Reprint ISSN 1923-7766 (Web Version)

International Journal of Experimental Agriculture

(Int. J. Expt. Agric.)

Volume: 9 Issue: 2 September 2019

Int. J. Expt. Agric. 9(2): 13-19 (September 2019)

EFFICACY OF SOME CHEMICALS TO CONTROL THE MAJOR DISEASES OF BANANA AT THAKURGAON AND DINAJPUR DISTRICTS

R. PARVIN, R. FANCY, M.E.K. CHOWDHURY, S.M.E. HASSAN AND M.M. HASAN

An International Scientific Research Publisher

Green Global Foundation©

Web address: http://ggfjournals.com/e-journals archive
E-mails: editor@ggfjournals.com and editor.int.correspondence@ggfjournals.com

ISSN-1923-7766 (Online)
Int. J. Expt. Agric. 9(2):13-19(September 2019)

EFFICACY OF SOME CHEMICALS TO CONTROL THE MAJOR DISEASES OF BANANA AT THAKURGAON AND DINAJPUR DISTRICTS

R. PARVIN[1], R. FANCY[2], M.E.K. CHOWDHURY[3], S.M.E. HASSAN[4*] AND M.M. HASAN[4*]

[1]MS Student, [2]Associate Professor, [4]Professor, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh; [3]Senior Scientific Officer, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.

[*]Co-corresponding authors & address: SM Emdadul Hassan; E-mail: emdadul.hassan@yahoo.com; Md. Mohidul Hasan; E-mail: mhasan@hstu.ac.bd
Accepted for publication on 29 August 2019

ABSTRACT

Parvin R, Fancy R, Chowdhury MEK, Hassan SME, Hasan MM (2019) Efficacy of some chemicals to control the major diseases of banana at Thakurgaon and Dinajpur districts. *Int. J. Expt. Agric.* 9(2), 13-19.

The study was aimed to find out the effective chemicals to control the most devastating diseases of banana including sigatoka, panama and bunchy top in some selected orchard of Thakurgaon and Dinajpur districts. Altogether six banana orchards including three from each district were selected and the experiment was laid out following randomized block design with three replications. Two fungicides Carbendazim and copper oxychloride along with an insecticide imidacloprid were sprayed to evaluate their effect to control the diseases. Among the chemicals, carbendazim was found to show the minimum sigatoka severity (1.00%) after 150 days of plantation at Thakurgaon region where, copper oxychloride gave minimum sigatoka severity (1.00%) followed by carbendazim (10.00%) at Dinajpur region after 150 days of plantation. In both the region, highest sigatoka severity was observed without spraying any chemicals (40.00 and 61.00%). Minimum panama disease severity (5.00% and 1.00%) was recorded with the spraying of copper oxychloride both at Thakurgaon and Dinajpur, respectively. Carbendazim also showed the reduced panama severity (6.00 and 10.00%) after copper oxychloride in Thakurgaon and Dinajpur, respectively where, control gave the higher disease severity in both the regions. Imidacloprid increased the leaf area (4.0%), leaf number (2-folds) and plant height (2 leaves) where, carbendazim increased the leaf number (2-folds) and plant height (1 cm) and copper oxychloride increased the leaf area (4.0%) and plant height (2 cm). Plant without treated with any chemicals also found to increase the leaf number (2-folds) where it did not increase leaf area or plant height. All the chemicals used in this study show their effectiveness to control the major diseases of banana, however; copper oxychloride could be the suggested to treat several banana diseases.

***Key words**: banana, major diseases, effective control, chemicals, sigatoka*

INTRODUCTION

Banana (*Musa* spp.) belonging to the family musaceae is one of the most popular nutritious fruits in Bangladesh (Khader *et al.* 1996). It ranks first in terms of area coverage (46,734 ha) and production (7,77,427 mt) (BBS 2017) in Bangladesh. The fruit is available round the year with a great demand to the peoples for its cheap, easily digestible and palatable in nature. One hundred gram of edible portion of banana contains 70% water, 27% carbohydrate, 0.5% fiber, 1.2% protein, 0.3% fat, 0.9% ash, 290 ppm phosphorus, 80 ppm calcium, 6 ppm iron, 0.5 ppm β carotene, 0.5 ppm riboflavin, 7.0 ppm niacin and 120 ppm ascorbic acid (Haque 2001).

There are many causes for low yield of banana where, diseases are considered as one of the major factors. Black Leaf Streak (BLS), commonly referred to as black sigatoka caused by *Mycosphaerella fijiensis* plays a major role in the yield loss of banana (Carlier *et al.* 2000). Sigatoka reduces photosynthetic assimilation (50-100%) and thus cause yield losses of 50% or more and premature ripening (Ploetz 2001). Control of sigatoka disease mainly has been achieved through the application of chemicals (Romero and Sutton, 1997 and Marin *et al.* 2003). Different group of fungicides such as dithiocarbamates, benzimidazoles, azoles, and more recently strobilurins are being used to control the sigatoka disease in banana plantations (Romero and Sutton, 1997; and Marin *et al.* 2003). Banana wilt caused by *Fusarium* is another destructive disease of banana (Ploetz *et al.* 2003). Fusarium wilt caused by the root, corm, and pseudo-stem infecting fungus *Fusarium oxysporum* f. sp. *cubense*. Fusarium wilt of banana (often called panama) is a fungal disease causing severe banana crop losses worldwide (Pegg *et al.* 1996; Ploetz 2006). However, among the fungal diseases of banana, panama and sigatoka are the most destructive diseases responsible for significant yield losses. Banana Bunchy Top disease caused by Banana Bunchy Top Virus (BBTV) is the most destructive virus disease of banana in Bangladesh. Because of the disease, banana plant become dwarf and suffer from malformation that leads to premature death of infected plant causing yield losses of about 100%.

The control of such kind of devastating diseases of banana is very important. Several control measures are practiced to control the diseases, however; the most effective and popular practices include the chemical control because of its retention ability, availability and broad spectrum effect against different pathogens. Chemical methods act rapidly, and are able to eliminate pests completely by killing them. Moreover, chemical controls are also dominant over other practices in terms of reduction of yield loss.

Thakurgaon and Dinajpur are the major banana growing areas in the northern region of Bangladesh. For these reasons, proper care should be taken in the orchard to avoid the diseases and to ensure quality banana production and increasing the yield. So far, very little study has been conducted in the mentioned area to reduce the yield loss of banana by means of chemicals. Hence, the study was aimed to assess the effect of some chemicals including fungicides and insecticide for easy control of major diseases of banana.

MATERIALS AND METHODS

Experimental site

The experiment was conducted from July 2016 to June 2017 in six banana orchards of Thakurgaon and Dinajpur, districts of Bangladesh. In Dinajpur district, 3 orchards were located between 25 N latitude and 88.23 E longitude and about 37.5 m above sea level. Three orchards in Thakurgaon district were located between 26 N latitude and 88.46 E longitude and about 37.5 m above the sea level. The orchard was selected far from the road side to minimize the side effects. All the orchards were well protected by the brick boundary or wicker fence. The minimum distance of the boundary was kept about 5 M to minimize the boundary effects. The orchards were well ventilated with irrigation and drainage facilities. Disease of banana on inflorescence and fruits were not considered for the study.

Selection of orchard

Three different Banana orchards from each of Thakurgaon and Dinajpur districts were selected with the help of Upazila Sub-Assistant Agriculture Officer (Table 1).

Table 1. Location of Banana orchard in Thakurgaon and Dinajpur districts

Districts	Locations	Total plants	Age of the Plant (months)	Selected plants (no.)
Thakurgaon	Nischintopur	500	5	12
	Thakurgaon Road	500	5	12
	Nischintopur	400	4	12
Dinajpur	Basherhat-1	800	5	12
	Basherhat-2	600	5	12
	Basherhat-3	550	4	12

Experimental design

The experiment was carried out in Randomized Completely Block Design (RCBD) with two factor factorial experiment having three replications where location is one factor and treatments is another factor.

Treatments

There were four treatments. Foliar spray was conducted at 30 days interval. The treatments were as follows: T_0 = Control; T_1 = Spraying of Knowin 50 WP (Carbendazim) @ 2 g/L; T_2 = Spraying of Oxyvit 50 WP (Copper oxychloride) @ 3g/L; T_3 = Spraying of Tido plus (Imidacloprid) @ 2 ml/ L.

Application of spray solution

Required amount of spray solution were sprayed five times on the selected plants at 30 days interval where, the first spray was done at 1st January, 2017. Adequate precautions were taken to avoid drifting spray materials from one plant to another. Special attention was taken to complete the coverage of the plants with the spray solution. Only fresh water was sprayed as control with the same time of spraying of chemicals.

Assessment of disease severity

Disease severity was defined as the percentage of leaf area diseased. Disease severity was assessed and expressed as the mean disease severity per plant. Disease severity was calculated using the following formula (Johnston 2000).

$$Disease\ severity\ (\%) = \frac{Area\ of\ leaf\ tissue\ infected\ by\ diseases}{Total\ area\ per\ leaf} \times 100$$

Data collection

Each plant was observed carefully to collect the data on disease severity. Data on disease severity was recorded five times at one-month interval where, first time data was recorded at 30th January, 2017. The data were recorded five times on the following parameters: severity of sigatoka disease; severity of panama disease; bunchy top disease (leaf area, plant height and emerging of new leaves). Plant height, leaf area and leaf emergence were recorded on every time of data collection. Leaf area was estimated by measuring the leaf length and maximum width and multiplying the results by a conversion factor of 0.83 (length × width × 0.83) as described by Robinson and Neil, (1985). The leaf numbers were counted and leaf production rates were determined as measured by Turner (1971). As such, a leaf was regarded as emerged if the ventral surface of the midrib was fully exposed and at least half of the leaf was unfurled. Plant height was measured as the distance from the ground to the fork created by the petioles of the uppermost fully emerged leaf (Smith *et al.* 2000).

Statistical analysis

Data on various parameters were subjected to analysis of variance following MSTAT-C computer program and the means were compared by Duncan's New Multiple Range Test (DMRT).

RESULTS

Three different diseases *viz.* Sigatoka, panama and bunchy top were observed and data were recorded on the effect of different fungicides.

Severity of sigatoka and panama diseases at Thakurgaon

Severity of sigatoka and panama disease of three banana orchards at Thakurgaon region were recorded after different days of pesticide application (Table 2). The severity of sigatoka was found to vary significantly according to the location and the treatment applied. All the treatments applied to control the sigatoka disease showed significant effect on the severity of sigatoka disease of banana. The highest (40.00%) disease severity of sigatoka was observed in orchard located at Nischintopur in the banana plant without applying any chemical where, lowest (1.00%) sigatoka disease was recorded in the same orchard with the spraying of Carbendazim after 150 days of first spray. Interestingly, the insecticide Imidacloprid also found to reduce the severity of sigatoka and it showed best activity after one month (5.00%) of first spray and its effect reduced with the time after spraying. Similar to the sigatoka disease, severity of panama disease was also found to vary significantly with the location and treatment applied. The lowest (5.00%) panama disease severity was recorded in orchard located at Nischintopur with the Copper oxychloride just after one month of first spray. However, Carbendazim also resulted lower (6.00%) panama severity in the orchard located at Thakurgaon Road after 150 days of first spray (Table 2). Likewise, sigatoka, the insecticide also showed its effect on the lowering (13.00%) the disease severity of panama after 30 days of first spray, although the severity of the disease was increased with time after spraying.

Severity of sigatoka and panama diseases at Dinajpur

Severity of sigatoka and panama disease of three banana orchards at Dinajpur also varied in relation to the treatment applied. The severity of sigatoka varied significantly according to the location and treatment where, highest severity (61.00%) was observed in orchard 1 located at Basherhat without spraying any fungicide after 150 days of first scheduled spray. The lowest (1.00%) severity was recorded in orchard 3 located at Basherhat after 150 days of first spraying with Copper oxychloride followed by Carbendazim (10.00%) with the same days of interval. Similar to the Thakurgaon regions, the insecticide Imidacloprid also showed reduced severity (10.00%) just after one month of spraying (Table 3). The severity of panama disease in different orchard located in Dinajpur region also varied significantly with location and chemicals used. However, lowest (5.00%) panama severity was recorded 1 of Basherhat after 150 days of first spray with Carbendazim followed by orchard 3 (8.00%) with the same interval of time, whereas, highest severity (54.00%) was recorded after 120 days of first spray in the orchard 2 without spraying any chemicals. As like previous, insecticide also showed lower panama disease severity (15.00%) after 30 days of spraying in orchard 3 (Table 3).

Table 2. Effect of different fungicides on disease severity of sigatoka and panama diseases of banana after spraying in Thakurgaon region

Locations	Treatments	Severity of Sigatoka (Days after first spray)					Severity of Panama (Days after first spray)				
		30	60	90	120	150	30	60	90	120	150
Nischintopur	Control	35.00a	36.00a	38.00a	37.00a	39.00a	25.00c	30.00bc	32.00bc	33.00bc	35.00bc
	Carbendazim	10.00cde	10.00def	8.00de	7.00de	6.00de	32.00b	32.00b	30.00bc	28.00d	25.00de
	Copper oxychloride	12.00cd	12.00cde	10.00d	8.00d	6.00de	5.00f	5.00g	6.00g	7.00h	9.00ij
	Imidacloprid	15.00c	16.00c	17.00c	18.00c	20.00c	45.00a	47.00a	48.00a	49.00a	50.00a
Thakurgaon Road	Control	28.00b	29.00b	31.00b	32.00b	33.00b	25.00c	27.00c	28.00c	29.00cd	30.00cd
	Carbendazim	5.00ef	5.00fg	4.00ef	3.00ef	2.00ef	12.00de	12.00ef	10.00efg	8.00h	6.00j
	Copper oxychloride	8.00def	8.00efg	7.00de	6.00de	4.00ef	15.00d	17.00d	18.00d	21.00e	22.00ef
	Imidacloprid	12.00cd	14.00cd	15.00c	17.00c	18.00c	8.00ef	13.00de	15.00de	16.00f	18.00fg
Nischintopur	Control	35.00a	37.00a	38.00a	39.00a	40.00a	30.00b	32.00b	34.00b	35.00b	37.00b
	Carbendazim	3.00f	3.00g	2.00f	1.00f	1.00f	12.00de	11.00ef	9.00fg	8.00h	7.00ij
	Copper oxychloride	8.00def	8.00efg	7.00de	6.00de	4.00ef	5.00f	8.00fg	9.00fg	11.00gh	12.00hi
	Imidacloprid	5.00ef	7.00efg	8.00de	9.00d	10.00d	8.00ef	9.00efg	13.00def	15.00fg	16.00gh
LSD		4.616	5.324	4.066	3.835	4.238	4.463	4.404	5.207	4.299	5.515
CV %		18.59	20.40	15.57	14.85	16.41	14.25	12.84	14.64	11.72	14.64

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Table 3. Effect of different fungicides on disease severity of sigatoka and panama diseases of banana after spraying in Dinajpur region

Locations	Treatments	Severity of Sigatoka (Days after first spray)					Severity of Panama (Days after first spray)				
		30	60	90	120	150	30	60	90	120	150
Basherhat	Control	55.00a	57.00a	58.00a	60.00a	61.00a	20.00d	23.00d	26.00d	27.00d	28.00c
	Carbendazim	35.00b	35.00b	33.00b	31.00b	32.00b	10.00e	9.00g	8.00f	7.00g	5.00e
	Copper oxychloride	20.00de	20.00de	15.00c	18.00c	10.00d	12.00e	13.00fg	15.00e	17.00ef	19.00d
	Imidacloprid	10.00fg	12.00f	13.00c	14.00cd	15.00cd	16.00de	20.00de	23.00d	25.00d	26.00c
Basherhat	Control	55.00a	54.00a	57.00a	58.00a	59.00a	50.00a	52.00a	53.00a	54.00a	55.00a
	Carbendazim	15.00ef	15.00ef	13.00c	11.00d	10.00d	20.00d	18.00def	15.00e	12.00fg	10.00e
	Copper oxychloride	25.00cd	25.00cd	20.00c	14.00cd	12.00d	35.00c	36.00c	38.00c	40.00c	42.00b
	Imidacloprid	30.00bc	32.00b	33.00b	35.00b	36.00b	40.00bc	43.00b	45.00b	48.00b	50.00a
Basherhat	Control	28.00c	29.00bc	30.00b	32.00b	34.00b	45.00ab	47.00ab	48.00ab	50.00ab	53.00a
	Carbendazim	20.00de	19.00de	18.00c	15.00cd	14.00cd	20.00d	18.00def	16.00e	10.00g	8.00e
	Copper oxychloride	5.00g	4.00g	3.00d	2.00e	1.00e	35.00c	37.00c	39.00c	41.00c	42.00b
	Imidacloprid	10.00fg	15.00ef	17.00c	18.00c	19.00c	20.67d	15.00efg	17.00e	19.00e	20.00d
LSD		5.729	6.310	6.553	4.868	5.830	5.915	5.737	5.695	5.649	5.797
CV %		13.18	14.11	14.98	11.20	13.64	12.95	12.28	11.77	11.44	11.48

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Bunchy Top disease

Bunchy top disease severity was recorded after five months of first date of pesticide application. The control treatment has no effect on leaf area but pesticides application increased the leaf area marginally. Among the pesticides, leaf area was found to be increased by imidacloprid (4.0%) and copper oxychloride (4.00%) where, carbendazim did not show any effect (Fig. 1 A). Except copper oxychloride, all other chemicals including control increased the number of leaf by two folds (Fig. 1 B). Plant height of banana was found to be increased by applying of all the chemicals except the control (Fig. 1 C).

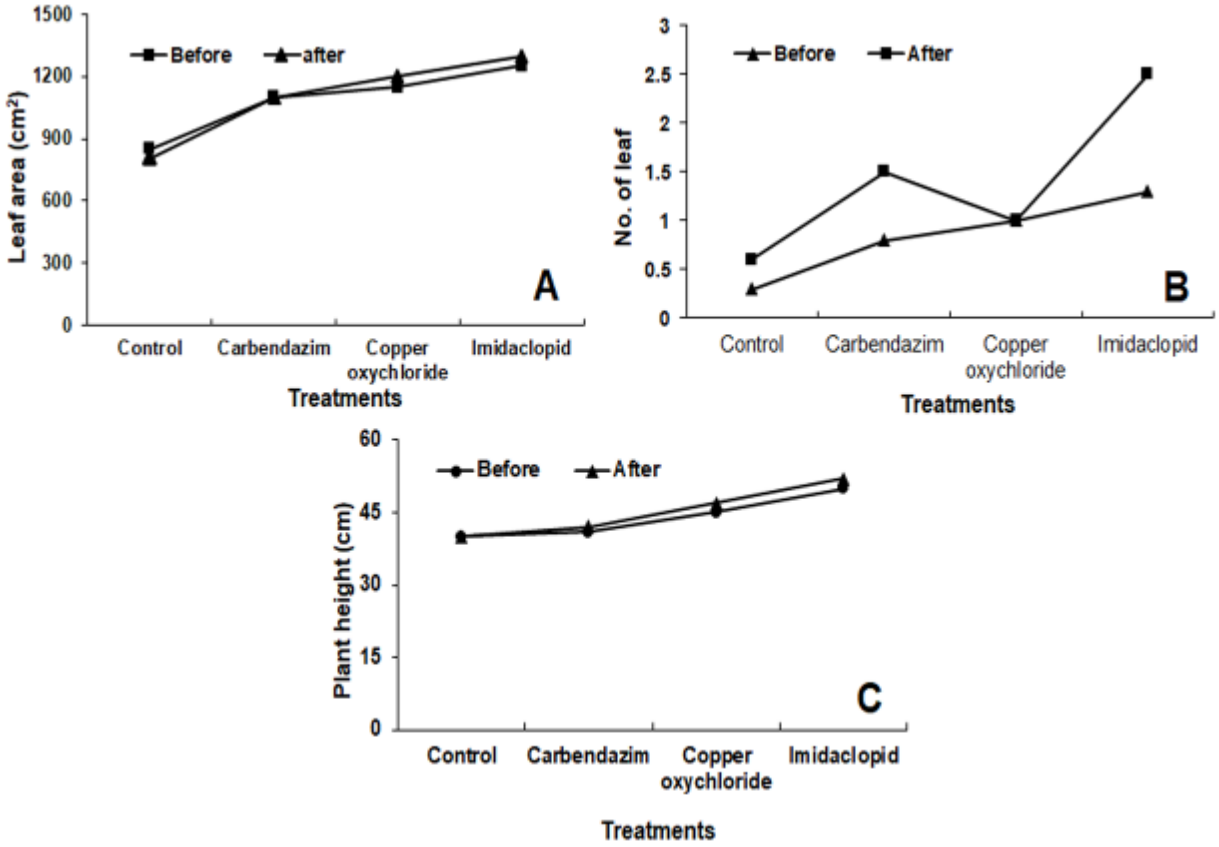

Fig. 1. Effect of chemicals on: **A.** leaf area **B.** Number of leaf and **C.** Plant height

DISCUSSION

An investigation was undertaken to study the effect of different fungicides along with an insecticide on different major diseases of banana in some banana orchards of Thakurgaon and Dinajpur region during July, 2016 to June, 2017. The diseases were assessed five times based on symptoms expressed on leaves at the interval of one month after spraying of the chemicals. Two fungal diseases, namely sigatoka and panama and one viral disease namely banana bunchy top were found to differ significantly ($P \geq 0.05$) among different orchards and spraying of chemicals. All the chemicals used in the experiment were showed the potential effectiveness on the occurrence of disease by reducing the disease severity compared to control. Similar kind of variation in the severity of different banana diseases were also reported previously (Freitas *et al.* 2016; Gutierrez-Monsalve *et al.* 2015; Khan *et al.* 2015; Mukwa *et al.* 2014; Niyongere *et al.* 2013; Kaewjan *et al.* 2012; Hossain 2011; Hossain *et al.* 2011). In this study, Carbendazim showed the promising effect against sigatoka diseases, as other reports also showed the effectiveness of the fungicide (Patel 2009; Huq *et al*. 1994). The reduced severity in sigatoka disease may be happened due to the inactivation of the virulence of the pathogen somewhat by their less number of inocula and spreading attitude owing to retention of fungicides on the leaf surfaces. Copper oxychloride combat pathogenic population through the attenuation of their fructification as well as dissemination or dispersal from foliage to foliage, so that; colonization and further spread of the pathogenic propagules within the host tissue may be interrupted. Maximum reduction in disease in the fifth month might occurred due to the residual effect of the fungicide residing on leaf surfaces for the period being spraying effectively develop harmonious relationship with the chemicals against disease as suppressing their rate of infection,

development of infection foci, frequency of life cycle as well as possibility of further invasion and rapid dispersal of inoculum.

Interestingly, reduced severity in panama disease also observed by the spraying of chemicals. This might happen because of spraying of the whole plant where, some spray solution may also reach to rhizosphere. Additionally, Carbendazim is a broad spectrum fungicide with systemic in nature and long residual activity, thus, give protection against the soil borne fungi (Gupta 2011). On the other hand, Copper oxychloride create a chemical barrier against fungal attack by interfering the enzyme system of spores and mycelium which also inhibit the soil borne fungal attack. Significant reduction in petiole size (length and distance), plant canopy and height, leaf area, pseudostem diameter and chlorophyll content (cholorosis) also reported because of the application of pesticides (Hooks *et al*. 2008). Imidacloprid resulted maximum effect in increasing the leaf area, leaf production and plant height of banana compared to carbendazim and copper oxychloride. Despite the significant size difference in leaf area between treated and control plants, each treatment produced new leaves at a similar rate. As such, no significant differences were detected in the number of leaves produced by control and treated plants. This may be happened due to the suppression of aphid population incapable of infecting newly emerged as well as older leaves of banana (Israeli *et al*. 1993; Hooks *et al*. 2008).

CONCLUSION

Results from the present study showed that two fungicides carbendazim and copper oxychloride along with insecticide imidacloprid was effective in reducing severity of sigatoka, panama and bunchytop of banana in the field. Sigatoka and panama disease severity was reduced by 1-10% due to application of the fungicides. Insecticide Imidacloprid was found to increase the leaf area by 4.0%, leaf number by 2-folds and plant height by 2 cm. However, further trial is necessary to make any recommendation to the farmers for the field use of such kind of chemicals.

REFERENCES

BBS (2017) Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the Peoples' Republic of Bangladesh, Dhaka. P.196.

Carlier J, Zapater MF, Lapeyre F, Jones DR, Mourichon X (2000) Septoria Leaf spot of banana: a newly discovered disease caused by *Mycosphaerella emusae* (Anamorph *Septoria emusae*). *Phytopathol.* 90, 884-890.

Freitas AS, Pozza EA, Alves MC, Coelho G, Rocha HS, Pozza AAA (2016) Spatial distribution of Yellow Sigatoka Leaf Spot correlated with soil fertility and plant nutrition. *Precis. Agric*. 17, 93-107.

Gupta PK (2011) Reproductive and Developmental Toxicology. Academic press. pp. 503-521.

Gutierrez-Monsalve JA, Mosquera S, González-Jaramillo LM, Mira JJ, Villegas-Escobar V (2015) Effective control of black Sigatoka disease using a microbial fungicide based on Bacillus subtilis EA-CB0015 culture. *Biol. Control*, 87, 39-46.

Haque MA (2001) Modern Production Technology of Banana, Horticulture Research Center, BARI. Gazipur, Bangladesh. P. 3.

Hooks CRR, Wright MG, Kabasawa DS, Manandhar R, Almeida RPP (2008) Effect of banana bunchy top virus infection on morphology and growth characteristics of banana. *Annals Appl. Biol*. 153, 1-9.

Hossain I (2011) Nursery diseases of some selected fruit species in Bangladesh. Eco-friendly Plant Disease Management Laboratory, Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. P. 13.

Hossain I, Islam MR, Khan MAH (2011) Surveillance of seedling diseases of some important fruit species in Bangladesh with molecular characterization of pathogens and eco-friendly model development for their management. Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 24-25.

Huq MI, Ahmed HU, Malaker PK (1994) Control of sigatoka of banana with foliar fungicides. Plant Pathology Division, Bangladesh Agricultural Research Institute, Jessore, Bangladesh. 29, 81-85.

Israeli Y, Shabi E, Slabaugh WR (1993) Effect of banana spray oil on banana yield in the absence of Sigatoka (*Mycosphaerella* sp.). *Sci. Hortic.* 56, 107-117.

Johnston PR (2000) The importance of phylogeny in understanding of host relationships within *Colletotrichum*. In: Prusky D, Dickman MB Freeman S, eds. *Colletotrichum* host specificity, pathogenicity and host-pathogen interactions. St. Paul, Minnesota: APS. pp. 21-28.

Kaewjan P, Sittikul C, Cheewangkoon R, Hyde DK, Akarapisan A (2012) *Mycosphaerella* and Other Fungi Associated with Banana Leaf Diseases from Northern Thailand. *CMU. J. Nat. Sci.* 11, 25-32.

Khader MAJ, Chellappan BMK, Chattopadhaya PK, Pillai OAA (1996) Banana. In: Fruits: Tropical and Subtropical. Eds. Bose TK, Mitra SK, Prokash N, 206 Bidhan Sarani, Calcutta, India. pp. 130-134.

Khan MAH, Hossain I, Ahmad MU (2015) Impact of weather on sigatoka leaf spot of banana (*Musa* spp. L.) and its eco-friendly management. *The Agriculturist*, 13, 44–53.

Marin DH, Romero RA, Guzman M, Sutton TB (2003) Black Sigatoka: an increasing threat to banana cultivation. *Plant Dis*. 87, 208-222.

Mukwa LFT, Muengula M, Zinga I, Kalonji A, Iskra-Caruana ML, Bragard C (2014) Occurrence and distribution of banana bunchy top virus related agro-ecosystem in South Western, Democratic Republic of Congo. *Am. J. Plant Sci.* 5, 647-658.

Niyongere C, Losenge T, Ateka EM, Ntukamazina N, Ndayiragijie P, Simbare A, Nintije P, Blomme G (2013) Understanding banana bunchy top disease (BBTD) epidemiology in Burundi for an enhanced and integrated management approach. *Plant Pathol.* 62, 562-570.

Patel PR (2009) Chemical control of sigatoka leaf spot (*Mycosphaerella musicola*) of banana. *Int. J. Plant Prot.* 2, 98-100.

Pegg KG, Moore NY, Bentley S (1996) Fusarium wilt of banana in Australia: a review. *Aus. J. Agric. Res.* 47, 637-650.

Ploetz RC (2001) Black sigatoka of banana. *The Plant Health Instructor*. DOI: 10.1094/PHI-I-2001-0126-02.

Ploetz RC (2006) Fusarium wilt of banana is caused by several pathogens referred to as *Fusarium oxysporum f*. sp. *cubense*. *Phytopathol*. 96, 653-656.

Ploetz RC, Thomas JE, Slabaugh WR (2003) Diseases of banana and plantain. In Ploetz RC (ed), Diseases of tropical fruit crops, CABI publishing, CAB International, Wellingford, Oxon, pp. 73-137.

Robinson JC, Neil DJ (1985) Comparative morphology, phenology and production potential of banana cultivars 'Dwarf Cavendish' and 'Williams' in the Eastern Transvaal Lowveld. *Sci. Hortic.* 25, 149-161.

Romero RA, Sutton TB (1997) Sensitivity of *Mycosphaerella fijiensis*, causal agent of black Sigatoka of banana, to propiconazole. *Phytopathol*. 87, 96-100.

Smith MK, Searle C, Langdon PW, Schaffer B, Whiley AW (2000) Comparison between micro propagated banana (Musa AAA; 'Williams') and conventional planting material during the first 12 months of development. *J. Hort. Sci. Biotech.* 76, 83-87.

Turner DW (1971) Effects of climate on rate of banana leaf production. *J. Trop. Agric.* 48, 283-287.