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Eco-friendly management of postharvest decay of Langra and Surjapuri mangoes

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ABSTRACT

Mahogani leaf extract, bishkatali leaf extract, garlic clove extract, brine solution and fruit washing were applied to investigate the efficacy for eco-friendly management of postharvest decay of Langra and Surjapuri varieties of mango. Chemical fungicide Bavistin (Carbendazim 50% WP), and non-treated control were used as positive and negative control treatments, respectively. Post-harvest decay caused by anthracnose and stem-end rot of mango were assessed. At 8th day of storage of Langra, lowest number of anthracnose spots were found in garlic clove extract followed by bishkatali. Significant reduction in anthracnose spots were observed in the treatments mahogani, fruit washing, Bavistin and brine solution, respectively. The lowest diseased area caused by anthracnose were found in Bavistin followed by garlic. The lowest number of stem-end rot lesions were found in mahogani followed by garlic and significantly reduced percentage of stem end rot lesions were observed in the treatments brine solution followed by Bavistin and bishkatali. In case of Surjapuri mango, the lowest number of anthracnose spots per fruit and disease area per fruit were obtained by garlic clove treatment. The lowest number of stem-end rot lesions was observed with bishkatali and mahogani leaf extracts, respectively and lowest stem-end rot diseased area per fruit was observed with garlic clove and mahogany leaf extracts, respectively. Overall higher number of anthracnose spot and stem-end-rot lesions per fruit was observed in control treatment. Garlic clove extract, bishkatali leaf extract and mahogani leaf extract were found effective in reducing post-harvest decay of mango.

Introduction

Mango (*Mangifera indica* L.), is the king of fruits in Bangladesh, belongs to the family Anacardiaceae (Mukherjee, 1997). Mango grows widely all over Bangladesh and there are innumerable varieties to charm the connoisseur. About 250 varieties of mangoes are grown in Bangladesh (Shafique, 2006). According to FAOSTAT (2016) the rank of Bangladesh in mango production is third among the tropical fruits grown in the world with a total production at nearly 35,000,000 tons. Furthermore, its rank is second in terms of area and occupies third position in production among the fruits grown in Bangladesh (FAOSTAT, 2016). Postharvest disease is a major constraint to the quality and shelf life of mango fruit thereby limiting its domestic and export marketing (Bally *et al*., 2009) as well as resulting in heavy economic losses (Barkai, 2001). Like other fresh commodities, mango is prone to postharvest fruit decay due to rapid disease development during storage and ripening (Prusky *et al*., 2009). Anthracnose caused by *Colletotrichum gloeosporioides* is regarded as one of the major postharvest diseases of mango (Bally *et al*., 2009). Stem-end rot and black spots (i.e., *Alternaria* rot) have also been reported to cause significant postharvest decay in mango (Prusky *et al*., 2009). Due to rapid increase in the severity and incidence of diseases in the mango growing countries, its management became a worldwide concern to ensure the postharvest fruit quality during the supply chains (Johnson *et al*., 1993). Chemical fungicides have often been used to control these diseases, but this practice is associated to negative environmental impacts, potential human exposure to pesticides, and deposition of residues on the fruits (Sales *et al*, 2016). However, the effectiveness of synthetic fungicides has been reduced by the frequent development of resistance by the pathogens. Hence, there is great demand for safer, alternative and effective chemotherapeutic agents and currently, the search for natural products with novel uses, particularly related to pathogen management is very active.

Aromatic and medicinal plants have attracted interests in the field of plant disease control, particularly plant extracts with antimicrobial properties and contain a spectrum of secondary metabolites such as alkaloids, quinones, flavonoids, glycosides, saponins, tannins and terpenoids (Sales *et al*., 2016). So, alternatives have to be developed to control postharvest diseases of mango in order to guarantee safe fruit production as well as the environment. The introduction of plant extracts with the

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aim to reduce or eliminate negative effects caused by chemicals used for controlling major postharvest mango diseases is a realistic option for solving the problem of chemicals in controlling plant diseases and are being discouraged all over the world. Mango is a seasonal fruit, so it is necessary to study and understand the shelf life of mango under different treatments to mitigate the postharvest losses. Hence, the present experiment was undertaken to manage the postharvest decay of Langra and Surjapuri varieties of mango by applying plant extracts.

Materials and Methods

The experiment was carried out in Microbiology and Bio-Control Laboratory, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. The two mango varieties were – i. Langra and ii. Surjapuri. Healthy and diseased fruits of different varieties were collected from local market. The experiment was laid out in Completely Randomized Design (CRD) with three replications. For the management of postharvest decay of mango, different treatments were used like T_1 = Mahogani (*Swietenia mahogany)* leaf extract (1:10), T_2 = Bishkatali (*Polygonum hydropiper*) leaf extract (1:10), T_3 = Garlic (*Allium sativum*) clove extract (1:10), T_4= Brine solution (1:100), T_5 = Fruit washing, T_6 = Bavistin (0.1%) and T_7 = Control. Fruits were randomly selected from each variety of the experimental fruit lot. The selected fruits were then individually dipped in Garlic clove extract, Mahogani and Bishkatali leaf extract, Brine solution, water and Bavistin, respectively.

The fruits were then air dried by using normal ceiling fan and placed on the table of the laboratory at spell out condition for observation. For control treatment, the fruits were then air dried by using normal ceiling fan without applying any extracts and chemical. Data on the following parameters were recorded from all the experimental fruits: i. Number of spots per infected fruit: the fruits which had spots on the surface were considered as infected fruits and after treatments this number of spots was counted. ii. Disease area in percentage per infected fruit: after treatments, disease area per infected fruit was counted and was expressed in percentage.

Results and Discussion

Effect of treatments on number of spot and percent diseased area of anthracnose of mango variety Langra

Effect of different treatments on number of anthracnose spot of mango variety Langra was evaluated and are presented in Table 1. Significant difference was found among the different treatments. During 4-8 days study, highest number of anthracnose spots (15.88) were observed in control (T_7) and lowest number of anthracnose spots were observed in garlic treated mangoes. At 8th day of storage, lowest number of anthracnose spots (9.25) were found in garlic (T_3). In comparison to control treatment, significantly reduced anthracnose spots were observed in the treatments mahogani (T_1 =14.20), fruit washing (T_5 = 14.20), Bavistin (T_6 = 14.25) and Brine solution (T_4 = 15.38), respectively.

Table 1. Effect of different treatments on number of Anthracnose spots of mango variety Langra

	No. of Anthracnose spots during storage (DAS)				
Treatments	4	5	6	7	8
T_1	9.50 c	11.50 b	13.80 a	13.80 b	14.20 b
T_2	8.00 d	8.750 c	10.63 bc	11.00 d	11.50 c
T_3	6.17 e	8.170 c	8.50 c	8.630 e	9.250 d
T_4	10.0 c	11.30 b	14.75 a	15.12 a	15.38 a
T_5	11.40 b	11.80 b	12.30 ab	13.50 bc	14.20 b
T_6	8.63 d	11.50 b	12.17 ab	12.60 c	14.25 b
T_7	12.83 a	13.83 a	14.75 a	15.00 a	15.88 a
LSD0.05	0.794	1.27	2.53	1.13	0.933
Level of sign.	**	**	**	**	**
CV (%)	4.77	6.61	11.67	5.03	3.94

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control; DAS = days after storage;

Data were subjected to Duncan's Multiple Range Test (DMRT) using a statistical computer package (MSTAT C). Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Among different treatments significant differences were observed on percent diseased area of anthracnose of mango variety Langra (Table 2). During 4-8 days study, highest percentage of diseased area (11.6) were observed in control (T_7) and lowest percentage of diseased area were observed in Bavistin treated mangoes. At 8th day of storage, lowest percentage of anthracnose diseased area (5.0) was observed in Bavistin (T_6). In comparison to control treatment, significantly reduced percentage of anthracnose diseased area was observed in the treatments mahogani (T_1 = 6.90), bishkatali (T_2 = 8.20), brine (T_4= 8.38) and fruit washing (T_5 = 9.0), respectively.

Garlic and Bavistin showed better efficacy as found in the present investigation is in line with Charles and Amusa (2015) who conducted an experiment on incidence and severity of anthracnose in mango fruits and its control with plant extracts and showed that 60% of mango surveyed were found to be infected with anthracnose and over 34% of fruits produced on those trees were severely infected. Thirty percent and ten percent concentration of *Annona squamosa* were highly effective in reducing the incidence of anthracnose when compared with Benomyl. Chowdhury (2005) conducted an experiment for evaluation of some plant extracts against *Colletotrichum gloeosporiodes* to control anthracnose of mango in Bangladesh Agricultural University, Mymensingh campus. He reported that three applications of Garlic (*Allium sativum*) extracts after harvesting reduced the incidence of mango anthracnose and resulted in significantly higher quality over control. He also reported that higher number of healthy fruits was recorded from Garlic extract followed by bishkatali

(*Polygonum hydropiper*) and neem (*Azadirachta indica*) extracts. Chalfo and Carvalho (1987) studied the inhibition of mycelial growth of *Gibberella zeae* (*Fusarium* growth) by treating with garlic extract and captafol. They reported that garlic extract was more effective to inhibit mycelial growth of *Gibberella zeae* than captafol. The most effective concentration was 10,000 ppm for garlic extract.

Table 2. Effect of different treatments on percentage of Anthracnose diseased area of mango variety Langra

Treatments	Anthracnose (%) diseased area (Day after storage)				
	4	5	6	7	8
T_1	3.50 c	4.50 c	6.20 bc	6.40 c	6.90 d
T_2	4.40 b	5.80 ab	6.40 b	7.90 b	8.20 c
T_3	4.80 b	5.10 bc	5.13 cd	5.50 d	5.88 e
T_4	4.40 b	4.70 bc	7.63 a	7.88 b	8.38 c
T_5	5.00 b	5.40 abc	6.00 bc	8.10 ab	9.00 b
T_6	4.20 bc	4.33 c	4.67 d	4.90 e	5.00 f
T_7	6.17 a	6.33 a	7.80 a	8.60 a	11.60 a
LSD0.05	0.734	1.05	1.07	0.583	0.492
Level of sign.	**	**	**	**	**
CV (%)	9.03	11.61	9.76	4.74	3.58

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Effect of treatments on stem-end rot lesion and percent diseased area of stem-end rot of mango variety Langra

Effect of different treatments on number of stem-end rot lesion of mango variety Langra was evaluated and are presented in Table 3. Significant difference was found among the different treatments. The highest number of stem-end rot lesions (1.17) were observed in untreated control (T_7) and lowest number of stem-end rot lesions were observed in garlic treated mangoes. At 8th day of storage, lowest number of stem-end rot lesions (0.58) were found in garlic (T3).

Table 3. Effect of different treatments on number of Stem-end rot lesions of mango variety Langra

Treatments	Number of Stem-end rot lesions (Day after storage)				
	4	5	6	7	8
T1	0.50 a	0.50 b	0.50 c	0.50 c	0.75 cd
T2	0.50 a	0.58 a	0.67 ab	0.67 b	0.67 de
T3	0.00 b	0.38 c	0.50 c	0.50 c	0.58 e
T4	0.00 b	0.00 d	0.58 bc	0.67 b	0.92 b
T5	0.50 a	0.50 ab	0.67 ab	0.75 ab	1.08 a
T6	0.50 a	0.50 ab	0.63 b	0.75 ab	0.83 bc
T7	0.50 a	0.50 ab	0.75 a	0.83 a	1.17 a
LSD0.05	0.095	0.078	0.096	0.124	0.123
Level of sign.	**	**	**	**	**
CV (%)	12.21	10.15	9.17	10.34	8.57

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Significant differences among different treatments were observed on percent stem-end rot diseased area of mango variety Langra (Table 4). The highest percentage of Stem-end rot diseased area (2.50) were observed in untreated control (T_7) and fruit washing (T_5) and the lowest percentage of Stem-end rot disease area were observed in mahogani and garlic treated mangoes. At 8th day of storage, lowest percentage of Stem-end rot diseased area (2.08) were found in Mahogani (T_1) and garlic (T_3). As compared to control, significant reduction of Stem-end rot diseased area were observed in the treatments brine (T_4 = 1.50), Bavistin (T6 = 1.83) and bishkatali (T_2=2.42), respectively.

Table 4. Effect of different treatments on percentage of Stem-end rot diseased area of mango variety Langra

Treatments	Stem-end rot (%) diseased area (Day after storage)				
	4	5	6	7	8
T_1	1.50 a	1.50 c	1.50 bc	1.63 c	2.08 bc
T_2	1.58 a	2.00 a	2.08 a	2.25 a	2.42 ab
T_3	1.50 a	1.50 c	1.67 b	2.00 b	2.08 c
T_4	0.00 d	0.00 f	1.00 de	1.16 e	1.50 d
T_5	1.50 a	1.75 b	1.75 b	2.00 ab	2.50 a
T_6	1.00 b	1.25 d	1.25 cd	1.50 cd	1.83 cd
T_7	0.38 c	0.50 e	0.75 e	1.33 de	2.50 a
LSD0.05	0.157	0.199	0.271	0.247	0.337
Level of sign.	**	**	**	**	**
CV (%)	8.45	9.47	10.87	8.31	8.99

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Effect of treatments on number of spot and percent diseased area of anthracnose of mango variety Surjapur

The effect of different treatments on number of anthracnose spot of mango variety Surjapuri was evaluated and are presented in Table 5. Significant difference was found among the different treatments. The highest number of anthracnose spots (17.33) were observed in fruit washing (T_5) and lowest number of anthracnose spots (6.67) were observed in garlic treated mangoes. At 8th day of storage, lowest number of anthracnose spots (6.67) were found in garlic (T_3). At 1st day to 3rd day of storage, there was little or no anthracnose spot on the fruit surface. In comparison to control treatment (T_7 = 13.75), significantly reduced anthracnose spots were observed in the treatment of Mahogani (T_1 =10.67) and Bavistin (T_6 = 8.67), respectively.

Significant difference of treatments on percent anthracnose diseased area of mango variety Surjapuri were observed (Table 6). The highest percentage of anthracnose diseased area (5.50) were observed in fruit washing (T_5) and lowest percentage of anthracnose diseased area were observed in garlic treated mangoes and untreated control. At 8th day of storage, lowest

percentage of anthracnose diseased area (2.16) were found in garlic (T_3). At 1st day of storage, there was no anthracnose disease area on fruit surface. In comparison to control treatment (T_7 = 3.50), significantly reduced percentage of anthracnose diseased area were observed in the treatments bishkatali (T_2 = 2.67) and mahogani (T_1 = 3.0).

Table 5. Effect of different treatments on number of Anthracnose spots of mango variety Surjapuri

Treatments	No. of Anthracnose spots (Day after storage)				
	4	5	6	7	8
T_1	6.25 c	8.00 c	8.67 c	9.67 c	10.67 c
T_2	4.25 d	5.50 d	5.67 d	6.67 de	8.00 d
T_3	2.67 e	3.67 e	5.00 d	6.33 e	6.67 e
T_4	8.00 b	9.00 c	11.33 b	13.00 b	14.66 b
T_5	12.25 a	14.25 a	14.33 a	15.33 a	17.33 a
T_6	4.75 d	5.33 d	6.00 d	7.33 d	8.67 d
T_7	8.25 b	10.75 b	11.75 b	13.00 b	13.75 b
LSD0.05	0.875	1.03	0.986	0.730	0.936
Level of sign.	**	**	**	**	**
CV (%)	7.54	7.29	6.28	4.09	4.69

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Table 6. Effect of different treatments on percentage of Anthracnose diseased area of mango variety Surjapuri

Treatments	Anthracnose (%) diseased area (Day after storage)				
	4	5	6	7	8
T_1	2.03 b	2.17 bc	2.33 d	2.67 d	3.00 d
T_2	0.88 e	1.25 e	1.67 f	2.17 e	2.67 de
T_3	0.63 e	0.770 f	1.50 g	2.00 e	2.16 f
T_4	1.75 bc	2.330 b	3.00 b	3.670 b	4.67 b
T_5	4.00 a	4.250 a	4.330 a	4.830 a	5.50 a
T_6	1.38 d	1.83 d	2.17 e	2.17 e	2.43 ef
T_7	1.50 cd	2.00 cd	2.50 c	3.00 c	3.50 c
LSD0.05	0.336	0.259	0.135	0.207	0.350
Level of sign.	**	**	**	**	**
CV (%)	11.11	7.13	3.02	4.03	5.88

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

The effect of different treatments on number of stem-end rot lesions of mango variety Surjapuri

The effect of different treatments on number of stem-end rot lesions of mango variety Surjapuri was evaluated and are presented in Table 7. Significant difference was found among the different treatments. During 4-8 days study, the highest number of stem-end rot lesions (1.00) were observed in fruit washing (T_5) and lowest number of Stem-end rot lesions were observed in mahogani and bishkatali treated mangoes.

At 8th day of storage, lowest number of stem-end rot lesions (0.33) were found in mahogani (T_1) and bishkatali (T_2). In comparison to control treatment (T_7 = 0.75), significantly reduced stem-end rot lesions were observed in the treatments garlic (T_3 = 0.67), brine (T_4= 0.67) and Bavistin (T_6 = 0.67). The effect of different treatments on percent stem-end rot diseased area of mango variety Surjapuri was evaluated (Table 8). The highest percentage of stem-end rot diseased area (2.67) were observed in fruit washing (T_5) and lowest percentage of stem-end rot diseased area were observed in mahogani and garlic treated mangoes.

At 8th day of storage, lowest percentage of Stem-end rot diseased area (0.25) were found in mahogani (T_1) and garlic (T_3). In comparison to control treatment (T_7 = 2.50), marked reduction of stem-end rot diseased area were observed in the treatments brine (T_4= 0.76) and Bavistin (T_6 = 0.83).

Table 7. Effect of different treatments on number of Stem-end rot lesions of mango variety Surjapuri

Treatments	Number of Stem-end rot lesions (Day after storage)				
	4	5	6	7	8
T1	0.25 c	0.33 c	0.33 d	0.33 c	0.33 c
T2	0.25 c	0.25 c	0.33 d	0.33 c	0.33 c
T3	0.67 a	0.67 a	0.67 b	0.67 b	0.67 b
T4	0.25 c	0.33 c	0.33 d	0.33 c	0.67 b
T5	0.50 b	0.50 b	1.00 a	1.00 a	1.00 a
T6	0.25 c	0.33 c	0.67 b	0.67 b	0.67 b
T7	0.25 c	0.50 b	0.50 c	0.75 b	0.75 b
LSD0.05	0.055	0.078	0.078	0.110	0.095
Level of sign.	**	**	**	**	**
CV (%)	8.40	11.10	7.50	7.31	6.69

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Table 8. Effect of different treatments on percentage of Stem-end rot diseased area of Mango variety Surjapuri

Treatments	% of Stem-end rot diseased area (Day after storage)				
	4	5	6	7	8
T_1	0.06 d	0.17 e	0.17 e	0.17 e	0.25 c
T_2	0.19 c	0.25 e	0.33 d	0.50 d	0.50 bc
T_3	0.33 a	0.42 c	0.75 c	1.67 b	0.25 c
T_4	0.25 b	0.33 d	0.33 d	0.50 d	0.76 b
T_5	0.25 b	0.50 b	1.50 a	2.33 a	2.67 a
T_6	0.06 d	0.20 e	0.42 d	0.58 d	0.83 b
T_7	0.38 a	0.63 a	1.13 b	1.50 c	2.50 a
LSD0.05	0.055	0.078	0.095	0.123	0.336
Level of sign.	**	**	**	**	**
CV (%)	6.51	11.83	8.22	7.10	17.25

T_1= Mahogani leaf extract, T_2 = Bishkatali leaf extract, T_3 = Garlic leaf extract, T_4= Brine solution, T_5 = Fruit washing, T_6 = Bavistin, T_7 = Control. Each value represents the mean and standard deviation of three replications. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **P < 0.01 versus control treatment (Significant at 1% level of probability).

Sarkar (2012) conducted an experiment and showed that tablets of garlic clove extract were effective in improving the quality and extending the shelf life of mango. Five different doses of garlic tablet viz. 1:1, 1:2, 1:3, 1:4 and 1:5 were applied as postharvest treatments. All the doses showed good results compared to the control. The color of the mangoes was changed slowly due to the action of the garlic extracts. The total soluble solids content was increased gradually but less than the control. Content of reducing sugar was increasing during storage but it was less than the Control.

It was observed that, the shelf life of mango was longer than the Control. Assadi and Behroozin (1987) compared the efficacy of onion and garlic extracts in inhibition of mycelial growth of *Fusarium spp.* and *Sclerotium cepivorum.* They found that Garlic extract was more effective than Onion extract in inhibiting the growth of pathogen. Vidyasagar and Rajasab (2001) tested different concentrations of leaf extracts (1, 5, 10, 15, 20, 25 and 50%) of Neem and Parthenium and bulb extract of Garlic to assess their effect on conidial germination of *Phyllactinia corylea* and powdery mildew disease development on mulberry leaves. They reported that all concentrations of garlic bulb extract and neem and parthenium leaf extracts exhibited inhibitory effect on conidial germination. They found that garlic extract showed maximum effects in disease control followed by neem and parthenium.

Ashrafuzzaman and Hossain (1992) evaluated the extract of bishkatali *(Polygonum hydropiper) in vitro* against *Rhizoctonia solani* in two separate experiments and found that the extract inhibited the mycelial growth and spore germination effectively. Obagwu and Korsten (2003) conducted an experiment to test the efficacy of water and ethanol extracts of garlic cloves in the control of *Penicillium digitatum* and *P. italicum,* the cause of citrus green and blue mold respectively. They applied the extracts to artificially inoculated citrus Fruits (orange and grape fruit). They reported that all concentrations of extracts were more effective than water in inhibiting the growth and development of both the pathogens.

Dubey and Dwivedi (1991) studied fungitoxic properties of leaves and bulb of onion and garlic, fruit and bark of *Acacia arabica* against vegetative growth and sclerotial viability of *Macrophomina phaseolina.* They found that all the extracts inhibited growth of the pathogen and garlic bulb extract was more effective than others. Fruit washing with normal water also have some effect in reducing anthracnose and stem-end rot of mango (Table 5-8). Uzzal *et al*. (2014) reported that washing with water and treatment with garlic extract are effective to reduce storage seed borne-pathogens. Thorough seed washing with running tap water can effectively reduce the storage mycoflora on seeds of *Hibiscus sabdariffa* and cucumber (Islam *et al*., 2013; Mallick *et al*., 2013). Thus, garlic clove treatment and washing of harvested mango might increase the shelf life by reducing post-harvest anthracnose and stem-end rot.

Conclusion

Considering the findings from the present study it may be concluded that significant variations existed among the different postharvest treatments with different plant extracts in respect of diseased spots and diseased area. Highest disease occurrence was observed in control treatment. Among the plant extracts, garlic clove extract treatment effectively reduced the post harvest decay of mango. In comparison with control treatments, leaf extracts of mahogani, bishkatali and garlic are effective to reduce post harvest decay of mango. Even fruit washing with water is effective to control the post harvest diseases of mango.

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