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Impact of Weather on Sigatoka Leaf Spot of Banana (*Musa* spp. L.) and its Ecofriendly Management

M. A. H. Khan[1]*, I. Hossain[2] and M. U. Ahmad[2]

[1]On-Farm Research Division, Bangladesh Agricultural Research Institute, Gazipur; [2]Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh

**Corresponding author and Email: helim1367@yahoo.com*

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Abstract

A study was carried out during July 2010 to April 2012 to understand the effect of weather prevalence on sigatoka disease of banana suckers in different areas of Bangladesh and to develop an environment friendly disease management practice. Four locations viz. Dinajpur, Bogra, Rangpur and Madhupur were surveyed. To find out suitable and ecofriendly management practices for controlling sigatoka disease of banana, seven treatments were used viz. i) Soil drenching with BAU- Biofungicide (2%), ii) BAU-Biofungicide as foliar spray (2%), iii) Soil drenching with BAU-Biofungicide (2%) plus foliar spray (2%), iv) Bavistin (carbendazim) spray (0.2%), v) Dithane M-45 (mancozeb) spray (0.2%), vi) Soil drenching with BAU-Biofungicide (2%) plus Bavistin spray (0.2%); and vii) control. The average highest incidence (26.42%) and severity (22.84%) of sigatoka disease of banana suckers were recorded during October at Bogra, while the lowest incidence (9.75 %) and severity (8.51%) were recorded during January at Dinajpur. Out of the control measures employed, BAU-Biofungicide (2%) either alone or in combination with Bavistin (0.2%) was found as an excellent biocontrol means for controlling sigatoka disease of banana suckers.

Keywords: Banana sucker, sigatoka disease, eco-friendly management, BAU-Biofungicide

1. Introduction

Bananas (*Musa* spp. L.) are monocotyledonous plants that belong to the family Musaceae and the genus *Musa* originated in Southeast Asia (Ploetz, 2001). It is one of the most important fruits in the world and is widely grown in the tropical and sub-tropical countries (Simmonds and Shepherd, 1955). Banana is grown over 120 countries worldwide (Thangavelu and Mustaffa, 2012) covering about 10 million hectares with an annual world production estimated at 127 million tons. In Bangladesh, it is grown throughout the year but the production is still low as compared to other banana producing countries of the world (FAO, 2008). Bangladesh produced 414000 tons of bananas in 53609 hectares of land (BBS, 2012). Bananas supply an appreciable amount of vitamins and minerals. 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, 0.58 ppm, β carotene, 0.5 ppm riboflavin, 7.0 ppm Niacin and 120 ppm ascorbic acid (Haque, 2001). Banana is the major important fruit crops in Bangladesh due to its calorific and nutritive values and of their versatile use by the consumers.

Success of an orchard depends on the quality of the planting materials. The climate of Bangladesh harbors plant pathogen and provides luxuriant environment for the growth and reproduction of large number of plant pathogens which cause hundreds of different diseases of crops (Fakir, 2001). Determining the effect of weather parameters on the formation, release and germination of inoculum in different pathosystems have been focused by many researchers in worldwide (Pinkerton *et al*., 1998; MacHardy *et al*., 2001; Mondal and Timmer, 2002). Plant disease play an important role in reducing yield of horticultural crops in the tropics. It has been estimated that production could be increased at least by 28% if the crop could be confined against various diseases and many of these diseases have been reported to be transmitted through the planting material (Rawal, 1990).

Banana is grown widely in Bangladesh. However, sigatoka disease of banana suckers has not been thoroughly investigated here. Little information is available about the presence, prevalence, epidemiology and management of sigatoka disease of banana in Bangladesh, although the disease poses a potential threat to seedlings of fruit species by causing enormous loss in plant quality and disruption of production schedules. Therefore, it is necessary to investigate banana field to asses the incidence, severity, epidemiology and management of the pathogen that causes sigatoka disease. The present study was therefore, undertaken to investigate the effects of temperature, rainfall and humidity on the sigatoka disease of banana suckers and to suggest an eco-friendly management package for the disease.

2. Materials and Methods

2.1. *Study sites*

Major growing areas of banana were identified and selected based on information gathered from government and non-government organizations. Twenty banana fields in four locations of Dinajpur, Rangpur, Bogra and Madhupur were surveyed and sigatoka disease of banana suckers was observed.

2.2. *Isolation of causal organism*

Suckers of banana were observed carefully and symptoms of the disease were recorded following the description of Ploetz *et al*. (1998). Diseased samples were collected and brought to the laboratory and the samples were washed thoroughly under running tap water and surface was sterilized with 4% NaOCl. The diseased parts were then cut into 1.0 cm long pieces. One set of the pieces was placed on three layers of wet blotters equidistantly in Pyrex plates and another set was placed on PDA medium. Both sets were incubated for 7 days under 12/12 hr. alternate cycles of near ultra violet light and darkness at 22±2^{o}C. The plates were checked after 3 days for fungal growth and continued for 7 days. After incubation, the inoculated PDA plates were observed to identify the causal organisms.

2.3. *Survey on sigatoka disease of banana suckers*

Four visits were made as per locations and growing areas of banana in Bangladesh over a period of one year and the study was carried out during July 2010 to April 2012. In each banana field, 30 suckers were considered for disease incidence and severity. Moreover, meteorological data on temperature, rainfall and relative humidity were collected from weather yards located at Dinajpur, Rangpur, Bogra and Tangail throughout the study period.

2.4. *Assessment of disease incidence and severity*

Percent Disease Incidence (PDI) was calculated using the formula of Rai and Mamatha (2005) and Percent Disease severity (PDS) was calculated using the formula of Johnston (2000) as:

Percent disease incidence (PDI) =

$$\frac{\text{Number of diseased leaves on each plant}}{\text{Number of total leaves on each plant}} \times 100$$

Percent disease severity (PDS) =

$$\frac{\text{Area of leaf tissue infected by disease}}{\text{Total area of leaf}} \times 100$$

2.5. *Eco-friendly disease management trial*

The study was conducted at the Field of the Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh during July 2010 to April 2012.

2.5.1. Preparation of pits

Pits were prepared in the field as per method of Mondal (2000). Fertilizers and manures were applied following Fertilizer Recommendation Guide of Bangladesh Agricultural Research Council.

2.5.2. Treatments

The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications and 15 suckers per treatment were used. For the management of sigatoka disease of banana suckers seven different treatments were employed on the variety Amritsagor. Two fungicides viz. Bavistin (carbendazim) and Dithane M-45 (mancozeb) and one *Trichoderma* based preparation known as BAU-Biofungicide were used for the management of sigatoka disease. The fungicides were used as foliar spray at 30 days interval but BAU-Biofungicide used as foliar spray as well as soil drenching. The treatments were as T_1 = Soil drenching with BAU-Biofungicide (2%), T_2 = BAU-Biofungicide as foliar spray (2%), T_3= Soil drenching with BAU-Biofungicide plus foliar spray (2%), T_4 = Bavistin spray (0.2%), T_5 = Dithane M-45 spray (0.2%), T_6 = Soil drenching with BAU-Biofungicide (2%) and Bavistin spray (0.2%) and T_7 = Untreated control.

2.5.3. Application of bio-agent

BAU Bio-fungicide is a formulated product of *Trichoderma harzianum* developed in Ecofriendly Disease Management Laboratory, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh (Hossain, 2003). BAU Bio-fungicide was thoroughly mixed with the soil @ 6.4g/m^2 soil (Lo *et al*., 1996).

2.5.4. Assessment of disease incidence, severity and disease reduction over control

Assessment of incidence and severity of sigatoka disease were done by using the formulae described in 2.4. Percent disease reduction (PDR) was calculated by using the formula of Rai and Mamatha (2005).

2.5.5. Data analysis

Collected data on different parameters were compiled and analyzed statistically. Duncan's Multiple Range Test (DMRT) was performed to determine the level of differences and to separate the means within the parameter by using the computer software program MSTAT-C (Russell, 1986)

3. Results and Discussion

It was revealed that sigatoka was the most common disease in the banana suckers. The first symptom of sigatoka appeared as minute yellowish green flecks on the third or fourth leaf from the top of the plant. These flecks elongated to narrow yellowish green to yellow streaks (Picture 1.; A and B). The causal organism of sigatoka disease was identified as *Cercospora musae* from the diseased leaves of banana suckers (Picture 1. C). Conidiophores were pale, straight often bottle shaped and lack septa. The conidiophores apex was round and lack conspicuous scars. Conidia were borne terminally and singly. They were pale, smooth, straight, multicellular and cylindrical. The findings of the present study have been supported by Fullerton *et al*. (1990).

3.1. *Incidence and severity of sigatoka disease of banana suckers at different locations of Bangladesh*

A great variation was observed in the incidence and severity of sigatoka disease of banana from one counting to another as well as one location to another. Significant variation in relation to incidence and severity of sigatoka disease of banana suckers were recorded that ranged from 12.70-20.78% and 10.79-18.83% in 2010-2011 (Table 1). The highest incidence and severity were recorded at Bogra and the lowest incidence and severity were observed at Dinajpur. But in

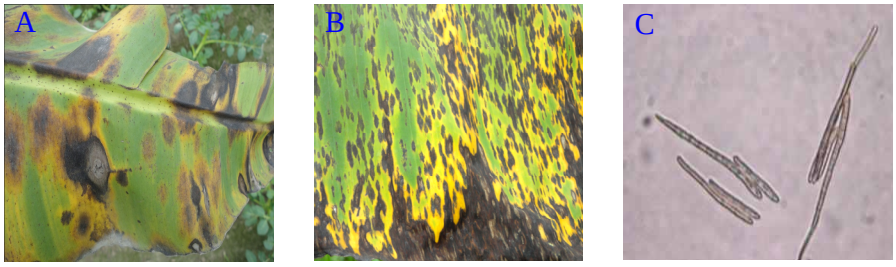
2011-2012, the highest incidence was recorded at Rangpur and the lowest was observed at Dinajpur. Similar trend was also observed in severity of sigatoka disease of banana suckers in 2011-2012. This might be due to the effects of weather factors. The findings of the study are supported by Pathak (1989). In a survey carried out by Hossain (2011) also reported that sigatoka was the most important disease of banana suckers.

3.2. *Incidence and severity of sigatoka disease of banana suckers at different time of the year*

In 2010-2011, incidence and severity of sigatoka disease of banana suckers varied significantly during July 2010 to April 2011 that ranged from 12.57-22.79 % and 11.00-19.33 % (Table 2). The highest incidence and severity were recorded during October 2010 and the lowest incidence and severity were recorded in January 2011. Similar trend was also observed in sigatoka disease incidence and severity of banana suckers in 2011-2012. The results are in agreement with Hossain (2011).

3.3. *Incidence and severity of sigatoka disease of banana suckers at different times and locations of Bangladesh*

In 2010-2011, incidence of sigatoka disease of banana suckers varied significantly from season to season as well as location to location and that ranged from 10.40 27.05 % (Table 3). The highest incidence (27.05%) was recorded in October 2010 at Bogra while the lowest incidence (10.40 %) was recorded in January 2011 at Dinajpur. The severity of sigatoka disease also varied significantly from season to season as well as location to location that ranged from 8.60-22.29%. The highest severity was recorded in October 2010 at Bogra and the lowest severity was recorded in January 2011 at Madhupur preceded by January and April 2011 at Dinajpur. Similar trend was also observed in 2011-2012.



Picture 1. A and B= Symptom of sigatoka disease of banana and C= Conidia of C*ercospora musae*

Table 1. Incidence and severity of sigatoka disease of banana suckers at different locations of Bangladesh during July 2010 to April 2012

Locations	2010-2011		2011-2012	
	Sigatoka		Sigatoka	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Dinajpur	12.70d	10.79c	12.33d	11.68d
Bogra	20.78a	18.83a	16.85b	15.08b
Rangpur	15.39c	15.00b	17.59a	15.61a
Madhupur	17.39b	14.93b	15.12c	12.83c
CV (%)	6.87	6.59	6.84	5.52

In a column, figures having same letter(s) do not differ statistically at 5% level of significance by DMRT. Each data represent the mean value of five nurseries.

Table 2. Incidence and severity of sigatoka disease of banana suckers at different times during July 2010 to April 2012

Times (Month)	2010-2011		2011-2012	
	Sigatoka		Sigatoka	
	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
July	16.54b	15.25b	14.03b	12.34b
October	22.79a	19.33a	22.84a	21.33a
January	12.57d	11.00d	11.09c	9.60d
April	14.37c	13.95c	13.93b	11.93c
CV (%)	6.87	6.59	6.84	5.52

In a column, figures having same letter (s) do not differ statistically at 5% level of significance by DMRT. Each data represent the mean value of five nurseries.

Table 3. Incidence and severity of sigatoka disease of banana suckers at different times and locations of Bangladesh during July 2010 to April 2012

Location	Time (Month)	2010-2011		2011-2012	
		Sigatoka		Sigatoka	
		Incidence (%)	Severity (%)	Incidence (%)	Severity (%)
Dinajpur	July	11.50l	10.20i	11.40i	9.93i
	October	16.23h	14.26g	19.42d	20.32c
	January	10.40n	8.87k	9.09j	8.14k
	April	12.66k	9.81k	9.42j	8.31k
Bogra	July	16.50g	15.80f	15.91f	14.38e
	October	27.05a	22.29a	25.79a	23.38a
	January	17.36f	16.67e	11.54i	10.36h
	April	22.23d	20.55b	14.17g	12.21f
Rangpur	July	15.30i	16.60e	18.83e	16.19d
	October	23.69c	20.22c	24.04b	21.42b
	January	11.21m	9.86j	11.87i	10.36h
	April	11.37lm	12.96h	15.60f	14.46e
Madhupur	July	14.18j	13.20h	13.22h	10.60h
	October	24.18b	20.56b	22.10c	20.20c
	January	11.15m	8.60k	11.87i	9.53j
	April	20.05e	17.69d	13.29h	11.00g
CV (%)		6.87	6.59	6.84	5.52

In a column, figures having same letter (s) do not differ statistically at 5% level of significance by DMRT. Each data represent the mean value of five nurseries.

3.4. *Effects of weather factors on the incidence and severity of sigatoka disease of banana suckers*

Effects of different weather factors (temperature, rainfall and relative humidity) on the incidence and severity of sigatoka disease of banana suckers were studied during July 2010 to April 2012. In 2010-2011. Figure 1 shows that the highest temperature prevailed during July (29.28 °C) and an equable temperature prevailed during

August to September. A fall of temperature was observed during October (25.20 °C) to the end of December (18.40 °C) and the coolest period prevailed during January (14.54 °C). About 80 % annual rainfall occurred during the monsoon (late May to mid October). April was the least humid month while the average relative humidity was 78.08, 76.42, 79.58 and 79.25% in Dinajpur, Bogra, Rangpur and Madhupur, respectively. The relative humidity during June to October was above 80% and during November to February was 75%. In 2011-12, the weather parameters showed the similar trend as previous year. Based on the analysis of weather parameters four disease recording times were selected to observe the effect of weather on incidence and severity of sigatoka disease of banana suckers. The highest incidence (22.84%) and severity (21.33%) were recorded during the month of October 2011 at temperature, rainfall and relative humidity of 27.18°C, 54.80 mm and 79.83%, respectively (Figure 1). On the other hand, the lowest incidence (11.09%) and severity (9.60%) were recorded during the month of January 2012 at temperature, rainfall and relative humidity of 17.38°C, 14.75 mm and 77.25 %, respectively. These results are in agreement with that reported by Hossain (2011).

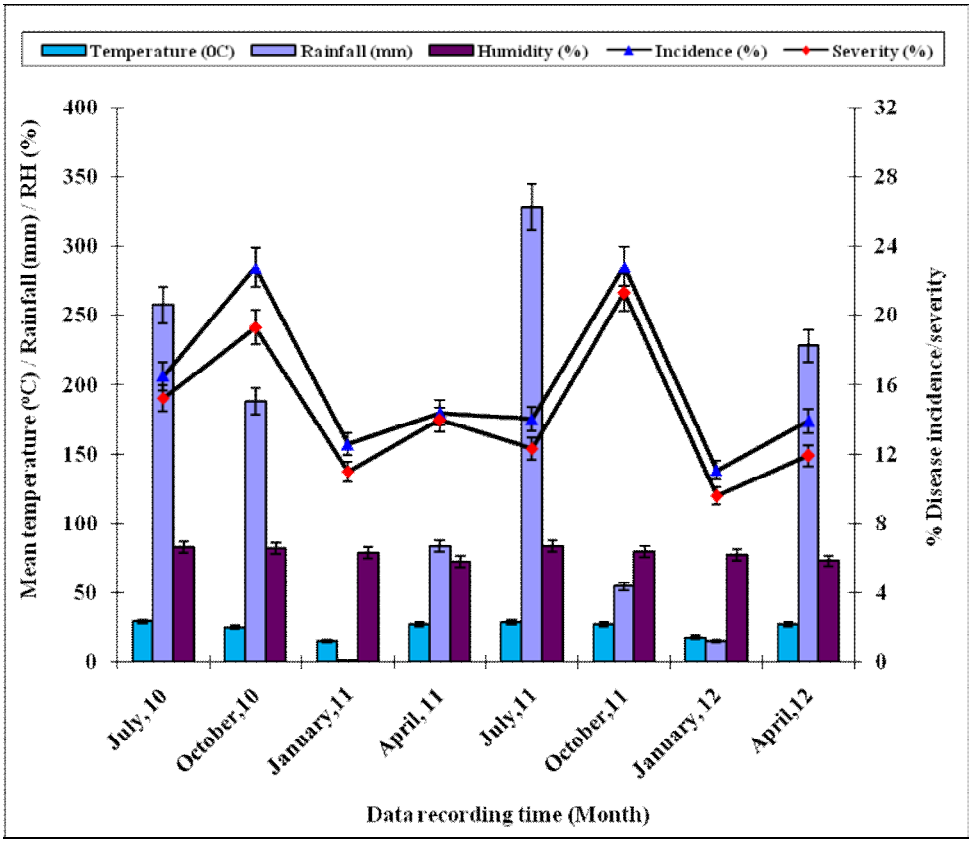


Figure 1. Effcet of weather factors on the incidence and severity of sigatoka leafspot of banana

Table 4. Correlation and linear regression analysis of temperature, rainfall and relative humidity on the incidence and severity of sigatoka disease of banana suckers

Weather factors	Coefficient of Correlation (r)		Slope (b)		Coefficient of Determination (R^2)	
	Incidence	Severity	Incidence	Severity	Incidence	Severity
Temperature	0.43	0.26	2.53	1.83		
Rainfall	0.28	0.23	0.049	0.03	0.82**	0.80**
Relative humidity	0.02	0.02	0.53	0.48		

Table 5. Effects of different management practices on the incidence and severity of sigatoka disease of banana suckers during July 2010 to June 2012

Treat ments	Incidence (%)		% reduction over control		Severity (%)		% reduction over control	
	2010-2011	2011-2012	2010-2011	2011-2012	2010-2011	2011-2012	2010-2011	2011-2012
T_1	24.76bc	18.91bc	27.92	30.71	27.64b	10.63b	36.17	68.49
T_2	21.40cd	15.64cd	37.70	42.69	22.01cd	4.84de	49.17	85.65
T_3	18.55d	13.47de	45.99	50.64	18.94d	4.14ef	56.26	87.73
T_4	20.42cd	17.36c	40.55	36.39	20.91d	4.95d	51.71	85.32
T_5	20.06cd	18.28c	41.60	33.02	21.51d	5.34cd	50.32	84.17
T_6	17.62d	11.77e	48.70	56.87	18.60d	3.79f	57.04	88.76
T_7	34.35a	27.29a	-	-	43.30a	33.73a	-	-
CV (%)	9.11	10.17	-	-	7.88	8.19	-	-

Data represent the mean value of 3 replications; each replication was derived from 15 plants per treatments; in a column means having similar letter(s) are statistically similar at 5% level of significance by DMRT.

Treatments, T_1= Soil drenching with BAU-Biofungicide (2%); T_2= BAU-Biofungicide as foliar spray (2%); T_3= Soil drenching with BAU-Biofungicide (2 %) + foliar spray (2%; T_4= Bavistin spray (0.2%) T_5= Dithane M-45 spray (0.2%); T_6= Soil drenching with BAU-Biofungicide (2%) + Bavistin spray (0.2 %) and T_7= Control (Untreated)

3.5. *Relationship between weather factors and incidence as well as severity of sigatoka disease of banana suckers*

Correlation and linear regression analysis were performed to determine the relationship between weather factors (temperature, rainfall and relative humidity) and incidence as well as severity of sigatoka disease of banana suckers. It was revealed that incidence and severity were positively correlated with temperature (r=0.43, r=0.26) and rainfall (r=0.28, r=0.23) in both years. On the other hand, incidence (r=0.02) and severity (r=0.02) were positively and poorly correlated with relative humidity (Table 4). The results are in agreement with the findings of Khan and Hossain (2013). They reported that occurrence of seedling diseases were significantly influenced by temperature, rainfall and relative humidity. Jacome *et al*. (1991) reported that leaf wetness duration had a major effect on symptom appearance which was delayed up to 14 days when no leaf wetness was present. The delay may be associated with a longer water absorption period required for conidial germination. Conidia germinates at 20-35^oC over a wide range (92-100%) of relative humidity in less than 24hrs. Because, infection by conidia occurred even with no leaf wetness and when the relative humidity was high. The periods of high relative humidity may be

important for infection when duration of leaf wetness or a rain even is short or absent. Therefore, conidial infection may play an important role in the epidemiology of sigatoka during the dry season when humidity is the limiting factor for infection.

Maximum ascospores germination and growth on the leaf surface have been observed when a film of water is present (Stover and Simmonds, 1987). Thus, the greatest impact of ascospores as source of inoculum may be during the rainy season. Ascospore discharge and infection are less likely during the dry season.

The optimum range of temperature for disease development was 25-28 °C. Temperature did not cause any major effect on the number of lesions, except at 31 °C. Thus, differences in disease severity at a given temperature, among leaves and leaf wetness levels were primarily due to lesion expansion. Lesion size may be dependent on lesion number. Ricker *et al*. (1985) observed larger lesion size at lower inoculum densities of *Cercospora arachidicola*. Effects of temperature, rainfall, relative humidity, sun shine hour and leaf wetness on the incidence and severity of disease in different pathosystems have been reported by many researchers (MacHardy *et al*., 2001; Mondal and Timmer, 2002; Chowdhury and Hossain, 2011). Similar prevalence of sigatika disease caused by *Cercospora musae* (Akter, 2011) and black sigatoka disease caused by *Mycosphaerella fijiensis* in banana (Jacome and Schuh, 1992) had been reported to be influenced by excessive rain, humidity and temperature. However, warm temperature (25-28 ^{o}C), rainfall, leaf wetness and high humidity (>92%) can be important parameters in predicting the likelihood of sigatoka disease outbreak .

3.6. *Eco-friendly disease management trial*

BAU-Biofungicide and two other fungicides viz. Bavistin and Dithane M-45 were applied in the field of banana for controlling sigatoka disease. The highest incidence (34.35 and 27.29 %, respectively) of sigatoka disease in banana suckers was recorded in untreated control (T_7) and the lowest (17.62 and 11.77 %, respectively) was recorded when BAU-Biofungicide was drenched in soil @ 2 % and Bavistin was used as foliar spray @ 0.2 % (T_3). The highest reduction (48.70 and 56.87 %, respectively) of disease incidence was recorded over control when BAU-Biofungicide drenched in soil @ 2 % and Bavistin used as foliar spray @ 0.2 % in both years (Table 5). The lowest reduction of incidence (27.92 and 30.71 %, respectively) was recorded over control when only BAU-Biofungicide drenched in soil @ 2 % (T_1). The highest severity (43.90 and 33.73 %, respectively) of sigatoka disease was observed in untreated control and the lowest severity (18.60 and 3.79 %, respectively) was observed in BAU-Biofungicide drenched in soil @ 2 % and Bavistin used as foliar spray @ 0.2 % (T_6) which resulted the highest reduction of (57.04 and 88.76 %, respectively) severity over control in both years (Table 5). The lowest reduction of (36.17 and 68.49 %, respectively) severity over control was recorded when BAU-Biofungicide applied @ 2 % as soil drench (T_1) in both years.

Application of BAU Bio-fungicide as soil drench @ 2% and Bavistin used as foliar spray @ 0.2% (T_6) resulted maximum reduction of incidence and severity followed by BAU-Biofungicide drenched in soil as well as used as foliar spray @ 2% (T_3) compared to control. The findings of the present study are also agreement with that report by Akter (2011). She reported that BAU-Biofungicide was effective for controlling sigatoka disease of banana. Among the chemicals, Bavistin (0.2 %) as foliar spray was also found good when incorporated with BAU-Biofungicide as soil drenching for controlling sigatoka disease of banana suckers. The findings have been supported by Anaso and Olatunde (1989), Huq *et al*. (1994) and Prasadji *et al*. (2004).

4. Conclusions

The weather parameters have profound and significant effect on the prevalence of sigatoka

disease of banana suckers. Out of the control measures employed, BAU-Biofungicide (2%) either alone or in combination with Bavistin (0.2%) was found as an excellent biocontrol means for controlling sigatoka disease of banana suckers. *Trichoderma harzianum* based BAU-Biofungicide, a new means of disease control in the banana field could be employed against sigatoka disease of banana in Bangladesh as an eco-friendly disease management tool.

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