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Prevalence and Eco-Friendly Management of Some Important Nursery Diseases of Mango in Bangladesh

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Abstract

A survey was carried out to record the prevalence of the nursery diseases in four mango varieties (Gopalbhog, Langra, Amropali and Seedless) in some selected growing areas viz. Chapai Nawabganj, Rajshahi, Dinajpur and Mymensingh in Bangladesh. Altogether nine different diseases viz. anthracnose, die-back, malformation, scab, powdery mildew, sooty mould, red rust, gummosis and bacterial leaf spot were recorded during the period of survey. All the diseases were found in the nurseries of Chapai Nawabganj, but Gummosis was not observed in Rajshahi, Dinajpur and Mymensingh and die-back was also not found in Dinajpur. Only anthracnose was recorded in Kajla sinduri in Rajshahi and Kancha mithi in Dinajpur. Out of the 40 mango varieties surveyed occurrence of higher number of diseases were recorded in Amropali (9), Mollica (7), Langra (8), Aswina (8), Khirsapat (8), Fazli (8), Vustara (6), Bogra gooti (6), BARI Aam-2 (6), BARI Aam-4 (6), Mohananda (5), Polyembryony (7), Gopalbhog (7), Hybrid 10 (6), Nilambari (6), Mixed special (6) and Seedless (7). The efficacy of BAU-Biofungicide and four different fungicides viz. Amistar, Tilt 250 EC, Bavistin and Dithane M-45 in the nursery of four mango varieties (Gopalbhog, Langra, Amropali and Seedless) were evaluated in FTIP, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. BAU-Biofungicide showed good effect in controlling anthracnose, die-back, powdery mildew, bacterial leaf spot and sooty mould of mango whereas Dithane M-45 was found best for controlling red rust of mango. Dithane M-45 followed by BAU-Biofungicide and Bavistin resulted reduction of powdery mildew incidence over control while the severity of powdery mildew was lowest in Bavistin followed by Dithane M-45 and BAU-Biofungicide.

Keywords: mango, nursery diseases, Bangladesh, management

1. Introduction

Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae is one of the most important, popular and delicious fruits grown throughout the tropics and sub-tropics of the world including Bangladesh. Mango has been cultivated for more than 4000 years (Candole, 1984). The mango is considered to be a class one fruit in the country. Popenoe (1964) mentioned mango as “the king of the oriental fruits”. It was originated in the region of Eastern Indo-Bangladesh, Myanmar, Malaysia (Anonymous, 1989). It is widely grown all over Bangladesh with the quality mangoes solely concentrated in the north-western areas specially greater Rajshahi, Dinajpur and Rangpur (Karim, 1985). Mango ranks third among the tropical fruits grown in the world with a total production of 28848000 t (FAO, 2002). In Bangladesh mango ranks second fruit in terms of area and third in production. Bangladesh produced 640000 t of mango in 25910.93 ha of mango orchard during the period of 2005-06 (BBS, 2006). Mango is a popular fruit of the country having some special organoleptic features such as excellent flavour, pleasant aroma, attractive colour and taste. It is a rich source of vitamins, minerals and total soluble solids (Pramanik, 1995). It is also a medium source of carbohydrate as ripe mango pulp contains 16.9% carbohydrate (Salunkhe & Desai, 1984). The minimum dietary requirement of fruit/day/head is 85 g, whereas our availability is only 30-35 g, which is much lower than recommended daily allowance (Siddique & Scanlan, 1995).

The demand for fruit (mango) is increasing day by day with growing population and decline in production results in scarcity every year. Disease is a major cause for lower production of mango in Bangladesh (Meah & Khan,

1987). Mango is reported to be attacked with as many as 18 different diseases in Bangladesh. In Bangladesh, there exists a wide variability in mango due to its cross pollination and seed propagation. Altogether 55 germplasms of mango have been characterized as per IPGRI descriptor utilizing 56 characters (Anonymous, 2003). Besides, a number of unrecognized local variety available in Bangladesh. Almost all of these varieties are subjected to attack by various diseases.

Nursery diseases are an important consideration for mango production. Because healthy seedlings are prime need and is basic raw material for establishment of orchard for production of mango. But seedling diseases are one of the important problems in the tropics. Although a huge number of nurseries are engaged in producing seedlings, they fail to produce quality seedlings due to lack of their knowledge about diseases. Seeds after germination are liable to attack by different soil borne organisms. Even after emergence of the seedling, it could be attacked by different diseases which may produce distinct symptoms in the nursery bed or it may carry the organisms when it is transplanted in the orchard or any selected place. In severe cases, diseases cause mortality of many seedlings after plantation. For these reasons, seedlings are to be reared up with proper care in order to avoid the diseases and to ensure quality mango production and increasing yield. Thus production of healthy seedlings ensures good plantation and save money, labour and energy of mango gardener. But little attention has been given yet for the management of seedling diseases and their occurrence in the country. Therefore, it is necessary to survey the nurseries of major mango growing areas of Bangladesh for determining the seedling diseases and management of the diseases in the nurseries through sound and economic way. Keeping the facts in mind the present study was undertaken to know the prevalence of the nursery diseases of mango in selected mango growing locations of Bangladesh and to develop an eco-friendly management with BAU-Biofungicide and fungicides for management of nursery diseases of mango.

2. Methods

2.1 Survey on the Prevalence of Major Nursery Diseases of Mango

Survey was conducted during February 2007 to September 2007 at different nurseries of major mango growing areas of Bangladesh viz. Chapai Nawabganj, Rajshahi, Dinajpur and Mymensingh. In Chapai Nawabganj, four nurseries viz. nursery of Regional Horticulture Research Centre, N. Ahmed Nursery, and nursery of Horticulture Centre and Greenland Nursery were surveyed and in total 18 varieties of mango were evaluated. In Rajshahi, four nurseries viz. nursery of Fruit Research Institute, BADC Nursery, nursery of Horticulture Centre and Sonar Bangla Nursery were surveyed where 20 different varieties of mango were studied. In Dinajpur, five nurseries viz. BRAC Nursery, Hossain Nursery, Nayeem Nursery, Rana Nursery and BADC Nursery were surveyed where 19 mango varieties were evaluated. In Mymensingh, Germplasm Centre of Fruit Tree Improvement Project (FTIP), Department of Horticulture, Bangladesh Agricultural University was surveyed where 13 varieties of mango were studied.

2.2 Data Recorded on the Incidence during Survey

During the survey in the mango nurseries, total number of varieties of mango seedlings found at the nurseries was recorded. Then twenty seedlings were selected randomly from each of the selected beds. Each of the selected seedlings was observed carefully and symptoms of the diseases were recorded following the descriptions of Pathak (1980), Peterson (1986), Singh (1968, 1978, 1996, 1998), and Ploetz et al. (1998). Individual beds of mango varieties were selected randomly for each variety and data on the number of seedlings, number of healthy and diseased seedlings were counted from the selected nursery beds. Incidence of nursery diseases was calculated using the following formula:

$$\%Incidence = \frac{\text{Total number of infected plants}}{\text{Total number of plants}} \times 100 \quad (1)$$

2.3 Management of Nursery Diseases of Mango

The experiment was conducted at Germplasm Centre of Fruit Tree Improvement Project (FTIP), Department of Horticulture, Bangladesh Agricultural University, Mymensingh. The study was carried out from July 2007 to April 2008.The land type of Germplasm Centre of Fruit Tree Improvement Project (FTIP), Department of Horticulture, Bangladesh Agricultural University, Mymensingh is medium high belonging to the Sonatala soil series under the Agro-Ecological Zone (AEZ) - 9, Old Brahmaputra Flood Plain (UNDP and FAO, 1988). The soil of the farm is sandy loam in texture having a pH 5.5 to 6.8. Soil colour is dark grey due to rich in organic matter content.

2.4 Growing of Seedlings in the Nursery Bed

The size of each nursery bed was 12 m × 1.5 m which was divided into equal three parts. Each part of bed was

considered as plot where space between the plots was 1.5 m. The size of each plot was 4.5 m^2. The grafted seedlings of 1-2 years old were used in the present study. Each plot was treated as a replication for a treatment. Four varieties of grafted mango seedlings were used in the study. The varieties of mango were Gopalbhog, Langra, Amropali and Seedless. All the grafted (cleft grafted) seedlings were previously raised by FTIP, Department of Horticulture, BAU, Mymensingh. There were 40 grafted seedlings in each plot. Irrigation was done by basin method at an interval of 30 days in dry season but excess water was drained out from the nursery beds in the rainy season. Irrigation followed by foliar spaying with 2% urea was applied in the beds. Nursery beds were sprayed with insecticide, Decis (0.05%) to control leaf cutting weevil and leaf eating beetle. Weeding was done as and when necessary.

2.5 Treatments and Experimental Design

For the management of nursery diseases of mango, a total of six different treatments were employed on four varieties of mango viz. Amropali, Gopalbhog, Langra and Seedless. All the treatments were applied as foliar spray at 14 days interval with a specific dose as follows: Control (water), BAU-Biofungicide (*Trichoderma harzianum*) at 2.0%, Amistar (Azoxystrobin) at 0.1%, Tilt 250 EC (Propiconazole) at 0.1%, Bavistin (Carbendazim) at 0.1% and Dithane M-45 (Mancozeb) at 0.5%. The experiment was laid out in factorial Randomized Complete Bock Design with three replications.

2.6 Data Collection

The data were recorded on the total number of leaves/plant, number of diseased leaves/plant, percent diseased leaves/plant for different diseases viz. anthracnose, bacterial leaf spot, sooty mould, red rust and powdery mildew, percent leaf area diseased/plant for different diseases viz. anthracnose, bacterial leaf spot, sooty mould, red rust and powdery mildew, die-back infected plant/plot, number of diseased twigs/plant (in case of die-back) and percent area of die-back infected twigs at an interval of 30 days to assess the treatment effects.

2.7 Data Analysis

The recorded data on different parameters were subjected to statistical analysis by using MSTAT-C software to find out the significance of variation resulting from experimental treatments. The difference between the treatment means were judged by Duncan's Multiple Range Test (DMRT) following the procedure as described by Gomez and Gomez (1984).

3. Results

3.1 Prevalence of Some Important Nursery Diseases of Mango in Some Selected Growing Areas

In Chapai Nawabganj four nurseries having 18 varieties of mango were surveyed in order to determine the incidence of different diseases. Altogether nine different diseases viz. anthracnose, die-back, malformation, scab, powdery mildew, sooty mould, red rust, gummosis and bacterial leaf spot were recorded (Figure 1). The symptoms of different diseases as observed in the nurseries were as follows:

Anthracnose: Numerous oval, irregular brown spots of different sizes were found on the leaves. These spots were at the tip or on any other portion of the margin or center of the leaves. The spots elongated to necrotic areas resulting leaf a perforated or tattered appearance. Young leaves were most susceptible and the petioles turned grey to black, the leaves drooped down or became dry. Black and necrotic areas were formed on the affected twigs, which dry out from the tip to downwards. At this stage, the leaves on the twig shed, leaving it bare; the twig subsequently showed blackening, and finally dried up (Figure 1A).

Die-back: Die-back became evident by discoloration and darkening of the bark some distance from the tip. The dark area advanced and young green twigs started withering first at the base and then extending outwards along the veins of the leaf edges. The affected leaf turned brown and its margin rolled upward. Infected twigs showed internal discoloration. Brown streaking of vascular tissues was found on splitting the twigs lengthwise along the long axis (Figure 1B).

Malformation: Vegetative malformation was very common on seedlings of mango. Vegetative buds in axils or on the shoot apex produced misshapen shoots with dramatically shortened internodes and small stubby leaves. Leaves turned curl back toward the supporting stem and were usually brittle. In extreme cases, all apical buds were affected, and the entire plant remained stunted. In some cases, the shoots in the affected buds extended to produce a "witches broom" structure (Figure 1C).

Scab: On leaves, lesions usually found on the lower surface and were circular to somewhat angular and dark brown to black. During rainy weather, lesions were olive tan. As lesions enlarged, they became white to gray with narrow, dark borders. The affected leaves became significantly distorted and prematurely shed (Figure 1D).

Powdery mildew: Whitish or grayish powdery areas on tender foliage, scattered patches of superficial and whitish powdery bloom covered the leaves. Infected young leaves and twigs exhibited distorted growth. Young leaves affected by powdery mildew appeared bluish mauve to brown, particularly where the mycelia collapsed or was rubbed away (Figures 1E and 1F).

Sooty mould/sooty blotch: The disease was recognized in the field by the presence of a black velvety covering on the leaf surface. The entire leaf surface was covered by black mould in patches on the leaf. The mould formed a thin membranous covering over the affected parts. The covering rubbed off easily from the leaf surface (Figure 1G).

Red rust: Red rust was recognized by the presence of rusty- red spots mainly on leaves and sometimes on petioles and young twigs. The spots were greenish-gray in color and velvety in texture, hair on the spot turned reddish-brown and beared hair-like structure which gave the characteristic red-rust appearance. These spots often merged and formed large irregular patches (Figure 1H). Long after the spores were shredded, the algal matrix remained attached to the leaf surface, leaving a creamy white mark at the original rust spot. Rusty spots also occurred on twigs and branches causing the bark to crack.

Gummosis: Narrow cracks formed in the bark that released a pale yellow gum. Profuse production of the gum occurred in the lesion. The gum accumulated around the lesion. The margin of affected tissue was orange and often became bright pink. Wood decay often found when crack developed in the bark. Gumming often occurred on areas of the trunk where nearby attached twigs or limbs died (Figure 1I).

Bacterial leaf spot/blight: Minute water soaked lesions appeared in groups towards the tip of the leaf blade that turned brown to black in color and surrounded by chlorotic halos. They were surrounded by the veins and hence angular in shape. Large necrotic patches were formed by coalescing of several lesions. The patches sometimes dried up, often rough and raised due to heavy bacterial exudates. Petioles and tender stems were also infected and longitudinal cracks developed on the petiole (Figures 1J-1K).

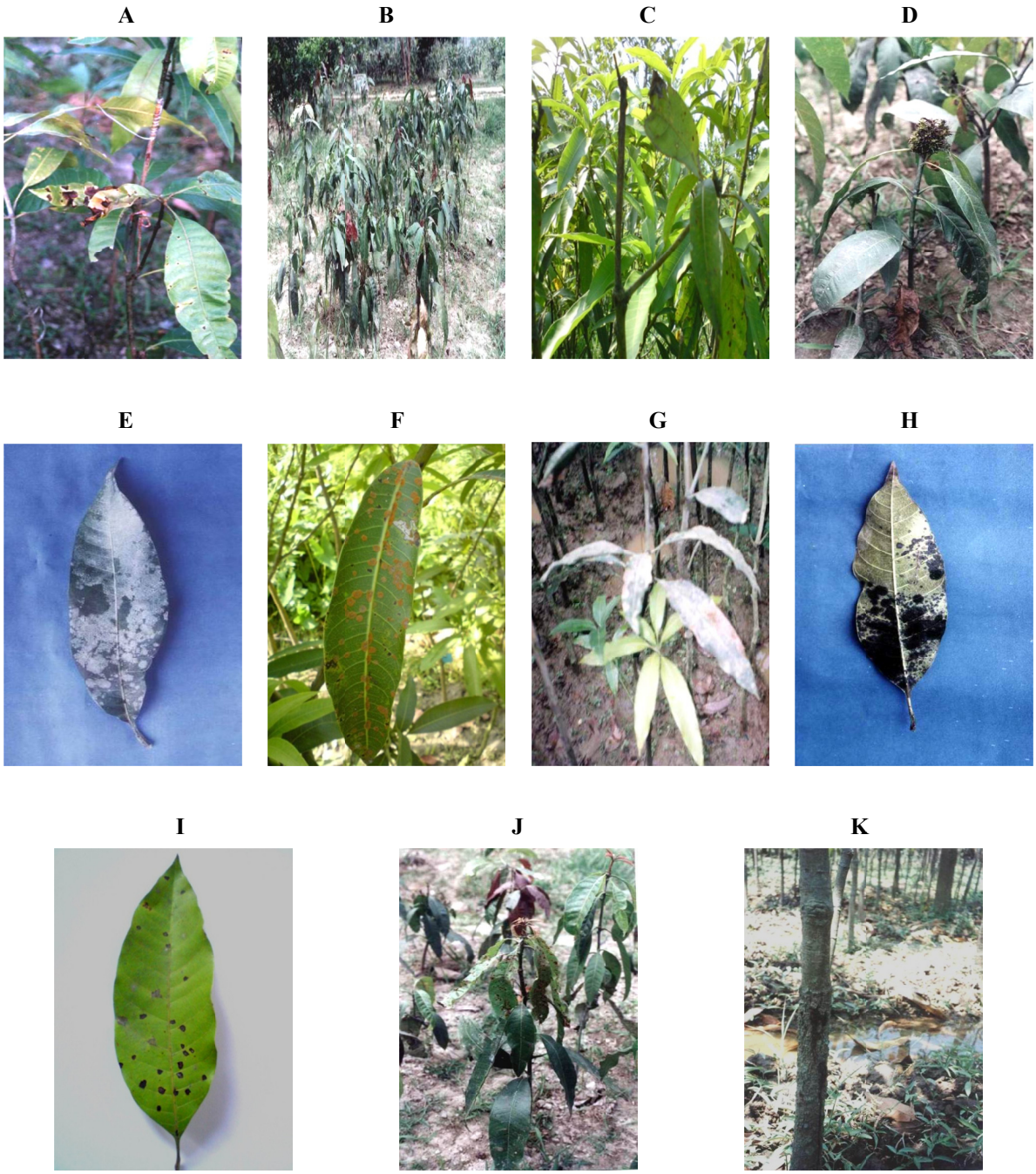

Figure 1. Symptoms of the nursery diseases recorded at four locations surveyed

Note. A. Anthracnose, B. Malformation, C. Die-back, D. Scab, E. Powdery mildew on twigs, F. Powdery mildew on leaf, G. Sooty mold, H. Red rust, I. Gummosis, J. Bacterial leaf spot on the whole plant and K. Bacterial leaf spot on leaf.

3.2 Incidence of Some Important Nursery Diseases of Mango in Some Selected Growing Areas

In Chapai Nawabganj, nine different diseases (anthracnose 20 - 90%, die-back 15%, malformation 5 - 45%, scab 5 - 55%, powdery mildew 5 - 90%, sooty mould 5 - 65%, red rust 5 - 85%, gummosis 5 - 25% and bacterial leaf spot 5 - 80%) were recorded. In Rajshahi altogether 20 different varieties of mango in four different nurseries were surveyed where altogether eight different diseases (anthracnose 20 - 100%, die-back 20%, malformation 10 - 80%, scab 10 - 60%, powdery mildew 20 - 40%, sooty mould 20%, red rust 20 - 100% and bacterial leaf spot 20 - 60%) were recorded. In Dinajpur five nurseries were surveyed and six different diseases (anthracnose 10 - 100%, malformation 10 - 80%, scab 10 - 50%, powdery mildew 20 - 70%, red rust 10 - 100% and bacterial leaf

spot 10 - 100%) in 19 mango varieties were recorded. In Mymensingh eight different diseases (anthracnose 5 - 95%, die-back 16 - 20%, malformation 5 - 55%, scab 5 - 60%, powdery mildew 5 - 80%, sooty mould 5 - 60%, red rust 5 - 70% and bacterial leaf spot 5 - 70%) were recorded in 13 mango varieties in the nurseries of FTIP, BAU, Mymensingh (Table 1 and Figure 1).

Table 1. Disease recorded in different mango varieties at nurseries of four different locations

Disease	Incidence (%)			
	Chapai Nawabganj	Rajshahi	Dinajpur	Mymensingh
Anthracnose	20-90	20-100	10-100	5-95
Die-back	15	20	-	16-20
Malformation	5-45	10-80	10-80	5-55
Scab	5-55	10-60	10-50	5-60
Red rust	5-85	20-100	10-100	5-70
Bacterial leaf spot	5-80	20-60	10-100	5-70
Powdery mildew	5-90	20-40	20-70	5-80
Gummosis	5-25	-	-	-
Sooty mold	5-65	20	-	5-60

Note. The value indicate the range for the incidence of each disease in each location recorded in different mango varieties.

3.3 Management of Nursery Diseases of Mango

3.3.1 Comparative Efficacies of BAU-Biofungicide and Fungicides on the per Cent Diseased Leaf per Plant

Comparative efficacies of BAU-Biofungicide with four different fungicides viz. Amistar, Tilt 250 EC, Bavistin and Dithane M-45 were evaluated on percent diseased leaf per plant of four mango varieties viz. Gopalbhog, Langra, Amropali and Seedless. It has been found that the diseased leaf (%) per plant under different treatments of different varieties of mango varied profoundly from one to another (Table 2). In case of 1st counting (initiation of spray schedule) the highest diseased leaf (%) per plant (69.35%) was recorded in Seedless under Dithane M-45 followed by 68.70% in Seedless variety under BAU-Biofungicide and lowest (29.27%) in Langra under Amistar. In case of 2nd counting highest (86.45%) and lowest (33.21%) diseased leaf (%) per plant were recorded in Seedless variety under Bavistin and in Langra under Amistar spray schedule, respectively.

But the highest diseased leaf (%) per plant in 3rd, 4th, 5th and 6th countings were observed in Seedless under control treatment, while the lowest counts 32.62%, 38.15%, 26.00% and 26.85%, respectively were made in Langra under Amistar, BAU-Biofungicide, Amistar and also in Amistar spray, respectively. The spraying of BAU-Biofungicide and fungicides decreased the diseased leaf/plant by upto 52.99% by Dithane M-45 followed by Amistar (45.71%) in Amropali, where BAU-Biofungicide resulted reduction of diseased leaf/plant by 40% in Gopalbhog (Table 2).

Table 2. Comparative efficacies of BAU-Biofungicide and fungicides on per cent diseased leaf/plant

Treatment	Variety	Diseased leaf (%) per plant at different counts						% increase (+) or decrease (-) over 1st count
		1	2	3	4	5	6	
Control	Gopalbhog	50.07	62.14	76.88	82.24	83.13	69.21	+38.22
	Langra	33.80	37.34	36.50	47.78	49.95	54.99	+62.69
	Amropali	57.72	73.43	80.26	82.49	80.34	68.26	+18.26
	Seedless	66.16	85.15	83.49	86.65	87.69	94.40	+42.68
BAU-Biofungicide	Gopalbhog	46.95	47.82	56.73	56.49	43.00	28.17	-40.00
	Langra	44.43	34.90	35.95	38.15	37.24	28.88	-34.99
	Amropali	39.70	39.58	51.74	42.01	45.53	35.18	-11.38
	Seedless	68.70	77.23	79.42	77.86	73.40	49.31	-28.22
Amistar	Gopalbhog	59.43	62.06	72.41	72.77	59.84	36.37	-38.80
	Langra	29.27	33.21	32.62	44.86	26.00	26.85	-8.26
	Amropali	62.50	63.24	63.04	60.97	52.39	33.93	-45.71
	Seedless	58.71	78.90	76.86	77.83	63.03	37.69	-35.80
Tilt 250 EC	Gopalbhog	57.45	45.14	61.17	59.99	41.44	37.08	-35.45
	Langra	38.45	35.11	40.46	42.45	32.90	30.71	-20.13
	Amropali	63.30	65.86	56.57	54.06	50.85	46.08	-27.20
	Seedless	60.14	75.77	74.47	73.64	68.12	48.37	-19.68
Bavistin	Gopalbhog	44.78	41.23	58.61	59.21	53.61	39.81	-11.09
	Langra	55.43	57.30	62.83	67.72	62.99	51.16	-7.70
	Amropali	57.49	57.57	62.89	53.34	59.44	42.69	-25.74
	Seedless	68.54	86.45	76.26	84.16	77.51	62.56	-8.72
Dithane M-45	Gopalbhog	53.70	51.09	50.01	48.70	41.87	36.48	-32.06
	Langra	43.90	41.29	41.49	43.47	37.63	31.80	-27.56
	Amropali	64.17	69.58	61.83	59.23	41.90	30.16	-52.99
	Seedless	69.35	76.46	73.88	72.32	62.12	41.33	-40.40
Lsd (≥ 0.01)		8.926	2.288	6.309	8.683	7.90	4.476	-

Note. Data represents the mean of three replications.

3.3.2 Comparative Efficacies of BAU-Biofungicide and Fungicides on Anthracnose

Efficacies of BAU-Biofungicide and four different fungicides on incidence of anthracnose of four varieties of mango (Gopalbhog, Langra, Amropali and Seedless) are presented in Table 3. There was a wide variation in incidence of anthracnose under different treatments. The lowest incidence was recorded in Seedless variety with BAU-Biofungicide treatment followed by Seedless variety with Tilt, Bavistin and Dithane M-45 spray. IHowever, the highest incidence was recorded in Gopalbhog variety with Bavistin, Dithane M-45, Amistar, BAU-Biofungicide and Tilt spary. Regarding severity of anthracnose in four varieties of mango a wide variation was observed under different treatments as well as in different observations (Table 4). The minimum severity was recorded in Seedless variety when Tilt, BAU-Biofungicide, Amistar, Bavistin and Dithane M-45 spray were maintained. However, the maximum severity was recorded in Amropali variety when Dithane M-45 spray schedule was maintained followed by Gopalbhog with Amistar spray and Amropali with Biofungicide treatment.

3.3.3 Comparative Efficacies of BAU-Biofungicide and Fungicides on Bacterial Leaf Spot

The incidence of bacterial leaf spot on four varieties of mango (Gopalbhog, Langra, Amropali and Seedless) was recorded and results are presented in Table 3. The lowest incidence of bacterial leaf spot was recorded in Gopbhog where BAU-Biofungicide spray schedule was maintained followed by Gopalbhog with Amistar treatment and Dithane M-45. However, the incidence of bacterial leaf spot was recorded highest in Seedless nder BAU-Biofungicide treatment. The bacterial leaf spot severity of four different varieties of mango under different treatments was found to vary widely (Table 4). The lowest acterial leaf spot severity was recorded in Gopalbhog under BAU-Biofungicide treatment followed by Gopalbhog with Amistar, Dithane M-45 and Bavistis treatment.

The maximum bacterial leaf spot severity was recorded in Seedless variety with amistar treatment followed by Seedless variety with Dithane M-45, Amropoali with BAU-Biofungicide and Tilt except control.

3.3.4 Comparative Efficacies of BAU-Biofungicide and Fungicides on Sooty Mould

Sooty mould disease has not been recorded in Amropali throughout the study period (Tables 3 and 4), where maximum sooty mould incidence was recorded in Seedless under control treatment. BAU-Biofungicide and the chemical fungicides were found effective in controlling sooty mould in Seedless and Amropali. The maximum severity of sooty mould was in Gopalbhog under Dithane M-45 treatment followed by Langra in Tilt 250 EC among the treatements except control.

3.3.5 Comparative Efficacies of BAU-Biofungicide and Fungicides on Red Rust

Out of the treatments used for controlling red rust of four different varieties of mango, Dithane M-45 was recorded as superior one that resulted significant reduction of red rust of mango followed by BAU-Biofungicide, Amistar and Tilt as compared to the control treatment and Bavistin performed worst among the treatments in reducing red rust incidence except control (Tables 3). Similar observations were made in reducing the red rust severity of mango by Dithane M-45 followed Amistar, BAU-Biofungicide, Tilt and Bavistin as compared to the control treatment (Tables 4). However, the interactions effect of both treatments and varities were observed best in case of Seedless variety with Dithane M-45 treatment. Considering the interactions of the treatments with other varieties, Gopalbhog with BAU-Biofungicide treatment showed second best results in reducing the severity of the red rust.

Table 3. Comparative efficacies of BAU-Biofungicide and fungicides in reducing the incidence of anthranose, bacterial leaf spot, sooty mold and red rust of mango

Treatment	Variety	% Incidence			
		Anthracnose	Bacterial leaf spot	Sooty mold	Red rust
Control	Gopalbhog	62.99	3.61	9.61	3.92
	Langra	24.32	22.85	5.97	2.31
	Amropali	44.64	18.88	0.00	15.80
	Seedless	15.27	70.13	11.11	7.67
BAU-Biofungicide	Gopalbhog	29.77	0.64	0.37	0.40
	Langra	9.48	21.35	1.24	0.33
	Amropali	16.23	11.27	0.00	10.41
	Seedless	2.46	45.67	2.94	6.77
Amistar	Gopalbhog	30.71	1.90	0.90	0.64
	Langra	14.75	8.01	2.35	3.56
	Amropali	19.61	7.60	0.00	4.92
	Seedless	11.97	31.52	1.12	0.91
Tilt 250 EC	Gopalbhog	28.88	4.76	1.74	2.09
	Langra	16.50	10.22	3.34	1.65
	Amropali	22.93	15.19	0.00	14.97
	Seedless	3.20	42.80	0.00	10.00
Bavistin	Gopalbhog	32.61	6.26	1.80	2.77
	Langra	14.05	25.85	1.02	15.42
	Amropali	25.00	8.83	0.00	10.59
	Seedless	7.46	53.15	0.00	15.35
Dithane M-45	Gopalbhog	31.42	2.55	2.24	0.00
	Langra	15.57	15.44	1.78	0.00
	Amropali	27.03	3.89	0.00	0.88
	Seedless	8.04	34.03	0.00	0.00
Lsd ($\geq$ 0.01)		4.486	3.930	2.234	4.612

Note. Data represents the mean of three replications.

Table 4. Comparative efficacies of BAU-Biofungicide and fungicides in reducing the severity of anthracnose, bacterial leaf spot, sooty mold and red rust (%) of mango

Treatment	Variety	Severity (%)			
		Anthracnose	Bacterial leaf spot	Sooty mold	Red rust
Control	Gopalbhog	21.82	4.03	6.00	2.13
	Langra	8.61	10.89	3.38	1.10
	Amropali	20.89	15.61	0.00	8.75
	Seedless	3.17	18.92	4.33	2.72
BAU-Biofungicide	Gopalbhog	5.56	0.14	0.33	0.11
	Langra	3.57	5.77	0.55	0.22
	Amropali	9.61	8.23	0.00	6.45
	Seedless	1.88	6.96	0.94	1.65
Amistar	Gopalbhog	10.97	0.42	0.51	0.20
	Langra	3.92	1.98	0.94	0.77
	Amropali	6.99	3.71	0.00	1.02
	Seedless	2.90	13.90	0.38	0.04
Tilt 250 EC	Gopalbhog	9.22	1.74	0.94	1.27
	Langra	4.38	1.94	1.43	0.20
	Amropali	7.50	8.08	0.00	3.04
	Seedless	1.66	4.38	0.00	0.50
Bavistin	Gopalbhog	8.16	1.74	0.77	0.48
	Langra	5.86	4.85	0.27	3.23
	Amropali	9.43	3.20	0.00	2.75
	Seedless	3.63	5.95	0.00	1.34
Dithane M-45	Gopalbhog	7.96	0.73	1.55	0.50
	Langra	3.36	3.75	0.38	0.50
	Amropali	11.16	3.42	0.00	0.15
	Seedless	5.99	9.11	0.00	0.00
Lsd (≥ 0.01)		2.312	1.365	0.7849	1.60

Note. Data represents the mean of three replications.

3.3.6 Comparative Efficacies of BAU-Biofungicide and Fungicides on Die-Back in Amropali

Die-back disease was only recorded in Amropali in management programme (Table 5). The die-back infected plant under different treatments has been found to vary widely, where the highest (70%) and lowest (16.66%) counts were made in control and Bavistin, respectively. It has been recorded that Bavistin resulted maximum 76.20% reduction of die-back infection over control. Highest number of diseased twigs/plant was observed in control (1.5) and lowest count was made in Bavistin sprayed plants (0.66) which resulted (56.00%) reduction of number of diseased twigs/plant over control. Regarding per cent area of the twig infected by die-back it was found that highest and lowest dead area of the twig due to die-back disease was in control (56.50%) and in Dithane M-45 (30.00%) sprayed plant, respectively. Dithane M-45 spray schedule resulted (46.90%) reduction of per cent area of twig infection.

Table 5. Comparative efficacies of BAU-Biofungicide and fungicides on die-back in Amropali

Treatment	% plant infected	No. of diseased twigs/plant	% area of the twig infected
Control	70	1.5	56.5
BAU-Biofungicide	43.33 (38.10)	1.33 (11.33)	48.33 (14.46)
Amistar	44.16 (36.91)	1.29 (14.00)	35.83 (36.58)
Tilt 250 EC	50.00 (28.57)	1.33 (11.33)	47.00 (16.81)
Bavistin	16.66 (76.20)	0.66 (56.00)	34.16 (39.53)
Dithane M-45	38.33 (45.24)	1.33 (11.33)	30.00 (46.90)

Note. Data in parenthesis indicate decrease (%) over control.

3.3.7 Comparative Efficacies of BAU-Biofungicide and Fungicides on Powdery Mildew

The findings of the management practices showed that BAU-Biofungicide and fungicides viz. Amistar, Tilt 250 EC, Bavistin and Dithane M-45 resulted profound effect in controlling powdery mildew of mango under nursery management programme (Table 6). Dithane M-45 resulted maximum reduction of powdery mildew incidence (79.05%) followed by BAU-Biofungicide (77.07%) over the untreated control (Table 6). Minimum incidence of powdery mildew (0.53%) was recorded by applying Dithane M-45 followed by BAU-Biofungicide (0.58%). On the other hand, minimum severity of powdery mildew (0.34%) was obtained in plants that received spraying of Bavistin in the nursery which was followed by Dithane M-45 (0.41%). The Bavistin sprayed plant resulted 77.48% reduction of severity of powdery mildew followed by Dithane M-45 (72.84%) and BAU-Biofungicide (59.60%) in the management study.

Table 6. Effect of BAU-Biofungicide and fungicides on mean severity of powdery mildew (%)

Treatment	Incidence		Severity	
	Mean incidence (%)	% reduction over control	Mean severity	% reduction over control
Control	2.53	-	1.51	-
BAU-Biofungicide	0.58	77.07	0.61	59.60
Amistar	0.88	65.22	0.63	58.27
Tilt 250 EC	1.94	23.32	0.80	47.02
Bavistin	0.65	74.31	0.34	77.48
Dithane M-45	0.53	79.05	0.41	72.84

Note. Data represents the mean of four varieties of mango.

4. Discussion

4.1 Prevalence of Some Important Nursery Diseases of Mango in Bangladesh

Altogether nine different diseases viz. anthracnose, die-back, malformation, scab, powdery mildew, sooty mould, red rust, gummosis and bacterial leaf spot were recorded in four selected areas of Bangladesh. All the recorded nine diseases were found in Chapai Nawabganj. In Rajshahi all the diseases except gummosis was recorded. Out of the identified diseases, die-back and gummosis were not found in Dinajpur, while only gummosis was not found in Mymensingh. The incidence and severity of all the recorded diseases were found to vary from variety to variety, nursery to nursery as well as location to location. Similar variation of incidence and severity of the diseases has also been reported by Mortuza (1990) and Reza and Kader (1996b). As per survey of Bangladesh Agricultural Research Institute, anthracnose, sooty mould and powdery mildew were predominant diseases in Chapai Nawabganj and Rajshahi (Anonymous, 1990). But the present study revealed that anthracnose, red rust, malformation, bacterial leaf spot and powdery mildew were common in all the surveyed locations. Moderate incidence (5-65%) of sooty mould and scab (5-60%) were recorded in the surveyed locations. Anthracnose of mango has also been reported by Fitzell and Peak (1984), Peterson (1986), Mortuza (1990), Reza and Kader (1996a, 1996b), Conde et al. (1997) and Awasthi et al. (2005). The disease, scab has been recorded in mango by

Bitancourt and Jenkins (1943), Singh (1968) and Conde et al. (1997). Red rust of mango was also recorded as a common disease in the nurseries of mango. The findings of this study are strongly supported by Singh (1968), Pathak (1980) and Mortuza (1990). Mortuza (1990) reported red rust as a new disease of mango in Chapai Nawabganj and Rajshahi districts. The findings of powdery mildew of mango of the present study is in accordance with the findings of Singh (1968), Pathak (1988), Akhtar et al. (1999) and Tiwari et al. (2006). Malformation of mango has been recorded in all the surveyed locations. This disease has also been reported by others (Campbell & Marlatt, 1986; Peterson, 1986; Mortuza, 1990; Reza, 1995; Akhtar et al., 1999; Sarkar et al., 2004; Awasthi et al., 2005). Sooty mould in mango nurseries has also been recorded by Singh (1968), Pathak (1980), Anonymous (1990), Mortuza (1990), Reza and Kader (1996a). The occurrence of bacterial leaf spot of mango has been reported by Singh (1978) and Pathak (1980). The die-back disease of mango has also been observed by Pathak (1980), Burhan (1987) and Mortuza (1990). Gummosis has only been recorded in Dinajpur. This disease was also reported by Begum et al. (2003) and Khanzada et al. (2004). Regarding locations of survey, higher number of diseases were found in Chapai Nawabganj and Mymensingh and relatively lower number of diseases were observed in Dinajpur and Rajshahi. Out of the mango varieties surveyed, occurrence of higher number of diseases were recorded in Amropali (9), Mollica (7), Langra (8), Aswina (8), Khirsapat (8), Fazli (8), Vustara (6), Bogra gooti (6), BARI Aam-2 (6), BARI Aam-4 (6), Mohananda (5), Polyembryony (7), Gopalbhog (7), Hybrid 10 (6), Nilambari (6), Mixed special (6) and Seedless (7). It is interesting to point out that only single disease, anthracnose was recorded in Kajla sinduri in Rajshahi and Kancha mithi in Dinajpur.

4.2 Management of Some Important Nursery Diseases of Mango in Bangladesh

BAU-Biofungicide and four different fungicides viz. Amistar, Tilt 250 EC, Bavistin and Dithane M-45 were applied in the nursery of four varieties of mango viz. Gopalbhog, Langra, Amropali and Seedless for controlling the nursery diseases. It has been observed that the per cent diseased leaf per plant has been increased under control treatment over the initial counting (1st count) by upto 62.69%, while the treated plants were found to have reduced number of diseased leaf/plant. BAU-Biofungicide, Amistar, Tilt 250 EC, Bavistin and Dithane M-45 resulted reduction of diseased leaf (%) per plant over the 1st counting (initial count) by upto 40.00%, 45.71%, 35.45%, 25.74% and 52.99%, respectively. Incidence of anthracnose has been found to increase upto 93.78% over the initial counting (1st count) under control treatment. It has been observed that maximum reduction of anthracnose incidence by upto 57.02% was obtained by spraying Dithane M-45 in Seedless mango variety which was followed by BAU-Biofungicide that resulted upto 51.95% reduction of incidence of anthracnose in Seedless. On the other hand, the severity of anthracnose was found to increase over the 1st counting by upto 120.76% in Langra under control treatment, while maximum reduction has been achieved by applying BAU-Biofungicide in Gopalbhog (75.34%) which was followed by Dithane M-45 by 64.07% in the same mango variety. The findings are also supported by the research work done by BARI (Anonymous, 1988 and 1989). They reported that Dithane M-45 was superior among the fungicides used for controlling anthracnose of mango. Hossain (2007) opinioned that Bavistin and Tilt 250 EC were superior over others which is not in accordance with the findings of the present study. BAU-Biofungicide, as a bio-control means having *Trichodema harzianum* as active organism showed also excellent result in controlling anthracnose of mango. This is new means of biological control. This is the first time it has been employed in controlling anthracnose of mango in the nursery in Bangladesh. According to Prabakar et al. (2008) *Trichodema harzianum* exhibited maximum effects in arresting the anthracnose disease causal pathogen *Colletotrichum gloeosporioides*.

Bacterial leaf spot in the nurseries of mango in four selected locations was common. The disease incidence at first counting in different varieties of mango ranged from 1.00 to 66.18%, where lowest was in Gopalbhog and highest in Seedless. Bacterial leaf spot was found to increase with the time and 8.94 to 261.00% higher disease was recorded at final counting over the first counting. BAU-Biofungicide, Amistar, Tilt 250 EC, Bavistin and Dithane M-45 showed good effect in reducing the bacterial leaf spot incidence. Out of the treatments, Dithane M-45 was found best in Amropali followed by Amistar in Gopalbhog. Regarding the severity, bacterial leaf spot at first counting ranged from 0.22 to 18.64%, where lowest and highest counts were made in Gopalbhog and Seedless. The severity of bacterial leaf spot has been found to increase by upto 47.62% in control, where all other treatments (BAU-Biofungicide and fungicides) reduced the severity by upto 81.64% which was obtained by applying Bavistin in Gopalbhog followed by 81.08% also in Gopalbhog by Amistar. Visser (2004) used different chemicals for controlling bacterial leaf spot. Out of the fungicides used, copper sulphate was best, but mancozeb was also effective. The findings of the present study has clearly been pointed out that BAU-Biofungicide, Amistar, Tilt 250 EC, Bavistin and Dithane M-45 reduced the disease severity by upto 52.16%, 81.08%, 72.63%, 81.64% and 51.48%, respectively. Therefore, these means may be put forwarded for gardener to control the bacterial leaf spot of mango in the nurseries.

In the management programme it has been found that variety Amropali was free from sooty mould. The incidence and severity of sooty mould in three mango varieties (Gopalbhog, Langra and Seedless) ranged from 1.63% to 12.12% and 0.18% to 6.38%, respectively during the initial counting. All the treatments were found effective against sooty mould incidence, where maximum 100% reduction in sooty mould incidence was achieved by the application of Tilt 250 EC, Bavistin and Dithane M-45 in the variety Seedless which was followed by BAU-Biofungicide that resulted upto 94.04% reduction of sooty mould incidence in Gopalbhog over first counting. In case of sooty mould severity, maximum 81.93% increase was found in Seedless under control, while maximum reduction in severity upto 100% was obtained in Seedless under the treatments Tilt 250 EC, Bavistin and Dithane M-45. The findings are partially supported by the findings of Bangladesh Agricultural Research Institute (Anonymous, 1988). He evaluated eight fungicides in controlling sooty mould. Among the fungicides tested he found Dithane M-45 most effective for controlling sooty mould. It has been recorded that the incidence and severity of red rust of mango ranged from 0.50 to 8.50% and 0.05 to 1.55%, respectively in case of 1st counting. Out of the control measures employed, Dithane M-45 was found best for controlling the red rust of mango in the nursery. Pawar et al. (2004) applied mancozeb, copper oxychloride, copper hydroxide and carbendazim for controlling red rust of mango, where they recorded carbendazim as most effective. But the findings of the present study are not in support of that. Bavistin has been found to fail in controlling red rust. The present study has clearly been depicted that Dithane M-45 is excellent for controlling red rust of mango.

It has been found that the incidence of powdery mildew was maximum 2.53% in control treatment, while lowest (0.53%) in Dithane M-45. Application of Dithane M-45 resulted maximum 79.05% reduction of powdery mildew incidence compared to control followed by BAU-Biofungicide spray that resulted 77.07% reduction over control. In case of severity of powdery mildew, maximum 1.51% severity was recorded in control and minimum 0.34% was in Bavistin followed by Dithane M-45 (0.41%). Maximum of 77.48% reduction in severity of powdery mildew was recorded in Bavistin followed by Dithane M-45 (72.84%). Under the present study Dithane M-45 followed by BAU-Biofungicide was found best in reducing the powdery mildew incidence. Bavistin followed by Dithane M-45 and BAU-Biofungicide was found most effective in reducing severity of powdery mildew. Tilt 250 EC was found inferior for controlling powdery mildew of mango in the nursery. This finding does not agree with the findings of McKenzie (1988) and Reza and Mortuza (1997). They reported Tilt 250 EC as good fungicide for controlling powdery mildew of mango. During the management study, die-back of mango in the nursery has only been recorded in Amropali. The disease incidence has been found to decrease by BAU-Biofungicide, Amistar, Tilt 250 EC, Bavistin and Dithane M-45 by 38.10%, 36.91%, 28.57%, 76.20% and 45.24%, respectively. Accordingly number of diseased twigs/plant was found minimum by applying Bavistin. The findings of the present study is an accordance with the findings of Ahmed et al. (1995). They observed Benomyl was most effective and Tilt 250 EC as least effective in controlling die-back severity of mango.

5. Conclusion

It can be summarized that nine different diseases viz. anthracnose, die-back, malformation, scab, powdery mildew, sooty mould, red rust, gummosis and bacterial leaf spot were recorded in different varieties of mango during the period of survey. It is noteworthy to mention that higher number of diseases were recorded in Amropali, Mollica, Langra, Aswina, Khirsapat, Fazli, Vustara, Bogra gooti, BARI Aam-2, BARI Aam-4, Mohananda, Polyembryony, Gopalbhog, Hybrid 10, Nilambari, Mixed special and Seedless. From the findings, it may be concluded that BAU-Biofungicide may be advised for management of nursery diseases of mango as an alternative of chemical fungicides.

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