates are one of the good indicators of pollination effectiveness (Javoreketal, 2002). Honeybees are not shown to be as efficient in other tested diets as compare to syrup-3 in terms of pollination efficiency per visit by an individual. The syrup-3 is composed of one part of white sugar and one part of water and it was most inferior syrup among the supplied supplemented foods. Flower visitation rate of honey bee was high in the field treated with syrup-3. In the case probably bees meet up their extra nutritional requirements by collecting excess pollen and that’s why visit frequency was high. Actually the conditions of the pumpkin plants belong to syrup-3 treated colonies were not vigorous as compared to other fields and the quantity and quality of flowers were not satisfactory. This might also be reason to high visit frequency.

However, honeybees belongs to supplied colonies incorporated with the pumpkin cultivation system are the major flower visitors in the sandbar pumpkin fields. They provided the service of pollination for pumpkin which increased the fruit succession rate as well as pumpkin production. Walter and Taylor (2006) reported that even under field conditions with sufficient natural pollinators, the addition of honey bees increased the production of *C. pepo*. From this research, it was evident that the supplementary foods supplied to the bee colonies were effective for bee population and production of bee pollen, honey and, pumpkin in sandbar pumpkin cropping system.

Honeybees provided with supplementary feed produced high number of brood cells and increased the bee population resulting in better pollination.

ACKNOWLEDGEMENTS

The authors express their profound appreciation to the Practical Action Bangladesh (PAB) for providing research grant to conduct this research. Sincere thanks to pumpkin growers for permission to conduct studies in their fields. The authors also are grateful to PAB staffs for providing all necessary tools, space and other supports to complete this experiment.

LITERATURE CITED

Abdellatif, M. A., El-Gaisar, F. H. and Mohanna, N. M. 1971. Three forms of yeast as a pollen substitute. Am. Bee J. 111: 14-15.

Abd-Elmawgood, B. H., Al-Rajhi, M. A. and El-Ashhab, A. O. 2015. Effect of the internal size and thermal insulation of the hive on bee colonies strength and productivity. Egypt. J. Agric. Res. 93 (1): 185-195.

Barker, R. J. and Lehner, Y. 1978. Laboratory comparison of high fructose corn syrup, grape syrup, honey, and sucrose syrup as maintenance food for caged honey bees. Apidologie 9: 111-116.

Barker, R. J. 1971. Shouldn't a minimum food supply be specified for bee colonies rented for pollination? Gleanings in Bee Culture 99: 299-315.

Chhuneja, P. K., Brar, H. S. and Goyal, N. P. 1992. Studies on some pollen substitutes fed as moist-patty to *Apis mellifera* L. colonies 1.Preparation and consumption. Indian Bee J. 55: 17-25.

Degrandi-Hoffman, G., Wardell, G., Ahumada-Segura, F., Rinderer, T., Danka, R. and Pettis, J. 2008. Comparisons of pollen substitute diets for honey bees: consumption rates by colonies and effects on brood and adult populations. J. of Api. Res. and Bee World 47(4): 265-270.

Delaplane, K. S. and Mayer, D. F. 2000. Crop pollination by bees. New York: CABI Publishing. p 344.

Free, J. B. 1993. Insect pollination of crops. London: Academic Press.

Free, J. B. and Spencerbooth, Y. 1961. Effect of feeding sugar syrup to honey-bee colonies. J. Agric. Sci. 57: 147-151.

Fuchs, R. and Muller, M. 2004. Pollination problems in Styrian oil pumpkin plants: Can bumblebees be an alternative to honeybees? Phyton Annales Rei Botanicae 44: 155-165.

Ghosh, S. Jung, C. 2017. Nutritional value of bee-collected pollens of hardy kiwi, *Actinidia arguta* (Actinidiaceae) and oak, *Quercus* sp. (Fagaceae). J. Asia-Pac. Entomol. 20: 245-251.

Herbert, E. W. 1992. Honey bee nutrition. In: Graham JM, editor. The hive and the honey bee. Dadant and Sons. pp. 197-233.

Hurd, P. D. 1964. The pollination of pumpkins, gourds and squashes (genus *Cucurbita*). Bee World 47: 97-98.

Javaheri, S. D., Esmaili, M., Nkkhaohi, A., Mirhadi, S. A. and Tahnasebi, H. 2000. Honeybees with protein supplement and pollen substitute and its effects on development and resistance of honeybee's colonies and honey production. 7th IBRA Conf./5th AAA Conf., Changmai, Thailand. pp. 76 (Abstract).

Javorek, S. K., Mackenzie, K. E. and Vander kloet, S. P. 2002. Comparative pollination effectiveness among bees (Hymenoptera: Apoidea) on low bush blueberry (Ericaceae: *Vacciniumangustifolium*). Annals of the Entomol. Society of America 95: 345-351.

Kumar, J., Srivastava, S. and Kashyap, N. P. 1995. Effect of strength of worker bees on honey bee production in *Apis mellifera* colonies. Indian Bee J. 57: 174-176.

Matilla, H. R. and Otis, G. W. 2006. Influence of pollen diet in spring on the development of the honey bee (Hymenoptera: Apidae) colonies. J. of Econ.Entomol. 99: 604-613.

Mercola J. D. 2016. The use of bee pollen as a super. Retrieved from: http://www.mercola.com/ article/diet/bee_pollen.htm.

Nabors, R. 2000. The effects of spring feeding pollen substitute to colonies of *Apis mellifera*. Am. Bee J., 140: 322-323.

Nicodemo, D., Couto, R. H. N., Malheiros, E. B. and Jong, D. D. 2009. Honey bee as an effective pollinating agent of pumpkin. Scientia Agricola 66 (4): 476-480.

Rahman, K. A. U. and Reza, I. 2011. Accessing and Retaining Access to the Sandbars by the Extreme Poor: Experience from the Practical Action Project. Shiree, House 5, Road 10, Baridhara, Dhaka, Bangladesh-1212.

Sahinler, N., Sahin, A. and Kaya, S. 2003. The effect of supplementary feeding on honeybee (*Apis mellifera*) colony performance.Final Program and Abstracts, 38th Apimondia, Apic. Cong., Slovenia, August 24-29, 2003. pp. 158 (Abstract).

Seeley, T. 1995. The Wisdom of the hive: The social physiology of honey bee colonies. Harvard University Press,

Harvard, USA.
Somerville, D. 1999. Wintering bees. Agnote DAI/121.NSW Agriculture.
Somerville, D. 2000. Honeybee nutrition and supplementary feeding. Agnote DAI/178.NSW Agriculture.
Standifer, L. N., Owens, C. D., Mills, J. P. and Levin, M. D. 1973. Supplementary feeding of honey bee colonies in Arizona. Am. Bee J. 113: 298-301.
Walters, S. A. and Taylor, B. H. 2006. Effect of honey bee pollination on pumpkin fruit and seed yield. Hort. Sci. 41: 370-373.