



Effect of banana bunch covering technology for quality banana production in Bangladesh

MHK Rubel¹, MM Hossain^{1*}, MMH Hafiz¹, MM Rahman¹, MR Khatun²

¹Department of Horticulture, ²Department of Entomology, Bangladesh Agricultural University
Mymensingh 2202, Bangladesh

Abstract

This study was carried out at Horticulture farm of Bangladesh Agricultural University, Mymensingh in order to find out the effects of bunch covering materials on physio-morphological characters and shelf life of banana cv. Mehersagar. The experiment was undertaken during the period from July to November 2016 with four types of bunch covering materials namely white polythene bag, black polythene bag, blue polythene bag and old cloth along with control (no bunch covering). The experiment was laid out in randomized complete block design with five replications. The results of the investigation revealed that blue polythene bag required significantly minimum days to harvest (76.80 days) and maximum days to harvest (97.80 days) were recorded for control. Maximum bunch weight (19.90 kg), finger length (19.59 cm) and finger diameter (3.56 cm) were recorded for blue polythene bag whereas control showed minimum bunch weight (15.20 kg), finger length (14.57 cm) and finger diameter (3.07 cm). It was observed that blue polythene bag covered fruits showed minimum disease infection (2.33%), insect infestation (2.33%) and physiological disorder (1%) compared to control which experienced maximum disease infection (12.67%), insect infestation (50%) and physiological disorder (13.40%). Weight loss (11.18%), pulp moisture (66.16%), peel moisture (70.41%), disease infection (40%), disease severity (70.25%), skin colour change (4.95) were also lower in blue polythene bag than non covering control fruits. The bunches covered with blue polythene bag exhibited superior results in respect of pulp thickness (3.45cm), pulp to peel ratio (2.49), pulp dry matter (33.84%), peel dry matter (29.59%), TSS (24.28 % Brix), shelf life (11.40 days) than the rest of bunch covering materials used in this study. It can be concluded that bunch covering showed significant effect on physio-morphological traits and quality of banana.

Key words: Fruit bagging, fruit quality, shelf life, banana cv. Mehersagar

Progressive Agriculturists. All rights reserved

*Corresponding Author: mokter.agr@bau.edu.bd

Introduction

Banana is one of the important fruit crops in Bangladesh belongs to the family Musaceae. In Bangladesh, it is one of the top listed fruit crops, which is available throughout the year and consumption rate is higher than any other fruits. Banana is a very popular fruit due to its low price and is used both as vegetable and as a dessert fruit. It is also a nutritious fruit crop in

the world and grown in many tropical areas where they are used both as a staple food and dietary supplements (Assani *et al.*, 2001). It contains carbohydrate, crude fibre, protein, fat, ash, phosphorous, calcium, iron, β -carotene, riboflavin, niacin and ascorbic acid (Khader *et al.*, 1996). Besides these, it is rich in K, relatively lower amount of Na and Fe. Various post harvest

products like banana puree, powder, flour, chips, jam, jelly are prepared from the fruit. Besides high food value, it is also used for extraction of fiber. It helps in reducing risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis and kidney disorders.

Banana has high commercial significance. Bangladesh produces nearly 1.00 million tons of banana annually (Hossain, 2014). Bangladesh produces 810347 metric tons of banana from 121384 acres of land (BBS, 2018). Banana is cultivated almost everywhere in Bangladesh round the year. The principal banana growing areas are Rangamati, Barisal, Mymensingh, Bogra, Rangpur, Dinajpur, Noakhali, Faridpur, and Khulna. Among the cultivated varieties in Bangladesh, BARI kola-1, Amritsagar, Sabri, Mehersagar, Champa and Kabri are the major commercial cultivars (Haque, 1988).

In Bangladesh most banana fruits reach the market with blemishes that are acquired during the growing period from bird drops, dust and leaf scarring and from mechanical injuries during postharvest handling. To prevent the losses caused by biotic and abiotic factors, several practices are becoming popular throughout the world. The development of alternative techniques to improve the appearance and quality of fruit and to reduce disease and insect infestations is becoming increasingly important as consumer anxiety over the use of man-made agro-chemicals and environmental awareness are increasing. For example, integrated management of insects and diseases, organic production, use of fruit cover are noteworthy. Thus, more emphasis is being placed on reducing the use of pesticides to ensure worker safety, consumer health, and environmental protection (Islam *et al.*, 2015a; Shanmugasundaran *et al.*, 2002).

Fruit protection bags of various colours, perforated and non-perforated have been extensively used in both tropical and subtropical banana growing countries to improve yield and quality (Stover and Simmonds, 1987). The cover creates a microclimate that maintains

a high temperature and prevents chill damage. Depending on the study, the temperature over a 24-hour period increases on average by 0.5°C inside the cover (Ganry, 1975) and can increase by 7°C in the warmest hours (Vezina, 2016). This microclimate can reduce many days of flower-to-harvest interval (between 4 to 14 days depending on the type of cover and the environmental conditions) and increase bunch weight. Acceptable skin appearance and colour, increase in finger length and bunch weight as well as reduced fruit defects for example sunburn and fruit splitting have also been credited to bunch covering (Amarante *et al.*, 2002). The chaffing of fruit from leaves during growth has also been reported to be eliminated by bunch covers (Weerasinghe and Ruwaphirana, 2002). In addition, the incidence of postharvest anthracnose disease has been shown to be significantly less on fruit from sleeved bunches. On the other hand there were some toxicants residual activities in Banana reported by Islam *et al.* (2015b). Rather than residual contamination, pre-harvest bagging of fruits has also been found to increase yield and improve post-harvest quality of other fruits. For example, bunch covering was reported to increase moth infestation rate (Zirari and Ichir, 2010) and economic yield (Bashir *et al.*, 2015) of dates, and post harvest quality of guava (Rahman *et al.*, 2018).

For covering the fruit or bunches, different kinds of materials have been used so far. Brown paper, gunny bag, newsprint, old cloths, dried banana leaves, and polythene bags of different colors and thicknesses have been used (Debnath *et al.*, 2001). The decision of using a bagging material depends on the availability, price, local climate, and type of fruit. All of these materials have some advantages and disadvantages. Blue polyethylene perforated bunch covers have been used elsewhere in the tropics and have been shown to improve fruit visual appeal among other postharvest qualities (Robinson, 1996). But there is very limited information found in Bangladesh on effect of bunch covering and its impacts on physio-morphological traits and quality of banana cv. Mehersagar. Therefore,

this present research work has been undertaken to find out the effect of bunch covering materials on physio-morphological characters and shelf life of banana cv. Mehersagar.

Materials and Methods

The experiment was conducted in an existing banana orchard at Horticulture farm of Bangladesh Agricultural University, Mymensingh during the period from July to November, 2016. The climate of the experimental area was sub-tropical in nature characterized by high temperature, heavy rainfall, high humidity and relatively long day during the month of July to August and scanty rainfall associated with moderately low temperature, low humidity and short day during the month of September to November.

Experimental design and application of treatments:

The experiment was conducted following randomized complete block design with five replications. Five bunch covering materials viz., T₀: Control (non-cover), T₁: White polythene bag, T₂: Black polythene bag, T₃: Blue polythene bag, T₄: Old cloth. Banana (cv. Mehersagar) plant of uniform vigor and size were selected for this study. All plants were maintained under uniform cultural practices during the course of investigation. The size of bunch covers was 1.2 m in length, diameter 70 cm and thickness 5µm. Bunch covers were applied after the bracts covering the hands had fallen when the fingers were curling upwards, and the floral remnants had hardened. The covers were tied to the peduncle of the bunch with the help of rubber band. The bunch covers were left open at the bottom and hang at least 15 cm below the last hand of fruit. The control plants were not covered with bagging materials. Covers were left on bunches until harvest. Bunches were harvested when the ridges on the fruit surface change from angular to round and the colour of the skin turned from green to light green. The days to harvesting of fruits was determined by the counting of total number of days required from opening of spadix to maturity of bunch and expressed in days.

The finger length and diameter were measured by measuring scale and expressed in centimeter (cm). Bunch weight was recorded by digital weight balance and expressed in kilogram (kg). Disease incidence means percentage of banana infected with disease. The disease incidence was calculated as follows:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of banana infected}}{\text{Total number of bananas}} \times 100$$

Insect incidence means percentage of banana infested with insect. The insect incidence was calculated as follows:

$$\text{Insect Incidence (\%)} = \frac{\text{Number of banana infested}}{\text{Total number of bananas}} \times 100$$

Physiological disorders of Banana include choke throat, chilling injury, finger drop, peel splitting. The disordered fruits were identified carefully. The physiological disordered fruits were calculated as follows:

$$\text{Physiological disorder (\%)} = \frac{\text{Number of banana affected}}{\text{Total number of banana}} \times 100$$

Peel thickness, pulp and peel weights were taken at 2nd, 4th, 6th, 8th, 10th days of storage. Thickness was measured manually by a slide calipers and expressed in centimeter (cm). Peel and pulp weights were also taken separately by using an electric balance and the pulp to peel ratio was calculated.

Weight loss: Five fingers of each replication of each treatment were weighed by using a digital balance at the first day of storage and at every 2 days interval. Weight losses of fruit were estimated using following formula:

$$\text{Percent weight loss (WL)} = \frac{\text{Initialweight(g)} - \text{Finalweight(g)}}{\text{Initialweight(g)}} \times 100$$

Moisture content of pulp and peel: Ten grams banana pulp was weighed by digital balance and taken in a petridish from each treatment out of each replication. The petridish was placed in an electric oven at 80°C for 48 hours until the constant weight attained. It was then cooled and weighed again. The present moisture content of banana pulp was calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{Initialweight(g)} - \text{Finalweight(g)}}{\text{Initialweight(g)}} \times 100$$

Dry matter content of pulp and peel: Percent dry matter content of the pulp and peel was calculated from the data obtained during moisture content estimation using the following formula:

$$\text{Percent dry matter} = 100 - \text{percent moisture content.}$$

Disease incidence during storage: Disease incidence means percentage of banana infected with disease. The incidence of banana was recorded at every 2 days interval. The disease fruits were identified symptomatically. The disease incidence was calculated as follows:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of banana infected}}{\text{Total number of bananas}} \times 100$$

Disease severity: Disease severity represents the percentage of diseased portion of infected fruit. The infected fruits of each replication of each treatment were selected to determine fruit area infected, and was measured based on eye estimation.

Skin colour of finger during storage: Days required to reach different stages of color during storage and ripening were determined objectively using numerical rating scale of 1-6, where 1 = green, 2 = breaker, 3 = <25% yellow, 4 = <50% yellow, 5 = <75% yellow, and 6 = 75 to 100 % yellow.

Total soluble solids: Total soluble solids (TSS) content of banana fruit pulp was estimated using Abbe's refractometer. A drop of banana juice was squeezed from the fruit pulp on the prism of the refractometer and percent total soluble solids content were recorded as % Brix from direct reading of the instrument. Temperature corrections were made using the temperature correction chart that was accompanied with the instrument. The prism of the refractometer were properly washed and dried before recording observation each time.

Estimation of shelf life: The shelf life of banana fruits was estimated by keeping fruits from each treatment

under room temperature i.e. 25±1°C. Shelf life was calculated by counting days required to ripen fully retaining optimum marketing and eating qualities.

Statistical analysis: The collected data on various parameters were statistically analyzed using Mstatc statistical package. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was performed by F-test. The significance of difference between the pair of means was compared by least significance difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

Results

Days to harvest: Days required to harvesting after fruit setting was significantly influenced by different bagging treatments. The minimum harvesting time (76.80 days) was recorded for the blue polythene bagging treatment, and the maximum harvesting time (97.80 days) was recorded for the control (uncovered) (Figure 1). It was observed that uncovered treatment delayed the harvesting time by 11 days over the blue polythene bagging.

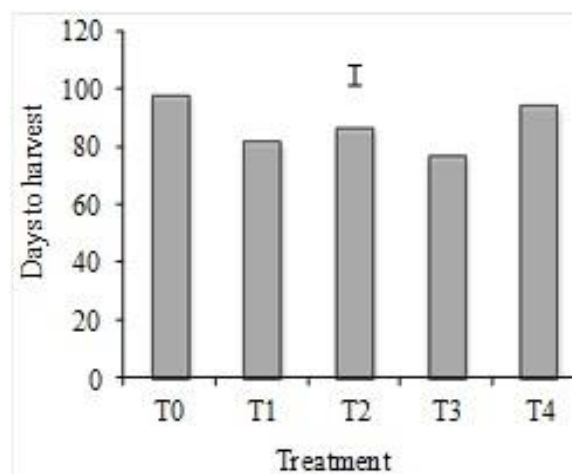


Figure 1. Effect of different bunch covering materials on the days to harvesting fruit. Vertical bar indicates LSD at 5% level of significance. T₀: Control (open fruit), T₁: White polythene bag, T₂: Black polythene bag, T₃: Blue polythene bag, T₄: Old cloth.

Finger length: There were significant differences of finger length among the bagging treatments. The highest finger length (19.59 cm) was recorded when the fruits were covered with blue polythene bag and the lowest (14.57 cm) was recorded when no fruit cover

was used (control) (Table 1). However, except control there was no difference of finger length among the different types of fruit cover. Blue polythene bag cover was responsible for 34% increased finger length over the control treatment.

Table 1. Effect of bunch cover treatments on finger length, finger diameter and weight of bunch of banana cv. Mehersagar.

Treatments	Finger length (cm)	Finger diameter (cm)	Weight of bunch (kg)
Control	14.57	3.07	15.20
White polythene bag	19.05	3.53	19.70
Black polythene bag	18.71	3.40	19.50
Blue polythene bag	19.59	3.56	19.90
Old cloth	18.64	3.39	17.10
LSD _{0.05}	1.39	0.13	2.28
LSD _{0.01}	1.92	0.18	3.15
Level of significance	**	**	**

** Significant at 1% level of probability

Finger diameter: Bagging also positively influenced the diameter of banana finger and the effect of different bagging was significant. Among the bagging materials, blue polythene cover produced the highest diameter of finger (3.56 cm) followed by white polythene bag (3.53 cm) and the lowest diameter (3.07 cm) was recorded for control (Table 1). Black polythene bag (3.4 cm) and old cloth (3.39 cm) showed statistically similar effect on finger diameter (Table 1). Blue polythene bag cover aided banana with 16% increased finger diameter over the control treatment.

Weight of bunch: Weight of whole banana bunch was significantly influenced by different bagging treatments. White, black, and blue polythene bag produced statistically similar bunch weight with the highest value (19.9 kg/bunch) for blue polythene bag. The lowest bunch weight (15.2 kg/bunch) was recorded for the control treatment (Table 1). An increase of 13% bunch weight was obtained by pre-harvest blue polythene bagging in comparison to no bagging (control) treatment.

Disease infection at harvesting: Disease infection was significantly affected by bunch covering materials. The highest disease infection (12.67%) was recorded for banana which was not covered during pre-harvesting period (control). The lowest disease infection (2.33%) was recorded for blue polythene bag which was 82% lower than that of control treatment (Table 2). Old cloth bagged banana showed statistically similar disease infection like no-bagging treatment.

Insect infestation at harvesting: Insect infestation of banana fruit at harvesting time was significantly influenced by different bunch cover treatments. The highest insect infestation (50.0%) was recorded with control treatment followed by the old cloth treatment (11.33%). The lowest insect infestation (2.33%) was recorded with the blue polythene bag treatment (Table 2).

Physiological disorder at harvesting: The results showed that physiological disorder was significantly different among the bunch cover treatments. Blue polythene bagging treatment showed much lower (1%) physiological disorder of banana at harvesting time. On

the other hand, higher physiological disorder (13.40%) was recorded for control (Table 2).

Pulp thickness: Pulp thickness of banana at different days after storage was significantly affected by bunch cover treatments. Blue polythene bagged banana showed the highest pulp thickness (3.36 cm), whereas the lowest value (2.52 cm) was recorded with control treatment (Table 3). It is clear that the increment of pulp thickness of banana was much conspicuous with

the blue polythene treatment than those of other treatments. At the final storage observation date (10th DAS) blue polythene bag treatment gave 20% higher pulp thickness than that of the control treatment. White polythene bag which produced the second highest pulp thickness (3.37 cm) was as good as blue polythene bag with statistically similar effect (Table 3).

Table 2. Effect of bunch cover treatments on disease infection, insect infestation and physiological disorder at harvesting time of banana cv. Mehersagar.

Treatments	Disease infection (%) at harvesting time	Insect infestation (%) at harvesting time	Physiological disorder (%) at harvesting time
Control	12.67	50.00	13.40
White polythene bag	4.33	5.00	8.00
Black polythene bag	5.33	10.67	8.33
Blue polythene bag	2.33	2.33	1.00
Old cloth	11.00	11.33	12.67
LSD _{0.05}	3.16	4.56	6.27
LSD _{0.01}	4.35	6.28	8.64
Level of significance	**	**	**

** Significant at 1% level of probability

Table 3. Effect of bunch cover treatments on pulp thickness of banana cv. Mehersagar at different days after storage.

Treatments	Pulp thickness (cm) at different days after storage				
	2	4	6	8	10
Control	2.52	2.66	2.71	2.81	2.87
White polythene bag	3.28	3.29	3.31	3.33	3.37
Black polythene bag	3.18	3.20	3.23	3.25	3.28
Blue polythene bag	3.36	3.38	3.40	3.42	3.45
Old cloth	3.09	3.12	3.15	3.16	3.19
LSD _{0.05}	0.11	0.12	0.15	0.19	0.10
LSD _{0.01}	0.15	0.17	0.21	0.26	0.14
Level of significance	**	**	**	**	**

** Significant at 1% level of probability

Pulp to peel ratio: Pulp to peel ratio of banana was significantly affected by different bagging treatment at

all observation dates after storage. Blue and white polythene bagging treatments augmented the pulp to

peel ratio from the early date (2nd DAS) and maintained the trend until the end of observation at 10th DAS. Though blue and white polythene bag showed significantly the similar effect on pulp to peel ratio, blue polythene bag produced the best result. At the end of observation, the highest pulp to peel ratio (2.49) was recorded in blue polythene bag, followed by the white polythene bag (2.35) at 10th DAS (Figure 2). Old cloth (1.80) and black polythene bag (1.97) had statistically similar effect on pulp to peel ratio of banana fruit. Control treatment (without fruit bagging) produced the inferior result (1.69) at all observation dates (Figure 2).

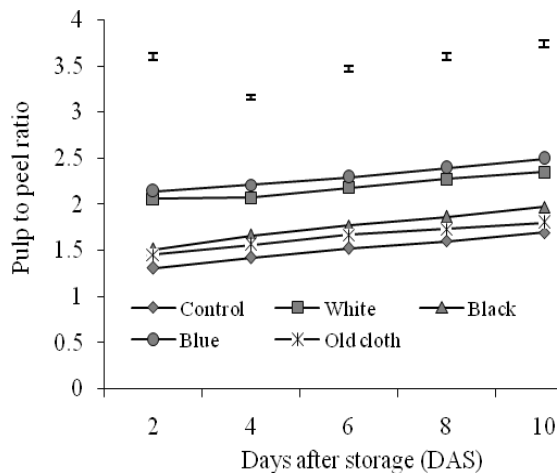


Figure 2. Effect of bunch cover treatments on pulp to peel ratio of banana cv. Mehersagar at different days after storage. The vertical bars represent LSD at 5% level of significance.

Weight loss: During storage, banana fruit lost weight linearly in all bunch cover treatments. However, bagging treatment statistically influenced on the weight loss of banana at different DAS and this trend seemed to continue until the end of observation. Banana lost much moisture (5.67%) at 2nd DAS when they were subject to no bagging in comparison to bagging treatment (Figure 3). It appeared that at 2nd DAS all bagging treatments (except control) had almost close weight loss values. However, the difference among the treatments became very distinct at the final observation date 10th DAS where the blue polythene bagged banana

showed the lowest moisture loss (11.18%) and the highest moisture loss (21.56%) showed in control (Figure 3).

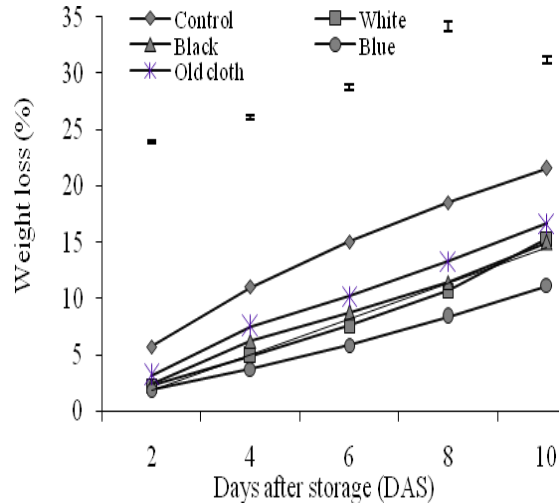


Figure 3. Effect of bunch cover treatments on weight loss of banana cv. Mehersagar at different days after storage. The vertical bars represent LSD at 5% level of significance.

Pulp and peel moisture content: Fruit from the bagged and non-bagged treatments significantly influenced pulp and peel moisture content. Moisture content of the peel reduced gradually during ripening while that of the pulp increased with ripening. The highest moisture content in pulp and peel obtained in control (73.31%) and (80.29%) respectively at 8th days after storage. On the other hand, the lowest moisture content in pulp and peel obtained in blue polythene bunch cover (66.16%) and (70.41%) respectively at 8th days after storage (Table 4).

Pulp and peel dry matter content: Significant variation was recorded in percent pulp dry matter content of different bunch cover treatments during storage. At 2nd DAS, the highest and the lowest pulp dry matter was recorded at blue polythene bag treatment (37.07%) and control treatment (29.86%) respectively (Table 5). At the last observation date, the trend of the result remained the same. The highest dry matter content (33.84%) was found in blue polythene bag and lowest

Banana bunch covering technology for safe banana

dry matter content (26.69%) was found in control at 8th DAS (Table 5). White and black polythene bagging had no significant difference in pulp dry matter value at any observation date.

Table 4. Effect of bunch cover treatments on pulp and peel moisture content of banana cv. Mehersagar at different days after storage.

Treatments	Pulp moisture content (%)				Peel moisture content (%)			
	at different days after storage (DAS)							
	2	4	6	8	2	4	6	8
Control	70.14	71.15	72.24	73.31	90.22	84.16	82.19	80.29
White polythene bag	64.80	66.35	68.22	69.60	82.24	80.17	75.29	72.02
Black polythene bag	65.30	66.44	68.37	69.65	82.79	80.38	78.18	77.64
Blue polythene bag	62.93	63.85	65.27	66.16	80.28	77.28	74.09	70.41
Old cloth	66.28	68.17	69.26	69.72	87.28	80.55	79.21	78.10
LSD _{0.05}	1.38	0.96	1.56	1.27	0.13	0.49	0.42	0.47
LSD _{0.01}	1.90	1.33	2.15	1.75	0.18	0.67	0.58	0.65
Level of significance	**	**	**	**	**	**	**	**

** Significant at 1% level of probability

Table 5. Effect of bunch cover treatments on pulp and peel dry matter content of banana cv. Mehersagar at different days after storage.

Treatments	Pulp dry matter content (%) at				Peel dry matter content (%) at			
	Different days after storage (DAS)							
	2	4	6	8	2	4	6	8
Control	29.86	28.85	27.76	26.69	9.78	15.84	17.81	19.71
White polythene bag	35.20	33.65	31.78	30.40	17.76	19.83	24.71	27.98
Black polythene bag	34.70	33.56	31.63	30.35	17.21	19.62	21.82	22.36
Blue polythene bag	37.07	36.15	34.73	33.84	19.72	22.72	25.91	29.59
Old cloth	33.72	31.83	30.74	30.28	12.72	19.45	20.79	21.90
LSD _{0.05}	1.33	1.35	1.57	1.13	0.35	0.50	0.75	0.29
LSD _{0.01}	1.83	1.86	2.16	1.55	0.49	0.69	1.04	0.40
Level of significance	**	**	**	**	**	**	**	**

** Significant at 1% level of probability

Peel dry matter of banana was significantly affected by different bagging treatments. At 8th DAS, the highest peel dry matter (29.59%) was recorded for blue polythene bagging treatment, followed by white polythene bag (27.98%), black polythene bag (22.36%)

respectively. The lowest value for the same was recorded for no bagging (control) treatment (19.71%) (Table 5). At the end of 8-day storage period of banana, the peel dry matter content of banana in the

control treatment became doubled from the initial value, whereas in case of blue polythene bagging the increment was only 50% (Table 5).

Disease incidence during storage: Disease incidence of banana at different DAS was significantly affected by pre-harvest bagging treatment. Banana fruit with control treatment is severely affected by disease incidence at all DAS comparison to other bagging treatments. Among different types of bagging materials, blue and white polythene bags were responsible for the least disease incidence of banana (4.0% for both) at 2nd DAS (Figure 4). It was noticeable that at the end of the storage observation of 10th DAS, blue polythene bag cover showed minimum disease incidence (40%) and banana fruit received no pre-harvest bagging gave 56% disease incidence which was 27% higher than the pre-harvest bagged by blue polythene bag (Figure 4).

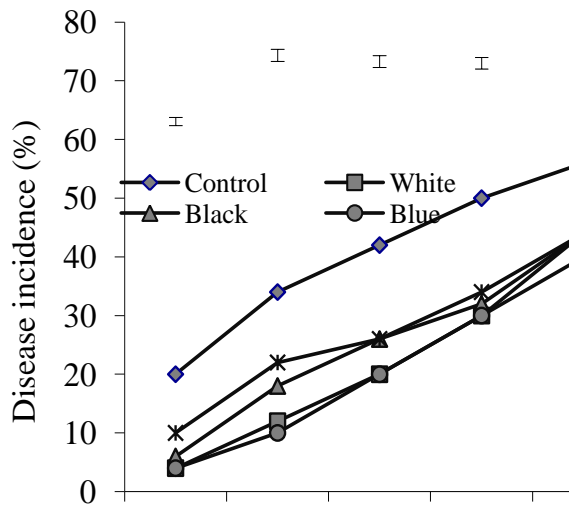


Figure 4. Effect of bunch cover treatments on disease incidence of banana cv. Mehersagar at different days after storage. The vertical bars represent LSD at 5% level of significance.

Disease severity: Use of different types of bagging materials during pre-harvest period showed significant effect on disease severity during storage. Banana in control treatment and those received different types of bagging had linear increment of disease severity in the

course of storage period. The conspicuous difference in disease severity was observed with the control at all DAS, which produced the worst disease severity. At the end of 10th DAS, the highest disease severity was recorded from control (100%), whereas it was reduced by 30% by using blue polythene bag (70.25%) (Figure 5).

Skin colour of finger during storage: Result revealed that the average days required reaching successive stage of ripening varied significantly due to the bunch cover treatment. The highest colour score (6.46) attained in control followed by old cloth bunch cover (6.29). The lowest color score (4.95) attained in blue polythene bunch cover at 10th DAS (Table 6). These results indicated that control treatment had faster development of colour of banana followed by other treatments.

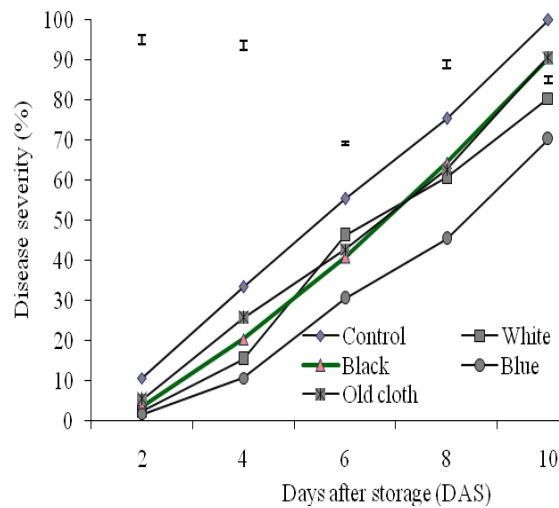


Figure 5. Effect of bunch cover treatments on disease severity of banana cv. Mehersagar at different days after storage. Vertical bars represent LSD at 5% level of significance.

Total soluble solids: Bagging treatments significantly affected the total soluble solids (TSS) percentage of banana fruit at all observation dates after storage. At all observation dates, the highest and lowest TSS was recorded for the blue polythene bag and control (no bagging) treatments respectively. The maximum total

Banana bunch covering technology for safe banana

soluble solids (24.28%) was found in blue polythene bagging treatment and minimum total soluble solids (TSS) (20.40%) was found in control at 10th DAS (Table 7). It is noticeable that blue polythene bagging treatment enhanced TSS of banana from the early date 2nd DAS and maintained the trend until the end of observation at 10th DAS. White polythene bag

produced the second highest values of TSS at all observation dates and followed the similar pattern that of blue polythene treatment. Control, black polythene and old cloth gave statistically similar values at almost all observations. At the 10th DAS, TSS value of banana increased 19% with blue polythene bagging treatment over control treatment (Table 7).

Table 6. Effect of bunch cover treatments on skin color of banana at different days after storage.

Treatments	Skin color at different days after storage					
	Initial	2	4	6	8	10
Control	1.00	1.98	2.80	4.04	5.15	6.46
White polythene bag	1.00	1.17	2.45	3.19	4.46	5.90
Black polythene bag	1.00	1.32	2.50	3.60	4.68	6.06
Blue polythene bag	1.00	1.00	1.79	2.41	3.71	4.95
Old cloth	1.00	1.43	2.61	3.73	5.03	6.29
LSD _{0.05}	-	0.50	0.64	0.66	0.42	0.41
LSD _{0.01}	-	0.69	0.88	0.91	0.58	0.56
Level of significance	-	**	*	**	**	**

** Significant at 1% level of probability, * Significant at 5% level of probability, Skin color was measured using the scale of 1-6, where 1 =green, 2 = breaker, 3 = <25% yellow, 4 = <50% yellow, 5 = <75% yellow, and 6 = 75 to 100 % yellow.

Table 7. Effect of bunch cover treatments on total soluble solids of banana cv. Mehersagar at different days after storage.

Treatments	Total soluble solids (%Brix) at different days after storage				
	2	4	6	8	10
Control	19.10	19.60	19.88	20.24	20.40
White polythene bag	21.12	21.72	22.24	22.48	22.72
Black polythene bag	19.62	19.92	20.16	20.72	21.00
Blue polythene bag	22.50	22.96	23.48	23.88	24.28
Old cloth	19.46	19.64	20.08	20.48	20.72
LSD _{0.05}	0.95	0.51	0.52	0.41	0.63
LSD _{0.01}	1.30	0.70	0.72	0.56	0.87
Level of significance	**	**	**	**	**

** Significant at 1% level of probability

Shelf life: Shelf life of banana fruit was significantly influenced by different bagging treatments. The lower shelf life (9.2 day) was recorded for banana which was not covered during pre-harvesting period (control). Old cloth bagged banana had statistically similar shelf life with that of no-bagging treatment with a mean value of 10 days. The longest shelf life of banana was obtained (11.4 days) from blue polythene bagging treatment (Figure 6). White and black polythene bag were as good as blue polythene in term of prolonging shelf life of banana (Figure 6).

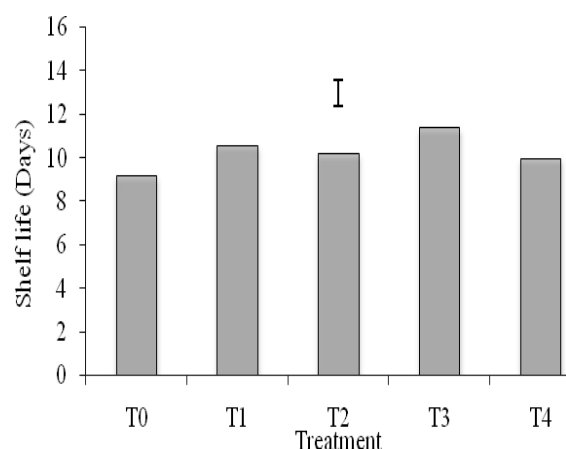


Figure 6. Effect of bunch cover treatments on shelf life of banana fruits cv. Mehersagar. The vertical bar indicates LSD at 5% level of significance. T₀: Control (open fruit), T₁: White polythene bag, T₂: Black polythene bag, T₃: Blue polythene bag, T₄: Old cloth.

Discussion

The study was carried out under field condition to observe the impact of bunch covering materials on physio-morphological characters and shelf life of banana cv. Mehersagar. In this study, we found that the minimum harvesting time (76.80 days) was recorded from the blue polythene bagging treatment, while the maximum harvesting time (97.80 days) was recorded from the control plants. So, non-bagged control fruits delayed harvesting time by 11 days over the blue polythene bag. Perforated bunch cover develops a

higher temperature inside the polythene bag than the surrounding temperature and this might be the reason why bunch cover caused less harvesting time. This observation is supported by Vargas *et al.* (2010) that crop duration, particularly days taken from flowering to maturity is influenced by different bunch cover treatments. And also Cuneen and McEntyre (1988), reported that the blue non perforated bags resulted in the highest temperature increase than the other bag types and they matured early in comparison to uncovered banana fruit especially during the winter season, which supports the findings of the present study. Daniells *et al.* (2001) also found shorter periods between emergence of inflorescence and harvest in bagged bunches which is similar to the result obtained for days to harvesting in the present study.

The highest value of bunch weight obtained from blue polythene bag (19.9 kg/bunch) and the lowest bunch weight (15.2 kg/bunch) was recorded for the control treatment. It is proved that effect of bunch cover on bunch weight is remarkable. This is supported by Weerasinghe and Ruwaphathirana (2002), they reported that the use of transparent and blue polythene covers enhanced bunch weight by 20 and 16%, respectively over the control (uncovered bunches). Galan *et al.*, (1996) recorded significant increase in bunch weight by bagging treatment in Dwarf Cavendish banana. However, Daniells *et al.*, (1992) found no difference among bagged and non-bagged fruits of variety Mysore cultivar. But in the present experiments it was noticed that bunch cover increased the bunch weight, it might be the covering materials which reduced transpiration loss, conserved moisture on fruit surface thus ultimately increased fruit weight subsequently bunch weight.

The highest finger length (19.59 cm) was recorded when the fruits were covered with blue polythene bag and the lowest (14.57 cm) was recorded when no fruit cover was used (control). Blue polythene bag cover aided banana with 16% increased finger diameter over the control treatment. Daniells *et al.*, (2001) reported

greater finger length, finger diameter and finger density in bunches covered with plastic wrap which supports the result obtained in the present studies. In South Africa, a 16.5% increase in Williams bunch weight was recorded due to a 10% increase in finger length. This may have been due to increased temperatures (0.5°C) under blue covers that favored growth (Robinson, 1996). Amarante *et al.*, (2002) also supported the present study. They observed banana bunches sealed with polyethylene bags had increased fruit size at harvest.

The highest disease incidence (12.67%) was recorded for banana which was not covered during pre-harvesting period (control). The lowest value (2.33%) was recorded with blue polythene bag which was 82% lower than that of control treatment. The reason might be the absence of disease inoculum. The result of the present study is supported by the findings of Amani and Avagyan (2014). They showed that the fungus like *Pyricularia grisea*, *Musicellium theobromae*, *Cercospora hayi*, *Fusarium moniliforme*, *F. solani* and *F. pallidoroseum* were isolated from samples. Symptoms of pitting, tip end rot, cigar end rot, brown spot, diamond spot and sunburn were observed in without bunch cover treatment. There was no such type fungus and symptom in covered bunch banana.

Insect infestation on fruit was recorded significantly very high on fruits of uncovered bunches (50.0%) as compared to minimal infestation on fruits of blue covered bunches (2.33%). Here, bunch cover might have provided physical barrier between bunch and insect. This work was similar with findings of Anonymous (2003) who found more visually appealing, free from scar fruit under bunch cover as compared to unbagged fruit.

In the present study physiological disorder mainly sunburn damage on uncovered bunch was the highest (13.40%) and the lowest value (1%) was obtained from blue polythene bag. This result is supported by the work of Turner (2013). He suggested that sunburn can be avoided if a protective covering such as paper is

placed between the fruit and the cover, or covers with a reflective coating on one side are used.

The highest pulp to peel ratio (2.49) was recorded in blue polythene bag and the lowest pulp to peel ratio (1.69) was recorded in control. Turner (1997) founded that in bananas, the pulp portion continues to grow even in the later stages of maturation. Muchui *et al.*, (2010) reported that shiny blue cover performed the best among all other treatments which found to increase the pulp to peel ratio during the early period of ripening. This also agrees with the result of the study.

At all observation dates, the highest and lowest TSS were recorded for the blue polythene bag (24.28°Brix) and control (20.40°Brix) treatments respectively. The use of blue polythene bag as covering material significantly increased the total soluble solids. Muchui *et al.* (2010) reported that in variety williams banana TSS and total sugar were not influenced by bunch covers but in variety Grand Naine TSS and total sugar were increased by the use of bunch covers. The blue cover was the most effective one like the results obtained from the present study which is in agreement with the findings of ShihChao *et al.*, 2004 and Watson *et al.*, 2002. ShihChao *et al.*, 2004 concluded that blue polyethylene covers showed to allow blue-green and ultraviolet lights and also infrared rays. Light exposure of 'Sunscrest'/GF 677 peaches showed increased reducing sugars (Watson *et al.*, 2002). Starch reduced as ripening progressed while TSS increased as expected in ripening banana (Nascimento *et al.*, 2006). However, in apples, bagging reduced starch content and fruit soluble solids at harvest (Mattheis and Fellman, 1999). In other reports, panicle bagging of pears was found to have no effect on total soluble solids (Cassandro *et al.*, 2002). Elsewhere, fruit ripening for mangoes was enhanced by preharvest bagging although there was no effect on TSS and sensory quality at the postharvest stage for the bagged and unbagged fruits (Hoffman *et al.*, 1997).

Moisture content of the peel reduced gradually during ripening while that of the pulp increased with ripening.

For this observation, it can be found that blue polythene bagging at pre-harvest period can save 29% more moisture of banana than that of no pre-harvest bagging treatment (control). Percentage fruit weight loss increased with days of storage in all the treatments. During normal ripening, the banana peel loses water to both the pulp and the atmosphere (Stover and Simmonds, 1987). Fruit weight loss is attributed to physiological weight loss due to respiration, transpiration and other biological changes taking place in the fruit during ripening (Rathore et al., 2007). Fruit surfaces are covered by cuticle covers which restrict water loss through transpiration, also. Fruits from the bagged and control bunches may have had similar cuticle structures (Amarante et al., 2002). Since the bunch covers in the current study had perforations, it is possible that the control and fruits grown under cover had similar humidity environment during growth and after harvesting. Pears grown under perforated covers and control ones where both the moisture content and weight loss were not significantly ($p>0.05$) affected by pre-harvest bagging as they had similar skin permeability due to similar wax content of the cuticle (Amarante et al., 2002). This is contradictory with the present study. This is due to varietal difference, different growing area and climatic requirement etc.

The banana of blue polythene bag and control treatment lost 9% and 11% pulp dry matter respectively within 8th days of storage period. From figure 5, it can be seen that during the early date of storage at 2nd DAS, the effect of bagging materials on reducing disease severity was not conspicuous, which however, was distinct at 10th DAS, giving much lower value to blue polythene bag.

Covering the bunch with blue polythene bag also significantly increase the shelf life of banana fruits as compared to other bunch covering materials tried. Use of blue polythene bag as bunch covering material extended the shelf life of banana fruits of the variety mehersagar to the extent of 11.4 days and this had been found to be significantly superior to all the values

recorded under all other treatment combinations tried. This is supported by Scott et al., (1971). They reported that banana grown under bunch covers had delayed ripening which extend the shelf life of fruits. Banana grown under blue polyethylene cover extends the green life as well as the shelf life of fruits.

Conclusion

Considering the findings it might be concluded that significant variation existed among the different pre-harvest bunch cover treatments in respect of days to harvesting, bunch weight, finger length, finger diameter, disease and insect incidence, physiological disorder, pulp-peel ratio, weight loss, total soluble solids and shelf life. From the experimental findings, it might be concluded that, among the four bunch cover materials, blue polythene cover showed the best result. The use of bunch covers should be coupled with proper postharvest handling procedures to ensure that the clean, visually appealing fruits are not bruised during the postharvest period. Such fruits could also be targeted for the export market where they might fetch better prices as the consumer clientele appreciates the visually appealing fruits and are willing to pay more for such fruits. The use of this kind of covering material can be recommended for commercial banana cultivation.

Acknowledgement

The authors are grateful for financial support from ministry of science and technology, Bangladesh.

References

- Amani M, Avagyan G (2014). Effect of polyethylene bunch cover on fungal diseases control of banana (*Musa acuminata* L.) in Iran. *International Journal of Farming and Allied Sciences*, 3(10): 1054-1057.
- Amarante C, Banks NH, Max S (2002). Effect of pre-harvest bagging on fruit quality and post-harvest physiology of pears (*Pyrus communis*). *New*

- Zealand Journal of Crop and Horticultural Science*, 30: 99-107.
- Anonymous (2003). Bunch covers for improving plantain and banana peel quality. National Agriculture Research Institute. Technical Bulletin no 4.
- Assani AR, Haicour G, Wenzel F, Cote F, Bakry F, Foughiwehr B, Ducreux G, Aguillar ME Grapin A (2001). Plant regeneration from protoplasts of dessert banana cv. Grande Naine (*Musa* spp., Cavendish sub-group AAA) via somatic embryogenesis. *Plant Cell Reports*, 20: 482-488.
- Bashir MA, Ahmad M, Shabir K (2015). Effect of different bunch covering materials on shamran date for enhancement of economical yield. *The Journal of Animal & Plant Sciences*, 25(2): 417-421.
- BBS (Bangladesh Bureau of Statistics) (2018). Yearbook of Agricultural statistics of Bangladesh. Bangladesh bureau of Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh.
- Cassandro A, Nigel H, Max BS (2002). Effect of postharvest bagging on fruit and postharvest physiology of pears (*Pyrus communis*). *New Zealand Journal of Crop and Horticultural Science*, 30(2): 99-107.
- Cuneen T, McEntyre C (1988). The colour of banana bags have an effect on the yield of bananas and the climate inside the bag. *Banana Bulletin*, 52: 14-15.
- Daniells JW, Farrell PJ, Mulder JC, Campbell SJ (2001). Effects of bunch covering and bunch trimming on bananas in Northern Queensland. *Queensland Journal of Agricultural Sciences*, 44: 101-105.
- Daniells JW, Lisle AT, Farrell PJ (1992). Effect of bunch covering methods on maturity bronzing, yield and fruit quality of bananas in Northern Queensland. *Australian Journal of Experimental Agriculture*, 32: 121-125.
- Debnath U, Suresh CP, Hasan MA (2001). Bunch management for profitable production in winter developing banana bunches. *Indian Journal of Horticulture*, 58(3): 202-207.
- Galan SV, Cabrera J, Gomez PM (1996). The evaluation of different bunch covers (*Musa acuminata*) in the Canary Islands. *Fruits*, 51: 13-24.
- Ganry J (1975). Influence du gainage des régimes du bananier avec une house de polyéthylène sur la température des fruits dans les conditions de Neufchateau (Guadeloupe) [Portuguese]. *Fruits*, 30(2): 735-738.
- Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons, New York. pp. 67-215.
- Haque MA (1988). Kalar Bagan (in Bengali). Banana Reserch Project, Bangladesh Agricultural University, Mymensingh. pp.1-4.
- Hoffman PJ, Smith LG, Joyce DC, Johnson GI, Meiburg GF (1997). Bagging of mango (*Mangifera indica* cultivar Keitt) fruit influences fruit quality and mineral composition. *Postharvest Biology and Technology*, 12: 83-91.
- Hossain MF (2014). A study of banana production in Bangladesh: Area, yield and major constraints. *ARNP Journal of Agriculture Biological Science*, 9: 206-210.
- Islam MA, Hossain MT, Khatun M, Hossen MS (2015a). Environmental impact assessment on frequency of pesticide use during vegetable production. *Progressive Agriculture*, 26: 97-102.
- Islam MA, Haque ME, Hossain MK, Hossain MS. 2015b. Investigation of formalin and ethepon in some fruits of three local markets of Mymensingh District using Gas Chromatograph. *Journal of Bangaldesh Agricultural University*, 13(1): 7-12.
- Khader MA, Chellappan K, Chattopadhy PK, Anchanam O (1996). Banana Fruits: Tropical and Subtropical. Naya Prokash, 206 Bidhan Sarani, Calcutta, India. pp.130-134.

- Matthesis JP, Fellman JK (1999). Preharvest factors influencing flavor of fresh fruit and vegetables. *Postharvest Biology and Technology*, 15: 227-232.
- Muchui MN, Mathooko FM, Njoroge CK, Kahangi EM, Onyango CA, Kimani EM (2010). Effect of perforated blue polyethylene bunch covers on selected postharvest quality parameters of tissue cultured bananas (*Musa* spp.) cv. Williams in Central Kenya. *Journal of Stored Products and Postharvest Research*, 1(3): 29 – 41.
- Nascimento JRO, Junior AV, Bassinello PZ, Cordenunsi BR, Mainardi JA, Purgatto E, Lajolo FM (2006). Beta-amylase expression and starch degradation during banana ripening. *Postharvest Biological Technology*, 40(1): 41-47.
- Rahman M, Hossain MM, Rahim MA, Rubel MHK, Islam MZ (2018). Effect of pre-harvest fruit bagging on post-harvest quality of guava cv. Swarupkathi. *Fundamental and Applied Agriculture*, 3(1): 363-371.
- Rathore HA, Masud T, Sammi S, Soomro AH (2007). Effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) variety Dosehari. *Pakistan Journal of Nutrition*, 6: 143-148.
- Robinson JC (1996). Bananas and Plantains. Institute for Tropical and Subtropical Crops, University Press, Cambridge, UK. pp.172-174.
- Scott KJ, Wills RBH, Rippon LE (1971). The use of sealed polyethylene bunch covers during growth as a retardant to the ripening of bananas. *Journal of Tropical Agriculture*, 48: 163-165.
- Shanmugasundaran KA, Manavalan RSA (2002). Postharvest characteristics of Rasthali bananas grown under different polyethylene covers. *Infomusa*, 11(2): 43-45.
- ShihChao C, DinFon K, ChunMei C, MeiJen C (2004). Comparison in the bunch development and post-harvest quality of banana as affected by kraft paper cover and polyethylene cover. *Journal of Chinese Society of Horticultural Science*, 50(3): 245-252.
- Stover RH, Simmonds NW (1987). Bananas. Third Edition, Longman, London. pp. 67.
- Turner, D.W. (2013). Crop physiology and cultural practices-a synergy in banana and plantain (*Musa* spp.). International ISHS-ProMusa Symposium on Bananas and Plantains, Belgium, 986, pp. 41-50.
- Turner DW (1997). In: Postharvest Physiology and Storage of Tropical and Subtropical Fruits. CAB International, Mitra S.K. (ed.), New York, NY, pp. 47-77.
- Vargas A, Valle H, Gonzalez M (2010). Effect of colour and density of polyethylene bunch covers on the dimensions, appearance and postharvest quality of banana and plantain fruits. *Agronomai Costarricense*, 34: 269-285.
- Vezina A. (2016). Bagging. In ProMusa: Mobilizing Banana Science for Sustainable Livelihoods. URL: <http://www.promusa.org/Bagging>. Accessed on 07 February, 2018.
- Watson R, Wright CJ, McBurney T, Taylor AJ, Linforth RST (2002). Influence of harvest date and light integral on development of strawberry flavour compounds. *Journal of Experimental Botany*, 53 (377): 2121-2129.
- Weerasinghe SS, Ruwaphathirana KH (2002). Influence of bagging material on bunch development of bananas (*Musa* spp.) under high density planting system. *Annals of Sri Lankan Department of Agriculture*, 4: 47-53.
- Zirari A, Ichir LL (2010). Effect of different kinds of bunch covering on date palm fruit (*Phoenix dactylifera* L.) moth infestation rate. Proceedings of ISHS Acta Horticulturae 882: IV International Date Palm Conference. Abu Dhabi, United Arab Emirates.