EFFECT OF ALTERNATIVE NECTAR SOURCE ON BEE HEALTH IN THE DEARTH PERIOD MANAGEMENT OF HONEY BEE (*Apis mellifera* L.)

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Abstract

Effectiveness of sugar syrup (sugar: water = 1: 1.25), waste chocolate syrup (chocolate waste: water = 1: 1) and sugar syrup + pineapple juice (1:1) as alternate nectar sources were evaluated in an apiary situated at Amtoli, Gazipur during the dearth period on honey bee health in replicated four framed uniform hives. Results indicated that the sugar syrup feeding hives significantly provided the highest percent of eggs (21.25%), larvae (23.75%), pupae (22.08%) and pollen deposition (7.45%) compared to those of other sources including control. The highest bee gain (6.0) in terms of occupied frame per hive was also obtained in the sugar syrup treated hives. The highest mean mortality of the bee (2.96) was recorded in the sugar syrup mixed with pineapple juice treated hive. The highest benefit cost ratio (2.23) was calculated in waste chocolate syrup feeding hives. It may be opined that the best alternative nectar source for artificial feeding was sugar syrup for bee health and the most cost effective artificial feeding of bees was waste chocolate syrup.

Key words: Nectar, alternative source, bee health, dearth period, honey bee.

INTRODUCTION

The honey bee is an important insect which is the oldest friend of the human society. It gives us honey, beeswax and different other valuable products. Most important of all, the pollination service of many crops is done by honey bee. The art of honey bee management in boxes and extracting surplus honey is called beekeeping. Beekeeping is a valuable and profitable venture to supplement farmers' income. At present beekeeping activity is practiced on a professional and part-time basis. Bangladesh government and other non-government organizations, including Bangladesh Institute of Apiculture (BIA), Proshika and Mouchak Unnayan Sangstha (MUS) etc. have taken various initiatives to provide technological support for training on beekeeping, its management, creating marketing facilities and supplying necessary equipment for the economic production of honey in the country.

The success of beekeeping depends on maintaining strong, vigorous colonies. Colonies can only develop large populations when the queen maintains a high egg-laying rate. She can only do so when there are adequate reserve of pollen and honey. When these forage resources are not available, they must be provided artificially. Supplemental feeding enables the colony to optimize its potential as a production unit and increase its ability to produce more honey and perform successful pollination.

Honey bees have no unusual nutritional requirements. They also require carbohydrates, proteins, fats, minerals, vitamins and water. These are needed for growth, development, maintenance and reproduction (Hyser 1980). Nectar and honey dew are the chief sources of supply for carbohydrates in the diet of bees, and pollen furnishes all the other indispensable constituents. Adult bees can survive on

carbohydrates (that is, honey or sucrose) and water; however, proteins, lipids or fats, minerals, and vitamins are necessary for the growth and development of young bees and in rearing larvae (Standifer *et al*. 1977).

Honey bees (*Apis mellifera*) are dependent on the supply of pollen and nectar. The activity of the honey bee is controlled largely by ambient conditions. In some habitats where the weather fluctuates annually, as in the 'Sub-tropical region" the warm season coincides with the lack of flowers and is considered the "Dearth period" (Eisikowitch 2004). In the cold season, when the flowers appear, the bees are at full activity, collecting and storing food, along with fulfilling their reproductive duties. Although bees are physiologically capable of being active in hot deserts, they suffer from the lack of food sources and water, the latter being used for cooling hives in addition to its physiological function. Honey bees are thus restricted to areas where blooming occurs at least for part of the year (Echazarreta and Paxton 1997).

Proper colony management should ensure adequate honey reserves, but sometimes carbohydrate supplement feeding also become necessary. Whenever colonies have little honey reserves, they should be fed with artificial foods. Carbohydrate foods have some value for stimulating queens to begin laying eggs, but no carbohydrate will support sustained egg laying or brood rearing in the absence of pollen or a protein supplementary food (Shimanuki 1971).

For successful management and rearing of honeybees in the dearth period, it is imperative to adapt beekeeping measures for colony development. Sugar syrup (1:1) is one of the most popular nectar substitutes whereas soybean flour, mung bean flour, corn flour, mixed flour etc. are different pollen substitutes for honey bee used during dearth period (Shimanuki 1971). Reports on the efficiency of such nectar and pollen substitutes at an economic dose in the maintenance of honey bee colonies are scanty.

In Bangladesh context cane sugar is important and used by beekeepers in the dearth period for colony management. In the domestic market sugar price fluctuates very often. Poor beekeepers are not able to buy sufficient amount of sugar for their colony management. Hence, they are always in search of cheap sources of sugar. Some beekeepers use rotten or waste pineapple juice mixed with sugar syrup due to cheap pineapple price during the dearth period. On the other hand, many beekeepers use chocolate waste from the chocolate industry to make the industrial management cost-effective. By keeping in front the above points, present investigation have been undertaken to know the effect of different carbohydrate food sources and to find out the cost-effective alternative carbohydrate food sources for honey bees *Apis mellifera* L. in the dearth period.

MATERIAL AND METHODS

The present study during the dearth period management of *Apis mellifera* in an Apiary with different type of sugar sources was undertaken at Aamtoli, Gazipur during July and August in the year 2011 utilizing different nectar and pollen substitutes. The impact of the food substitutes and management approaches on the growth and development of bees in the colonies was investigated. Data collection regarding the predetermined parameters and the analysis of data was performed to measure the effects of food substitutes and management practices on the colony development as a preparation for migratory beekeeping. The materials required and the methodology of the application of treatments and determining various parameters are described under the following sub-headings-

Agro-forest situation

The study was conducted during July and August in the year 2011. The apiary consisted of 112 bee hives placed under Jujube, Mango, Jackfruit and Palm trees. The apiary distantly situated from a lake and surrounded by various other trees. Herbs and shrubs are available surrounding the apiary. All these provided a species rich assemblage of plant-populations.

Honey bee (A. mellifera L.) colonies

To study the effects of food substitutes on the honey bee (*A. mellifera*) colonies, 16 uniform hives of the same species were selected. Each of the hive or colonies consisted of four frames (two brood frames+ two occupied/built frames) and a feeder frame. All the frames were considered for data collection.

Design and layout of the experiment

The experiment was set up in a Randomized Complete Block Design (RCBD). Food substitutes of three different carbohydrate sources were considered as four different treatments, viz. application of sugar syrup (sugar: water=1:1.25), chocolate waste syrup (chocolate waste: water=1:1), sugar syrup (sugar: water=1:1.25) + pineapple juice, and an untreated control without artificial food source (empty feeder).

Pollen supplement

Sufficient quantity (1kg) of soybean flour was kept in a wooden box measuring one cubic feet. Two boxes were kept at the middle of the apiary. Bees were allowed to forage on the open boxes to carry their required pollen from the flour.

Preparation of nectar and pollen substitute

For preparation of nectar substitute, three different sources were used. For sugar syrup one kg sugar was mixed with 1.25 liters of water. In a sauce pan one kg of sugar was taken and then 1.25 litres of water were poured into it (l:1.25) and started to boil on a gas burner. After 20 minutes of boiling the sugar dissolved in water and then the solution was passed through a soft cotton cloth placed on a bucket for filtration. For preparing the sugar syrup+ pineapple juice: 1 kg sugar was mixed with 1.25 liters of water. In a sauce pan one kg of sugar was taken and then 1.25 litres of water were poured into it (l:1.25) as described earlier and boiled on a gas burner for 20 minutes to dissolve sugar in water and made it one liter sugar syrup, and then the solution was passed through a soft cotton cloth placed on a bucket for filtration. Then a ripe pineapple was peeled, chopped and crushed to extract the juice in a blender. The extracted juice was allowed to pass through a soft cotton cloth placed on a bucket for filtration. Half of the sugar syrup and half of the pineapple juice were mixed and then supplied to the experimental feeder pot. For choclate waste: one kg choclate waste and one liter water were mixed thoroughly and boiled it to make one liter volume and filtered through a piece of cotton cloth. The mixed candy syrup was supplied to the experimental feeder pot. For control treatment only water was provided in the experimental feeder pot.

For preparation of pollen substitute, two kg of soybean were taken and kept them in water soaked condition overnight. The entire soybean was removed from the water and allowed it to dry in the

sunlight for half an hour. Finally soybean was ground in a grinding mill for making flour. The flour was allowed to dry again for an hour and kept them in an empty bee box for serving bees as a protein supplement.

Application of nectar substitute (treatments)

Five hundred ml of prepared sugar syrup, 500 ml of pineapple juice + sugar syrup (250 ml each), 500 ml of prepared chocolate waste syrup and 500 ml of water were poured equally into sixteen different feeder pots. Each feeder pot was then kept in each experimental hive. Every three days interval all the feeder pots were taken out one by one by replacing them by the same food source with the same quantity in new feeder pots. This was done early in the morning (6.30 am to 8.30 am) and continued until the end of experimental period.

Application of pollen substitute

The soybean flour was provided as pollen substitute. Two empty bee boxes (one cubic feet each) were used to supply the soybean flour for foraging by the bees. Each box contains one kg of soybean flour. Soybean flour was kept at the bottom of boxes with maintaining similar thickness. Each box was kept under a shed to protect from rain. Similar quantity of fresh soybean flour was supplied at 15 days interval during the experimental period.

Parasite and predator management

To avoid bee mites every hive was smoked with tobacco leaves twice in a week. To protect the hive from ant attack, the base of the hive stand was rubbed with thick vaseline mixed with Finish detergent/insecticide. To protect from wasps and bee eating birds, a full time day labour was appointed to kill the wasps with a badminton racket bat and drive out the birds by making sound with an empty tin container.

Data collection

In the experimental period from July to August 2011 the relative area covered by eggs, larvae, pupae and pollen inside the frame of the hives was measured visually by making a plastic paper similar to the size of the frame. The plastic paper was marked horizontally and vertically in centimeter distance to make a cm graph. The plastic paper was set on each side of frame to measure the percentage area covered by eggs, larvae, pupae and pollen. Weekly average mortality was also recorded. Required number of frame (occupied frame/built frame) was also recorded for every colony.

Data on aforesaid parameters were collected from each hive of the experimental colonies at seven days interval during the months of August and September. Percentage of eggs, larvae, pupae and pollen present were calculated by the following formula-

$$\text{Percentage of eggs or larvae or pupae or pollen in the hive} = \frac{\text{Area covered by eggs or larvae or pupae or pollen (cm)}}{\text{Total occupied area (cm)}} \times 100$$

The numbers of bees died were counted daily from inside and in front of the hive. Number of occupied/built frame was recorded weekly. Built frames were supplied on the basis of bee population to allow enough room inside the hive. Built frame was taken out when the population is not in sufficient quantity.

Economic analysis

Benefit cost ratio (BCR) was calculated considering the total expenditure of' management cost and the total return from that particular treatment as follows

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Adjusted net return}}{\text{Total management cost}}$$

In this study BCR was calculated for a four frame modified Langstroth type of bee hive. The cost was calculated by adding all costs incurred for labors (30Tk/hr), and Sugar (60Tk/kg), chocolate waste (15Tk/kg) and pineapple (10Tk/fruit) for each treatment including untreated control during the entire experimental period (2011). The yield (number of frame present in each hive at the end of experiment) from each treatment in terms of taka was calculated by multiplying the total yield by the unit price of per frame bee (400 Tk/ frame bee). Net return was calculated by subtracting treatment wise management cost from gross return. The adjusted net return was determined as shown below

Adjusted net return = Net return from the treated hive - Net return from the control hive.

Statistical analysis

The data for each parameter was analyzed statistically to find out the variation among the treatments. The percent data were transformed by square root transformation. The analysis of variance for different parameters was done using MSTAT-C software and the means were separated by Least Significance Difference (LSD) test.

RESULTS AND DISCUSSION

Effect of different carbohydrate sources on different life stages of A. mellifera

Different types of carbohydrate food sources have significant effect on honey bee egg laying, larval and papal development and pollen deposition inside the hive. Bee populations as a whole were also affected by different types of carbohydrate sources (Table 1). The effect of carbohydrate substitutes on queen's ability to lay eggs was evaluated during the experimental period. The highest percentage of egg (21.25%) was deposited in the hives treated with the sugar syrup (sugar: water) which was statistically similar to those found in the hives treated with chocolate waste syrup, but these were statistically differed significantly from those hives which were treated with sugar syrup mixed with pineapple juice and also with control (Table 1).

Statistically the lowest percentage of egg (5.54%) was obtained in the untreated control hives where no sugar substitute was supplied. Significantly the highest percentage of larva (23.75%) was found in the colony treated with the sugar syrup which was followed by the chocolate waste syrup (19.58%), sugar syrup mixed with pineapple juice (13.13%) and in untreated control hives (6.79%) (Table 1).

The highest percentage of pupa (22.08%) was observed in the sugar syrup treated hives whereas the lowest percentage of pupa (7.59%) was observed in the untreated control hive. The hives treated with

the chocolate waste syrup showed the second highest percentage of pupa (19.58%) which was followed by the hives supplied with the sugar syrup mixed with the pineapple juice (14.16%). All the treatments differed significantly from one another.

Table 1. Effect of different carbohydrate substitutes on *A. mellifera* eggs, larvae, pupae, pollen and occupied frame.

Treatments	Proportion	Egg/hive (%)	Larva/hive (%)	Pupa/hive (%)	Pollen/hive (%)	No. of occupied frame
Sugar syrup	Sugar: water (1:1.25)	21.25 (27.44)a	23.75 (29.16) a	22.08 (28.02)a	7.45 (15.83)a	4.79 a
Chocolate waste syrup	Chocolate: water (1:1)	18.75 (25.65)a	19.58 (26.26)b	19.58 (26.27)b	5.75 (13.86)b	4.21 b
Sugar syrup + pineapple juice	Sugar syrup: pineapple juice (1:1)	12.91 (20.99)b	13.13 (21.23)c	14.16 (22.10)c	5.50 (13.55)b	4.00 b
Untreated control	Without artificial supplement (water)	5.54 (13.60)c	6.79 (15.09)d	7.59 (15.96)d	2.58 (9.24)c	3.00 c
CV (%)	-	10.21	12.51	14.96	13.23	11.69
Level of significance		**	**	**	**	**

Mean followed by uncommon letters differed significantly (P<0.001) from each other by LSD.

Significantly the highest percentage of pollen deposition (7.45%) was evident in the hives treated with the sugar syrup which was followed by the hives treated with the chocolate waste (5.75%) and the sugar syrup mixed with the pineapple syrup (5.50%), the later two being insignificantly different. The lowest percentage of pollen deposition (2.58%) was observed in the untreated control hives (Table 1). Significantly the highest number of occupied frame (4.79) was observed in the hive treated with the sugar syrup which was followed by the chocolate waste syrup and the sugar syrup mixed with the pineapple juice, the later two being statistically similar; the lowest number of occupied frame (3.00) was recorded in the untreated control hives.

From these results it is evident that sugar syrup provided the best colony development among all treatments. It is also clear that the colonies without sugar substitute (untreated control) resulted weak colonies with lower population as their occupied frame was reduced in number than those initially present. This result is similar to those obtained by Detroy *et al*. (1981) who reported that the sugar syrup is consistently the best food for containerized bees.

Weekly egg laying

The highest percentage of egg (27.5%) laid by the honey bee queen was found on the 5^{th} week of treatment using the sugar syrup (Fig. 1). Similar pattern was also observed in the hives treated with the chocolate waste syrup, but lower compared to those of the sugar syrup treated hives except on the 4^{th} week. The hives treated with the sugar syrup mixed with pineapple juice showed lower level of egg deposition compared to other two carbohydrate substitutes. Gradual increase of egg laying was observed in this mixed substitute with the highest peak (16.25%) on the 6^{th} week of the study period. The hives

without sugar substitute (untreated control) had lower percentage of egg laying compared to all other treated hives. Decreasing trend of egg laying was observed in the untreated hives reached at a very low level (2%) on the 6th week of the study period.

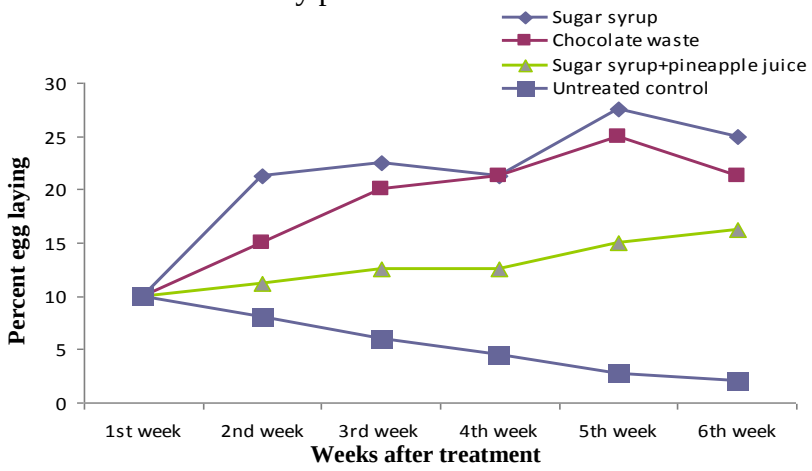

Fig. 1. Weekly egg laying performance of the honey bee queen feeding on different carbohydrate substitutes during the dearth period in the year 2011.

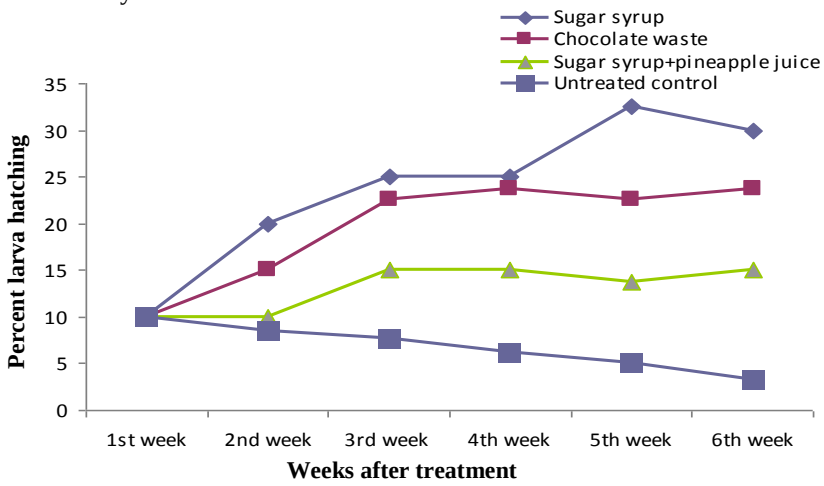

Fig. 2. Weekly differences on larval percentage of honey bee feeding on different supplemental carbohydrate containing foods during the dearth period of 2011.

Weekly larval hatching after treatment

The highest percentage of larvae (32.5%) hatched on the 5th weeks after applying the sugar syrup as substitute was higher than any other treatments (Fig. 2). The chocolate waste syrup treated hives showed the second highest percentage of larval hatching followed by the hives treated with the sugar syrup mixed pineapple juice. The hives without any sugar supplement (untreated control) showed the lower percentage of larval hatching compared to the treated hives. A trend of declining larval hatching was evident in the hives of untreated control (3.25%) on the 6th week of the study period.

Weekly pupation after treatment

The highest percentage of pupae (31.25%) was formed on the 4th and 6th weeks in the hives after treatment with the sugar syrup which was higher than any other treatments (Fig. 3). The chocolate waste

syrup treated hive showed the higher percentage of pupal formation in comparison to the hives treated with sugar syrup plus pineapple juice. Untreated hives showed lower percentage of pupal formation compared to treated hives. Gradual decreasing trend of pupal formation was evident in the untreated hive and reached to the lowest (3.25%) level on the 6th week of the study period.

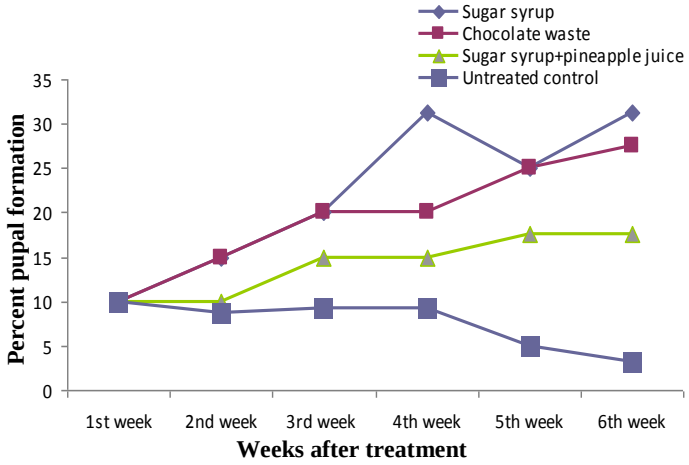

Fig. 3. Weekly pupation when feeding with different carbohydrate supplements during the dearth period of 2011.

It is evident that alternative food supplement is required for colony brood development in terms of egg, larval and pupal production. The brood percentage always found higher in sugar syrup treated hives. The lowest brood in the control treatment was due to food shortage and less number of bees.

Pollen deposition as influenced by carbohydrate supplement

The pollen deposition by worker bees inside the hive was observed during the study period. The pollen deposition percentage was found higher in the hives treated with the sugar syrup in compared to that of the other treatments. The highest pollen deposition percentage (8.75%) was recorded at the end on the 4th and 6th weeks (Fig. 4).

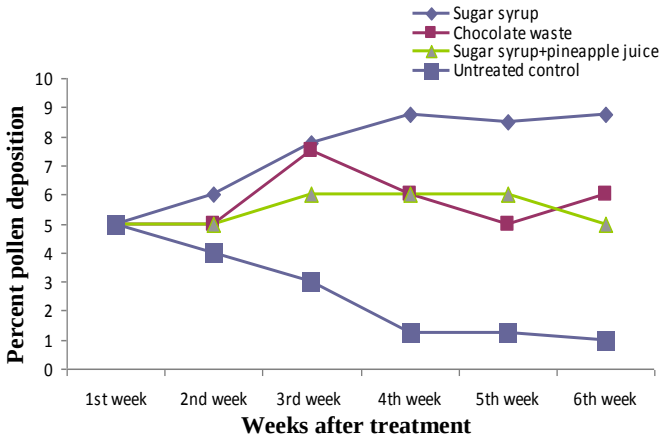

Fig. 4. Weekly pollen deposition from initial deposit (5.0%) as influenced by different carbohydrate supplements during the dearth period of 2011.

The hives treated with the chocolate waste syrup and sugar syrup mixed with pineapple juice showed fluctuating trend of pollen deposition throughout the experimental period. In the control treatment,

gradual decline of pollen deposition percentage was evident up to 4th week and then remain stable in between 4th and 6th week. The lowest (1%) pollen deposition was observed on the 6th week in untreated control hives having no sugar supplement (Fig. 4).

Pollen deposition percentage was affected by worker bee numbers and their good health. The hives of untreated control had scarcity of food and, therefore, the pollen deposition percentage was lower compared to the treated hives. It is evident that the sugar syrup feeding bees deposit more pollen as the hive was in good health.

Number of occupied frame

Up to second week all the treatments had similar number of occupied frame (Fig. 5). On the 6th week the highest number (6.0) of occupied frame was obtained in the hives treated with the sugar syrup which was higher compared to all other treatments. The second highest number (5.25) of the occupied frame was found in the hive treated with chocolate waste syrup. Sugar syrup mixed with the pineapple juice treated hive showed the third highest number (4.25) of the occupied frame (Fig. 5). All these were higher compared to that of untreated control. On the 6th week the lowest number (1.00) of the occupied frame was obtained inside the hives of untreated control. In the untreated control hive the queen was absconded and resulted nonfunctioning of the hive.

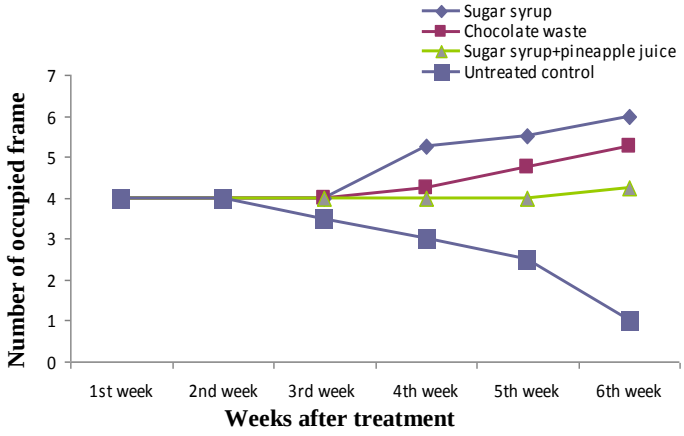

Fig. 5. Weekly occupation of frame from initial number (4.0) as influenced by different carbohydrate supplements during dearth period of 2011.

It is evident that higher number of the occupied frame means higher number of weight gain. Sugar syrup supplied healthy carbohydrate to the bees and probably had no toxicity effect, and therefore, the sugar syrup treated hives showed better result than any other treatments. This finding was similar to that found by Pesante *et al*. (1992).

Mortality of bees inside the hive in different treatments

The highest mean mortality (2.96) was observed in the hives treated with the sugar syrup mixed with pineapple juice during the study period (Fig. 6). The lowest mean mortality (0.21) of the bee was recorded in the hives treated with sugar syrup compared to all other treatments including control. The second highest mortality (1.13) was observed in the hives treated with the chocolate syrup. In the untreated control the mean bee mortality was 0.63 which was higher than the hives treated with sugar

syrup, but lower than that of the chocolate syrup and the treatment with sugar syrup mixed with pineapple juice.

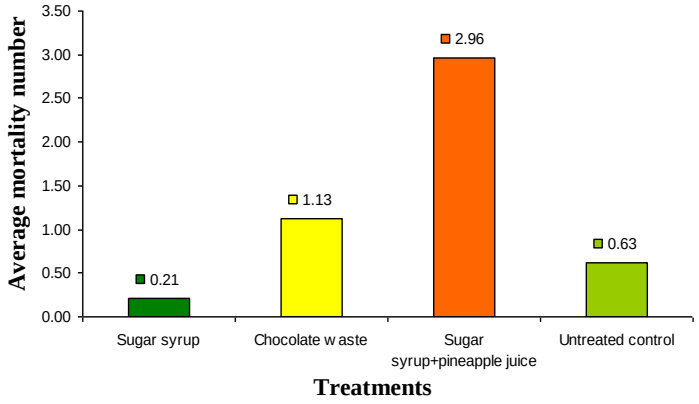

Fig. 6. Average bee mortality inside the hive of honey bee treated with different supplements containing carbohydrate during the dearth period of 2011.

In the control treatment absconding was evident due to the severe shortage of food which was also reported by several authors. The highest mortality was observed in the sugar syrup mixed with pineapple juice treated hive which might be due to the toxicity of the fruit components. This result is in conformity with the findings of Barker and Lehner (1978) who found the highest bee survival in sucrose syrup feeding bees. It may be opined that the fruit syrup reduces the survival rate causing dysentery or toxicity in bees. On the other hand, sugar syrup enhances bee growth and performed the best alternative food source of carbohydrate.

Economic analysis of the treatments

The highest adjusted net return per hive was obtained in the hives treated with the chocolate waste syrup (Tk. 1,175) followed by the sugar syrup treated hive (Tk. 1,160) and the sugar syrup mixed with pineapple juice treated hive (Tk. 530).The lowest net return (Tk. 400) was obtained from the untreated control hive (Table 2).

Table 2. Economic analysis and benefit cost ratio (BCR)) of various nectar substitute management of honey bee during the dearth period of 2011.

Treatment	Management cost (Tk/hive)	Average occupied frame/hive	Gross return/hive	Net return	Adjusted net return	BCR
Sugar syrup	840.00	6.0	2400.00	1560	1160	1.38
Chocolate waste syrup	525.00	5.25	2100.00	1575	1175	2.23
Sugar syrup mixed with pineapple juice	770.00	4.25	1700.00	930	530	0.68
No Sugar syrup (Untreated control)	--	1.00	400.00	400.00	--	--

The benefit cost ratio was the highest in the chocolate waste syrup treated hive (2.23) and the second highest was in the sugar syrup treated hive (1.38). This highest BCR was due to lower management cost

for this treatment in the dearth period. The lowest BCR was obtained from the hives treated with the sugar syrup mixed with the pineapple juice (0.68). The cause of this lowest BCR was due to comparatively lower yield, more death of bees and higher cost of management for the treatment in the dearth period. So, the chocolate waste syrup was the cheapest component of carbohydrate substitute used in the dearth period for the management of bee hives.

REFERENCES

Barker, R. J. and Y. Lehner. 1978. Laboratory comparison of high fructose corn syrup, grape syrup, honey, and sucrose syrup as maintenance food for caged honey bees. *Apidologie.* **9**(2): 111-116.

Detroy, B. F., L. O. Whitefoot and F. E. Mceller. 1981. Food requirements of caged honey bees. *Apidologie.* **12**(2): 113–123.

Echazarreta, C. M. and R. K. Paxton. 1997. Comparative colony development of Africanized and European Honeybees (*Apis mellifera*) in lowland neotropical Yucatan, Mexico. *J. Apic. Res.* **36**: 89-103.

Eisikowitch, D. 2004. Honey bee and nectariferous plants as an important factor to sustain modern desert agriculture. *Brazilian Archives of Biology and Technology*. **47**(3): 87.

Hyser, D. 1980. To feed or not to feed. *Minnesota Beekeepers Magazine*. **34**(3): 14-17.

Pesante, D. G., T. E. Rinderer, A. M. Collins, D. L. Boykin and S. M. Buco. 1992. Honey production in Venezuela: effects of feeding sugar syrup on colony weight gains by Africanized and European colonies. *Apidologie.* **23**: 545-552.

Shimanuki, H. 1971. Beekeeping in the United States. United States Department of Agriculture. *Agricultural Handbook*. **335**: 174.

Standifer, L. N., F. E. Moeller, N. M. Kauffeld, E. W. Herbert and H. `1Shimanuki. 1977. Supplemental feeding of honey bee colonies. United States Department of Agriculture. *Agriculture Information Bulletin*. **413**: 8.