

**INVESTIGATION ON THE LEAF ROT AND FOOT AND
ROOT ROT OF BETEL VINE (*PIPER BETLE* L.) IN
SATKHIRA DISTRICT OF BANGLADESH**

BY

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SHER-E-BANGLA AGRICULTURAL UNIVERSITY DHAKA-1207

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ROOT ROT OF BETEL VINE (*PIPER BETLE* L.) IN
SATKHIRA DISTRICT OF BANGLADESH**

BY

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INVESTIGATION ON THE LEAF ROT AND FOOT AND ROOT ROT OF BETEL VINE (*PIPER BETLE L.*) IN SATKHIRA DISTRICT OF BANGLADESH

ABSTRACT

An investigation on the diseases of betel vine was done in six upazillas of Satkhira district viz. Kalaroa, Tala, Satkhira Sadar, Assasuni, Debhata and Kaligonj. In Kalaroa, disease incidence and severity of leaf rot of betel vine were ranged from 4.17 to 34.49% and 6 to 30.67%, respectively. In case of foot and root rot of betel vine, disease incidence ranged from 0 to 22.92% where the highest and the lowest count were recorded in August and December for both the diseases. In Tala, disease incidence and severity of leaf rot of betel vine ranged from 12.67 to 46.94% and 11.83 to 34.17%, respectively. In case of foot and root rot of betel vine, disease incidence ranged from 5.21 to 40.75% where maximum and minimum diseases were recorded in August and December for both the diseases. In Satkhira Sadar, disease incidence and severity of leaf rot of betel vine ranged from 3.17 to 27.38% and 2.05 to 15.33%, respectively. In case of foot and root rot of betel vine in Satkhira Sadar, disease incidence ranged from 0 to 15.63%, respectively where maximum diseases were recorded in August and minimum diseases were recorded in November and December. In Assasuni, disease incidence and severity of leaf rot of betel vine ranged from 3.67 to 35.5% and 7.34 to 26.33%. In case of foot and root rot of betel vine, disease incidence ranged from 0% to 23.96% where maximum and minimum diseases were recorded in August and December for both disease. In Debhata, disease incidence and severity of leaf rot of betel vine ranged from 3.83 to 33.33% and 3.67 to 19.67%, respectively. In case of foot and root rot of betel vine, disease incidence ranged from 0 to 19.79% where maximum and minimum diseases were also recorded in August and December. In Kaligonj, disease incidence and severity of leaf rot of betel vine ranged from 8.49 to 40.5% and 3.17 to 28.67%, respectively. In case of foot and root rot of betel vine, disease incidence ranged from 2.08 to 40.63% where maximum diseases were recorded in August and minimum diseases were recorded in December for both the diseases. The highest disease incidence and severity were recorded in August at Tala and the lowest disease incidence and severity were recorded in December at Satkhira Sadar. In 29 °C and 85% R_H, the disease incidence and severity of leaf rot and foot and root rot of betel vine was the highest and with the decrease of temperature and humidity the incidence and

severity gradually decreased and was the lowest when the temperature laid around 18.7 °C and the R_H laid around 75%.

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CERTIFICATE

This is to certify that the thesis entitled, "***INVESTIGATION ON THE LEAF ROT AND FOOT AND ROOT ROT OF BETEL VINE (PIPER BETLE L.) IN SATKHIRA DISTRICT OF BANGLADESH***" submitted to the Department of Plant Pathology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in PLANT PATHOLOGY** embodies the result of a piece of bona fide research work carried out by **Md. Monirul Islam Mollah**, bearing Registration No. **10-04221** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Dated: June, 2012
Place: Dhaka, Bangladesh

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Dr. Md. Rafiqul Islam
Professor
Supervisor

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CHAPTER I

INTRODUCTION

The deep green heart shaped leaves of betel vine are popularly known as *Paan* in Bangladesh. It is an important cash crop in Bangladesh. It is also known as Nagaballi, Nagurvel, Saptaseera, Sompatra, Tamalapaku, Tambul, Tambuli, Vaksha Patra, Vettilai, Voojungalata etc in different parts of India (CSIR, 1969; Guha and Jain, 1997). All classes of people in Bangladesh chew betel vine not only as a habit but also as an item of rituals, etiquette and manners.

The scientific name of betel vine is *Piper betle* L. It belongs to the family Piperaceae. It is a climbing plant with shiny, green heart-shaped leaves. The stem initiates many short adventitious roots (Hassan and Shahzad, 2005). The vine is a dioecious (male and female plants are different), shade loving perennial root climber. There are about 100 varieties of betel vine in the world, of which about 40 are found in India and 30 in West Bengal (Guha, 1997; Maity, 1989; Samanta, 1994). Desi Bangla, Bangla, Kali Bangla, Jhali, Sanchi, Bhabna, Mitha, Geso, Bonhoogly etc. betel vine cultivars are found in Bangladesh.

The most probable place of origin of betel vine is Malaysia (Chattopadhyay and Maity, 1967). In spite of its alienness, the plant is much more popular in India than in any other country of the world since the antiquity. This would be evident from the numerous citations laid down in the ancient literature, particularly the Indian scriptures. In these citations, significance of the leaves has been explained in relation to every sphere of human life including social, cultural, religious and even day-to-day life, which is very much relevant even these days. For example, a well-prepared betel quid is still regarded as an excellent mouth freshener and mild vitalizer, routinely served on the social, cultural and religious occasions like marriage, Puja (religious festivals),

Sraddha ceremony (religious function performed after cremation) etc. It is also used as a special item offered to the guests in order to show respect and for such traditional use of betel leaf in the Indian society, the leaf really stands alone without any parallel even today (Guha, 1997; Mehrotra, 1981).

In fact, this edible leaf has achieved an esteemed position in the human society right from the dawn of civilization, particularly in the countries like Bangladesh, Myanmar, China, India, Indonesia, Malaysia, Nepal, Pakistan, Philippines, South Africa, Sri Lanka, Thailand etc. (Jana, 1996; Khoshoo, 1981; Samanta, 1994; Sharma et al., 1996), where leaves are traditionally used for chewing in their natural raw condition along with many other ingredients like sliced areca nut, slaked lime, coriander, aniseed, clove, cardamon, sweetener, coconut scrapings, ashes of diamond, pearl, gold and silver (Ayurvedic preparations), jelly, pepper mint, flavouring agent, fruit pulp etc. (CSIR, 1969).

Bangladesh is the second largest grower of betel vine on about 14,000 hectare. Total annual production of the crop in Bangladesh is about 72,500 tons. The average yield is 2.27 tons per acre (Anonymous, 2006). But the acreage of betel vine is decreasing fast because of some physical and socioeconomic barriers like unavailability of credit facilities, uncontrolled marketing system and infestation of diseases and pest (Islam 2005).

Disease damage to the crop is one of several known limiting factors. The betel vine is highly susceptible to diseases, pests and some natural climates (Sayeeduzzaman, 1988).

Disease is one of the most important barriers for betel vine cultivation. Among the diseases of betel vine, leaf rot caused by *Phytophthora parasitica* var. *piperina* and foot and root rot of betel vine caused by *Sclerotium rolfsii* Sacc. are the most devastating diseases which decrease the production of betel vine to

a great extent. In 2004, Sixty percent betel vine damaged due to foot rot disease in 3 upazilla of Rajshahi (Islam, 2005).

Humid and moist shaded conditions are favorable for its growth. But these humid and moist shaded conditions are also prone to root and foliage disease development of betel vine (Goswami *et al.*, 2002). Leaf rot of betel vine caused by *Phytophthora parasitica var. piperina* is the most common in betel vine garden in India (Dastur, 1935). This disease is also endemic and cause serious problem all over the betel vine growing regions in Bangladesh (Talukder, 1974; Chowdhury and Ahmed, 1985).

Phytophthora parasitica var. piperina is a soil borne fungus and found in soil throughout the year because of its potentiality to survive in wide ranges of temperature and high moisture (Goswami *et al.*, 2002). In soil, *Phytophthora parasitica var. piperina* firstly attacks the root, later spreading to the stem and leaf (Rangaswami and Mahadeven, 2002).

Sclerotium rolfsii Sacc. is a soil borne pathogenic fungus and harmful to many crops which are economically valuable in most of the tropical and subtropical region of the world (Aycock, 1996). It has a wide host range and has been referred as an almost omnipathogenic organism (Talukder, 1974). It is very difficult to control even by the use of chemical fungicide.

Foot and root rot of betel vine caused by *Sclerotium rolfsii* Sacc. is a devastating soil borne plant pathogenic fungus with a wide host range (Aycock, 1996). The fungus is a facultative parasite and can maintain continuity of generation under adverse situation by the formation of sclerotia (Ahmed, 1980).

As a creeper crop the basal part of the betel vine stem kept in soil by folding and it's a continuous process as the part of the cultivation practice of the crop. The stem kept in the soil often affected by the soil borne fungus *Sclerotium rolfsii*. The basal part of the stem become rotten and caused a huge loss of the

betel vine growers, reduces the quality of betel leaf and hence the farmers deprived from the usual market price. Satkhira is a well known and the major betel vine growing district in Bangladesh. Most of the marginal farmers are involved in betel vine cultivation, as it is a continuous source of income. The farmers of different upazillas viz. Kalaroa, Tala, Assasuni, Debhata, Kaligonj etc grows betel vine regular basis and contribute a lot to meet up the national demand as well as exporting betel vine leaf abroad. For continuous cultivation, the, Rhizom rot infestation seem to be alarming for inoculum potential. But recently they are in troubles to grow betel vine due to the various disease problem. Thus the area was selected for investigation.

On the basis of above facts the present investigation is undertaken with the following objectives :

1. Survey on the predominant betel vine diseases presently occurring in different upazillas of Satkhira district.
2. To find out the disease incidence and disease severity of foot and root rot and leaf rot of betel vine diseases.
3. To find out the effect of weather on disease incidence and severity of betel vine diseases.

CHAPTER II

REVIEW OF LITERATURE

Betel vine (*Piper betle* L.) is prone to attack of many diseases at all stages of growth. The diseases of betel vine have been studied in Bangladesh to a limited extent. Humid and moist shaded conditions are favorable for its growth. But these humid and moist shaded conditions are very prone to root and foliage disease development of betel vine. The serious diseases viz. leaf rot and foot and root rot caused a huge loss of the betel vine growers. Leaf rot of betel vine caused by *Phytophthora parasitica* var. *piperina* is the most common in betel vine garden and this disease is endemic and cause serious problem all over the betel vine growing regions in Bangladesh. Foot and root rot of betel vine caused by *Sclerotium rolfsii* Sacc. is also a devastating soil borne pathogenic fungus with a wide host range of agricultural and horticultural crops and very much difficult to control. The fungus *Sclerotium rolfsii* Sacc. is also a facultative saprophyte and can maintain continuity of generation under adverse situation by the formation of sclerotia.

In this chapter an attempt has been made to review the available literature about leaf rot and foot and root rot of betel vine, their history and geographical distribution, nomenclature, symptomatology and causal organisms, diseases status and their management.

The leaf rot and foot and root rot of betel vine have been reported from almost all betel vine growing countries in the world including Indonesia, Myanmar, Sri Lanka (Paul, 1939) and Bangladesh (Roy, 1948; Turner, 1969) etc. Dastur (1926) first reported this disease of Pan (*P. betle* L.) caused by *P. parasitica*. Stem portion of *P. betle* in Ceylon was reported to be attacked by *Phytophthora* sp. (Anonymous, 1928). In West Bengal, the highest intensity of foot and root rot and leaf rot have been recorded in Midnapore and Nadia district (Dasgupta

and Sen, 1997 & 1999). The extent of losses may vary from 30 – 100% in case of foot and root rot and 20 – 40% in case of leaf rot, leading to almost total crop failure (Maiti and Sen, 1982; Dasgupta *et al.*, 2000).

An epidemiological studies were reported that the maximum temperature, maximum relative humidity and rainfall played an important role in the development of both the diseases of betel vine (*Piper betle* L.). (Anonymous, 2000-2006; Maiti and Sen, 1982).

Dastur (1935) gave an well accepted description of the symptoms of *Phytophthora* diseases of betel vine (*Piper betle* L.). In *Phytophthora* induced foot rot, wet rot associated with wilting of vines is common. In the diseased plants fine young roots are infected first. Gradually the rotting spreads through older roots and ultimately reaches the foot or collar region of the plant. In a diseased plant, the whole underground portion gets more or less completely rotten. The soft tissues of old roots and the inter-nodal portion of the cuttings are completely decomposed by the pathogen, leaving only the fibrous portion. In case of leaf rot of betel vine, the initial symptoms appear in the form of water soaked spots, enlarging rapidly in size, on mature leaves near the soil. The spots are of two types, one type is circular, necrotic, deep brown in colour with distinct grey-brown zonation and the other is expanding, circular, dark-brown necrotic spot without any zonation. The central rotten portion of the spot drops out, leaving a hole with irregular edges. In both of these types, the symptoms develop on any part of the leaves, including tips and margins. The two types of spots are an expression of fluctuating (Type-I) and continuous high humidity (Type-II), respectively. (Maiti and Sen, 1977).

In case of foot and root rot of betel vine, the leaves and shoots turn yellow, wither and finally dry out to a pale brown colour. The fungus attack the roots and stem near the soil level. Black lesion develops following necrosis of the plant cells. The mycelium invades the stem and rots the affected portions. As a

result, the plant wilts and gradually dies. Abundant white mycelium and small light brown Sclerotia form on the rotted plants. Gradually the rotting spreads through older roots and ultimately reaches the foot or collar region of the plant. In a diseased plant, the whole underground portion gets more or less completely rotten. The soft tissues of old roots and the inter-nodal portion of the cuttings are completely decomposed by the pathogen, leaving only the fibrous portion. When the infection is first evident in internodes away from the soil surface, the aerial parts of the plants appear to remain normal and healthy for a long time as the internodes above the diseased portion still continue to function. The disease in internodes can be easily detected by the blackening of the tissues inside. The infection to aerial parts does not usually extend beyond one or two internodes because the plant is killed before the disease progresses further (Dastur ,1935).

Chattopadhyay and Maiti (1990) observed that the plants of betel vine are cultivated in conservatories under shady and humid conditions that also favors the development of many diseases. Vines grows best under the shaded, tropical forest ecological conditions with a rainfall of about 2250-4750 mm, relative humidity and temperature ranging from 40-80% and 15-40°C, respectively. A well-drained fertile sandy or sandy loam or sandy clay soil with pH range of 5.6 to 8.2 is considered suitable for its cultivation (CSIR, 1969; Guha and Jain, 1997). However, in the areas with lower rainfall (1500- 1700 mm) the crop is cultivated with small and frequent irrigations, i.e. every day in summer and every 3-4 days in winter, whereas adequate drainage is required during the rainy season (Jana, 1995).

Mc-Rae (1928) established the parasitism of *Phytophthora* species. Species identification of foot rot and leaf rot pathogen is still in a state of flux. There is considerable confusion regarding the nomenclature of the species of *Phytophthora* causing disease(s) under consideration. Later Mc Rae (1934) by

morphological study identified *P. nicotianae* var *parasitica*. The *Phytophthora* species reported to attack betelvine includes *P. nicotianae* var. *parasitica* (Mc Rae, 1934), *P. nicotianae* var. *piperina* (Dastur, 1927) *P. parasitica*, *P. palmivora* (Maiti and Sen, 1977). Turner (1969) referred all isolates of *Phytophthora* from Southeast Asia as ‘*palmivora*’ type and this was stated to be true for the Indian isolates as reported by Maiti and Sen (1977). Based on existing keys to *Phytophthora* spp. all the isolates from Assam were identified as *Phytophthora palmivora* (Butl.). Mohanty (2000) isolated 16 isolates *Phytophthora* from different betelvine gardens of West Bengal and identified the isolates as *parasitica*. A new species of *Phytophthora* (*P. capsici*) isolated and identified as pathogenic to betel vine was reported from Tamilnadu centre of AICRP.

CHAPTER III

MATERIALS AND METHODS

3.1. Location of survey

Survey was conducted at different upazillas of major betel vine growing locations in the district of Satkhira. Six upazillas viz. Kalaroa, Tala, Satkhira Sadar, Assasuni, Debhata and Kaligonj were the survey area. Altogether six borojes (betel vine garden) in six upazillas were evaluated for recording diseases of betel vine.

3.2. Period of survey

Surveys were made in August to December of two consecutive years, 2010 and 2011. The data collection was made once in a month. The time of data collection was scheduled on the basis of variations in temperature, relative humidity and rainfall.

3.3. Topography and soil

The experimental site was situated in the sub-tropical zone. The soil of the experimental site lies in Agro-Ecological Zone (AEZ No. 08)- Ganges Tidal Floodplain (AEZ-BARC/FAO/UNDP, 1988). The greater part of this region has smooth relief having large areas of salinity. Non-calcareous grey flood plain soil is the major component of general soil type. Acid sulphate soil also occupies a significant part of the area where it is extremely acidic during the dry season. Most of the top soils are acidic and sub soils are neutral to mildly alkaline. The land type of the different upazillas in Satkhira are medium high to medium low, the soil is silty clay and loam in texture having a pH 6.5 to 7. Soil colour is grey. Generally fertility level is high, with medium to high organic matter content.

3.4. Weather and climate

The experimental location is situated at 21⁰40¹ to 22⁰55¹ N latitude and 88⁰55¹ to 89⁰55¹ E longitude in Satkhira district and it is approximately 16 feet high above the sea level (Appendix-III). The macro-climate of the experimental areas are sub-tropical in nature characterized by two distinct seasons, the monsoon or rainy season extending from April to September and Rabi season extending from October to March. Hot and humid condition occurs in rainy season with high rainfall. Scanty rainfall and plenty of sunshine prevailing during Rabi season. Details of the meteorological data regarding temperature, rainfall and relative humidity during the period (2010 & 2011) of experiment were collected from the Weather Yard. Bangladesh Abohawa Odidoptor, Agargaon, Sher-e-Bangla nagar, Dhaka-1216, presented in Appendix-I and Appendix-II.

3.5. Data collection during survey

During the survey, the cultivation area of betel vine, name of the cultivars and different diseases observed in the “boroj” were recorded. In each growing upazilla, five survey spots randomly selected for data recording. Each spots covered an area of approx. 700 sq-m. farmers plots. Cultivars of betel vine available in those area were considered for investigation. Six visit were made to each spot in each year during the study period. Sixteen plants were selected randomly from each spot. Every selected plants was observed carefully and symptoms of the diseases were recorded.

Data were recorded on the following parameters:

- a) Total betel vine plants/selected spot
- b) Diseased plants/selected spot
- c) Total leaf/plant
- d) Leaf area diseased
- e) Total leaf area
- f) % Plant infection
- g) % Disease severity
- h) Relative Humidity (R_H), temperature and rainfall.

3.6. Assessment of disease incidence and severity

Assessment of disease incidence and severity of the diseases were calculated by the following formula:

$$\% \text{ Plant infection} = \frac{\text{Number of diseased plants}}{\text{Number of total plants inspected}} \times 100$$

% Disease severity was calculated using the formula as:

$$\% \text{ Disease severity} = \frac{\text{Area of leaf tissue infected by disease}}{\text{Total leaf area inspected}} \times 100$$

3.7. Isolation of causal organisms

The causal organisms of foot and root rot and leaf rot of betel vine were isolated from the diseased leaves, stem and affected root from different upazillas in Satkhira district. To identify the pathogen, the diseased leaves/stem were collected from the infected plant and transferred to the laboratory. The diseased leaves/stem were cut into small pieces (about 0.5-1cm) and surface sterilized by

dipping in 10% Sodium Hypochlorite (NaOCl) solution for 2-3 minutes. The cut pieces were then washed in sterilized water at the three times and were placed into PDA media in sterilized petridish with the help of sterile forceps and incubated at $22 \pm 2^{\circ}$ C for 7-10 days. Then the organisms that grow purely into the culture were isolated by hyphal tip culture method and recultured to get pure culture of the organism.

3.8. Preparation of Potato Dextrose Agar (PDA) medium

Potato Dextrose Agar (PDA) medium was prepared following the standard procedure. At first, 200g potato was taken followed by washing with tap water. Then the potato was peeled and cut in a slice and boiled in one liter water. When potato was soft fully, it was sieved. After that 20g dextrose and with a few minutes interval, 15g Agar were mixed slowly with it and stirred properly so that it can not be coagulated. The pH was adjusted to 6.5 of the media by using pH meter with the help of 1N HCL or 1N NaOH and kept the media in the conical flask and then sterilized the media in an autoclave at temperature of 121° C with 15 PSI pressure for about 20 minutes. All the works were done aseptically inside the laminar air flow cabinet.

3.9. Statistical analysis of data :

The data were statistically analyzed by using computer package program (MSTAT-C). The significant difference of the treatment means were compared by Duncan's Multiple Range Test (DMRT).

CHAPTER IV

RESULTS

In Satkhira district, six upazillas were surveyed to investigate on different diseases of betel vine. The upazillas were Tala, Kalaroa, Satkhira Sadar, Assasuni, Debhata and Kaligonj. Altogether 16 unions of those six upazillas were found to cultivate betelvine commercially in approximate 526 ha of land (Table-1). Mainly local cultivars Jhalpaan, Sanchipaan, Bhabnapaan, Mithapaan, Gesopaan and Bonhooglypaan were found to cultivate in that area. Jhalpaan occupied the 90% area of the cultivated land. The diseases and their symptoms as observed in six upazillas were as follows:

4.1. Leaf rot of betel vine

During rainy season when very wet conditions prevail for a number of days, leaves of betel vine is infected by the leaf rot. The disease characterized by the presence of circular black or brownish water soaked spots. The initial symptoms appear in the form of water soaked spots, enlarging rapidly in size, on mature leaves near the soil. The spots are of two types, one type is circular, necrotic, deep brown in colour with distinct grey-brown zonation and the other is expanding, circular, dark-brown necrotic spot without any zonation. The central rotten portion of the spot drops out, leaving a hole with irregular edges. In both of these types, the symptoms develop on any part of the leaves, including tips and margins. The two types of spots are an expression of fluctuating (Type-I) and continuous high humidity (Type-II), respectively. These spots rapidly increase in size and coalesce with each other, involving a major area in the leaf blade, which undergoes rotting when the weather is continuously wet. If the conditions still continue to be favorable, the rot proceeds to the petiole and eventually to the stem.

In dry conditions, the infected leaf shows wrinkles and becomes reduced in size. The infection also remains localized and the infected black area is surrounded by a brown zone and presents a dry parched appearance. Infection is mainly confined mainly to the leaves which are located within a couple of feet from the ground surface (Plate-1, 2 and 3).

4.2. Foot and root rot of betel vine

The leaves and shoots turn yellow, wither and finally dry out to a pale brown colour. The fungus attack the roots and stem near the soil level. Black lesion develops following necrosis of the plant cells. The mycelium invades the stem and rots the affected portions. As a result, the plant wilts and gradually dies. Abundant white mycelium and small light brown sclerotia formed on the rotten plants. Gradually the rotting spreads through older roots and ultimately reaches the foot or collar region of the plant. In a diseased plant, the whole underground portion gets more or less rotten. The soft tissues of old roots and the inter-nodal portion of the cuttings are completely decomposed by the pathogen, leaving only the fibrous portion. When the infection is first evident in internodes away from the soil surface, the aerial parts of the plants appear to remain normal and healthy for a long time as the internodes above the diseased portion still continue to function. The disease in internodes can be easily detected by the blackening of the tissues inside. The infection to aerial parts does not usually extend beyond one or two internodes because the plant is killed before the disease progresses further (Plate-5, 6 and 7).

4.3. Disease incidence (%) of leaf rot of betel vine in 2010

Disease incidence of leaf rot of betel vine in different upazillas of Satkhira district were found to vary significant from one upazilla to another upazilla and one month to another month (Table-2). Maximum disease incidence were recorded in Tala upazilla where disease incidence ranged from 13.33% to 38.54% and minimum disease incidence were recorded in Satkhira sadar upazilla where disease incidence ranged from 6.33% to 18.33%. The highest disease incidence were found in August (18.33% to 38.54%) and the lowest disease incidence were found in December (6.33% to 13.33%). Mean disease incidence for 2010 and 2011 was gradually decreased from August to December (Figure 1).

4.4. Disease incidence (%) of leaf rot of betel vine in 2011

Disease incidence of leaf rot of betel vine in different upazillas of Satkhira district were varied significantly from one upazilla to another upazilla and also from one month to another (Table-3). The maximum disease incidence were recorded in Tala upazilla where disease incidence ranged from 12% to 55.33% and the minimum disease incidence were recorded in Satkhira sadar upazilla where disease incidence ranged from 0% to 36.42%. The highest disease incidence were found in August (36.42% to 55.33%) and the lowest disease incidence were found in December (0% to 12%). Cumulative disease incidence for 2010 and 2011 was also gradually decreased from August to December (Figure1).

Table 1: Survey areas of betel vine in Satkhira district.

Upazilla	Union	Growing area (ha)	Cultivars name
Kalaroa	Keralkata	50	Jhalpaan
	Sonabaria		Mithapaan
	Kalaroa Sadar		
	Joynagar		
Tala	Islamkathi	200	Jhalpaan
	Jalalpur		Sanchipaan
	Kumira		Bhabnapaan
	Sorulia		Gesopaan
	Tala Sadar		
	Khalishkhali		
Satkhira Sadar	Jhaudanga	25	Jhalpaan
	Agardari		Sanchipaan
Assasuni	Budhata	100	Jhalpaan
	Kulla		Bhabnapaan
	Khajra		Bonhooglypaan
Debhata	Debhata Sadar	01	Jhalpaan
Kaligonj	Bharasimla	150	Jhalpaan
	Nalta		Sanchipaan
Total		526	

Table 2: Disease incidence of leaf rot of betel vine in different upazilla of Satkhira district in 2010.

Upazilla	% Disease Incidence (Monthwise)					
	July	August	September	October	November	December
Kalaroa	14.36 b	27.33 b	22.67 bc	20.00 b	13.00 b	8.33 b
Tala	20.33 a	38.54 a	24.33 a	22.33 a	17.33 a	13.33 a
Satkhira Sadar	7.00 d	18.33 d	14.33 e	7.00 d	6.67 d	6.33 b
Assasuni	14.33 b	28.67 b	22.33 c	13.33 c	9.33 c	7.33 b
Debhata	11.00 c	24.33 c	20.72 d	14.33 c	13.33 b	7.67 b
Kaligonj	19.67 a	27.33 b	23.67 ab	21.00 ab	16.33 a	11.33 a
LSD	1.635	2.031	1.015	1.542	2.319	2.912
cv%	4.37	2.86	1.84	3.65	7.07	12.42

Table 3: Disease incidence of leaf rot of betel vine in different upazillas of Satkhira district in 2011.

Upazilla	% Disease Incidence (Monthwise)					
	July	August	September	October	November	December
Kalaroa	36.33 c	41.65 c	17.33 d	16.67 c	11.33 c	0.00 c
Tala	49.00 a	55.33 a	42.33 a	36.33 a	24.00 a	12.00 a
Satkhira Sadar	29.67 d	36.42 d	17.00 d	17.33 c	11.33 c	0.00 c
Assasuni	36.33 c	42.33 c	30.33 c	5.33 e	1.75 e	0.00 c
Debhata	35.67 c	42.33 c	30.67 c	11.00 d	4.67 d	0.00 c
Kaligonj	41.67 b	53.67 b	35.00 b	24.00 b	17.33 b	5.67 b
LSD	2.746	1.626	1.896	1.548	2.408	0.6846
cv%	2.78	1.39	2.55	3.24	7.93	8.99

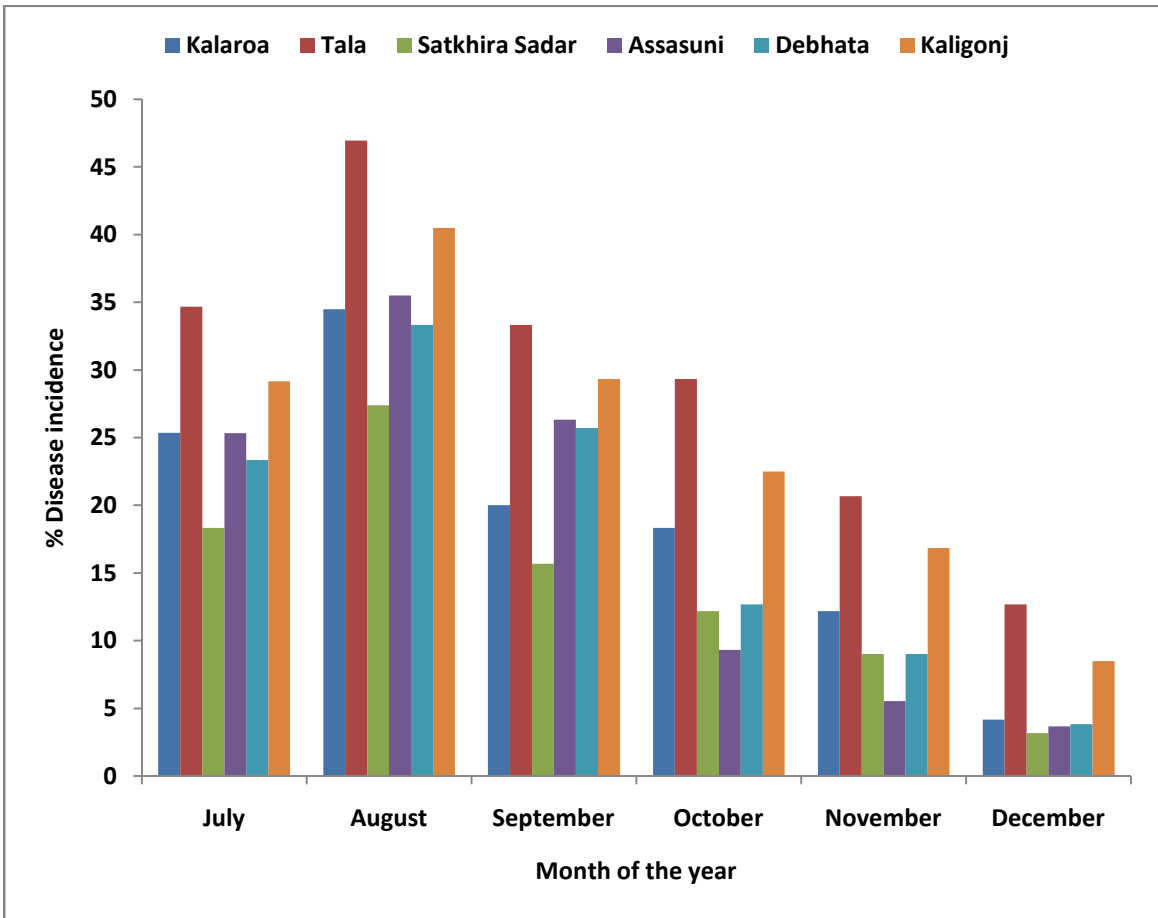


Figure 1: Mean disease incidence of leaf rot of betel vine in different upazillas of Satkhira district in 2010 and 2011.

4.5. Disease severity (%) of leaf rot of betel vine in 2010

Disease severity of leaf rot of betel vine in different upazillas of Satkhira district were found to vary from one upazilla to another upazilla and one month to another month (Table-4). The maximum disease severity were recorded in Tala upazilla, where disease severity ranged from 9.33% to 37% and the minimum disease severity were recorded in Satkhira sadar upazilla where disease severity ranged from 0.43% to 13.33%. The highest disease severity were found in August (13.33% to 37%) and the lowest disease severity were found in December (0.43% to 9.33%). Mean disease severity for 2010 and 2011 was gradually decreased from August to December (Figure2).

4.6. Disease severity (%) of leaf rot of betel vine in 2011

Disease severity of leaf rot of betel vine in different upazillas of Satkhira district were statistically different from one upazilla to another upazilla and one month to another month (Table-5). The maximum disease severity were recorded in Tala upazilla where disease severity ranged from 14.33% to 31.33% and the minimum disease severity were recorded in Satkhira sadar upazilla where disease severity ranged from 3.667% to 17.33%. The highest disease severity were found in August (17.33% to 31.33%) and the lowest disease severity were found in December (3.667% to14.33%). Mean disease severity for 2010 and 2011 was also gradually decreased from August to December (Figure2).

Table 4: Disease severity of leaf rot of betel vine in different upazillas of Satkhira district in 2010.

Upazilia	% Disease Severity (Monthwise)					
	July	August	September	October	November	December
Kalaroa	12.33 c	33.00 ab	23.67 b	16.67 b	3.00 d	3.00 b
Tala	27.00 a	37.00 a	27.00 a	19.00 a	17.33 a	9.33 a
Satkhira Sadar	9.67 e	13.33 e	10.17 a	8.33 d	2.33 d	0.43 c
Assasuni	11.00 d	23.33 d	16.00 c	8.67 d	4.33 cd	4.00 b
Debhata	13.00 c	13.67 e	14.67 d	7.00 e	5.67 c	2.33 bc
Kaligonj	16.00 b	27.33 c	26.00 a	14.33 c	11.00 b	2.00 bc
LSD	1.101	1.626	1.174	1.205	2.386	1.893
cv%	2.87	2.54	2.32	3.77	12.67	20.8

Table5: Disease severity of leaf rot of betel vine in different upazillas of Satkhira district in 2011.

Upazilla	% Disease Severity (Monthwise)					
	July	August	September	October	November	December
Kalaroa	15.33 c	28.33 c	24.00 b	21.00 a	13.33 b	9.00 b
Tala	21.00 a	31.33 a	26.33 a	21.00 a	19.00 a	14.33 a
Satkhira Sadar	7.67 f	17.33 e	15.33 d	10.00 d	7.33 d	3.67 c
Assasuni	14.33 d	29.33 bc	22.00 c	15.00 b	12.33 b	10.67 b
Debhata	11.33 e	25.67 d	21.33 c	15.67 b	9.67 c	5.00 c
Kaligonj	19.33 b	30.00 ab	24.33 b	12.00 c	7.67 d	4.33 c
LSD	0.9989	1.583	1.134	1.726	1.776	2.003
cv%	2.60	2.26	1.97	4.23	5.94	9.88

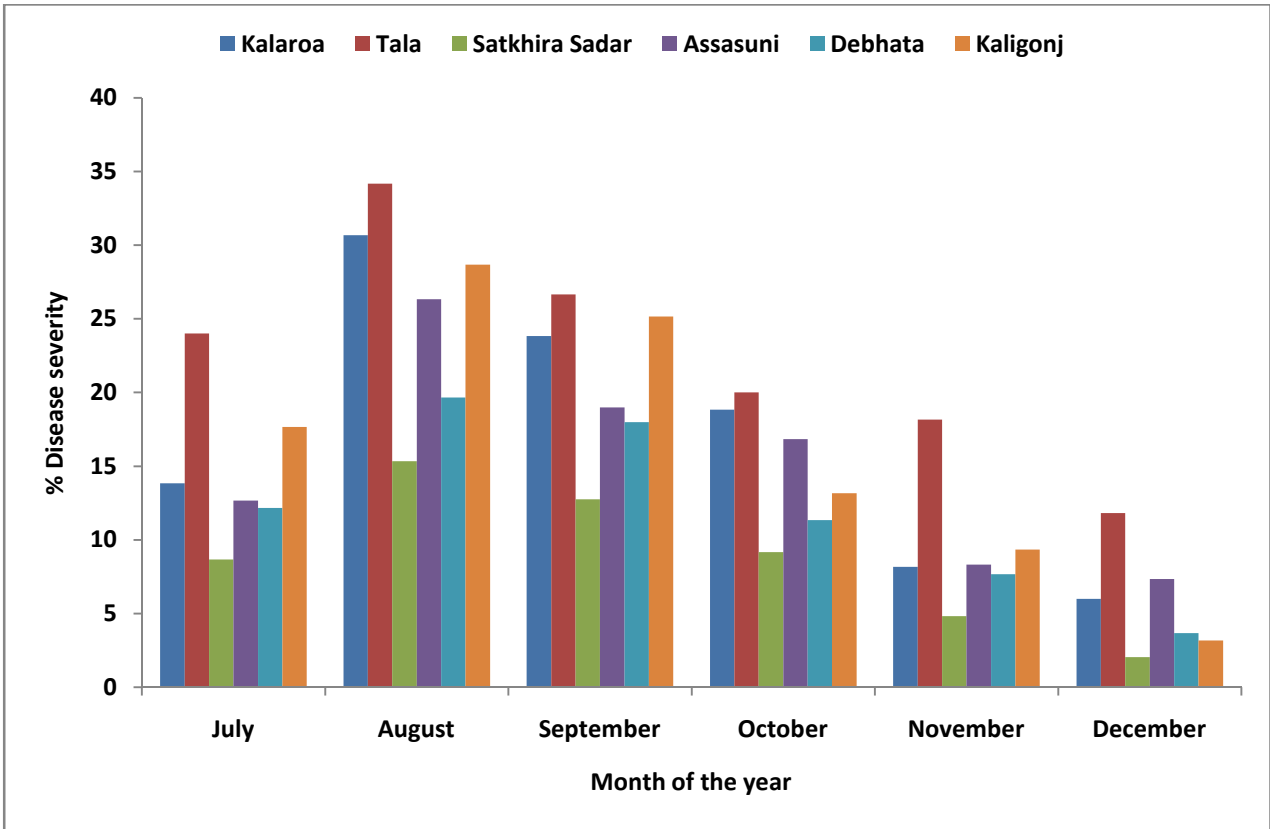


Figure 2: Mean disease severity of leaf rot of betel vine in different upazillas of Satkhira district in 2010 and 2011.



Plate 1. Field view of infected betel vine



Plate 2. Symptom of leaf rot disease of betel vine caused by *Phytophthora parasitica* .



Plate 3. Leaf rot symptoms in leaf.

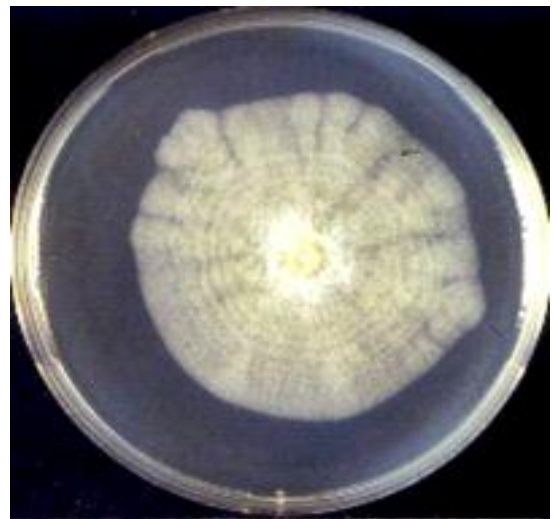


Plate 4. Pure culture of *Phytophthora parasitica*

4.7. Disease incidence (%) of foot and root rot of betel vine in 2010

Disease incidence of foot and root rot of betel vine in different upazillas of Satkhira district were significantly varied from one upazilla to another upazilla and one month to another month (Table-6). The maximum disease incidence were recorded in Tala upazilla where disease incidence ranged from 8.33% to 31.50% and the minimum disease incidence were recorded in Satkhira sadar upazilla where disease incidence ranged from 0% to 12.50%. Highest disease incidence were found in August (12.50% to 32.50%) and lowest disease incidence were found in December (0% to 8.33%). Cumulative disease incidence for 2010 and 2011 was gradually decreased from August to December (Figure-4).

4.8. Disease incidence (%) foot and root rot of betel vine in 2011

Disease incidence of foot and root rot of betel vine in different upazillas of Satkhira district were found to vary significantly from one upazilla to another upazilla and one month to another month (Table-7). The maximum disease incidence were recorded in Tala upazilla where disease incidence ranged from 2.08% to 50% and the minimum disease incidence were recorded in Satkhira sadar upazilla where disease incidence ranged from 0% to 18.75%. The highest disease incidence were found in August (18.75% to 50%) and the lowest disease incidence were found in December (0% to 2.08%). Cumulative disease incidence for 2010 and 2011 was also gradually decreased from August to December (Figure-4).

Table 6: Disease incidence of foot and root rot of betel vine in different upazillas of Satkhira district in 2010.

Upazilla	% Disease Incidence (Monthwise)					
	July	August	September	October	November	December
Kalaroa	14.58 ab	20.83 a	14.58 ab	4.17 c	0.00 c	0.00 b
Tala	22.92 a	31.50 a	19.00 a	20.83 a	10.42 a	8.33 a
Satkhira Sadar	6.25 b	12.50 a	6.25 b	0.00 c	0.00 c	0.00 b
Assasuni	10.42 b	25.00 a	14.58 ab	2.08 c	0.00 c	0.00 b
Debhata	8.33 b	20.83 a	8.33 ab	6.25 bc	0.00 c	0.00 b
Kaligonj	14.58 ab	33.33 a	16.67 ab	12.50 b	6.25 b	4.17 ab
LSD	8.693	20.77	10.62	6.379	3.812	5.114
cv%	26.15	33.44	31.00	32.27	53.03	94.87

Table 7: Disease incidence of foot and root rot of betel vine in different upazillas of Satkhira district in 2011.

Upazilla	% Disease Incidence (Monthwise)					
	July	August	September	October	November	December
Kalaroa	16.67 ab	25.00 b	14.58 bc	8.33 bc	2.08 bc	0.00 a
Tala	25.00 a	50.00 a	37.50 a	16.67 a	8.33 a	2.08 a
Satkhira Sadar	2.08 c	18.75 b	6.25 cd	0.00 c	0.00 c	0.00 a
Assasuni	12.50 bc	22.92 b	14.58 bc	6.25 bc	4.17 abc	0.00 a
Debhata	8.33 bc	18.75 b	8.33 cd	8.25 bc	2.08 bc	0.00 a
Kaligonj	18.75 ab	47.92 a	22.92 b	10.42 ab	6.25 ab	0.00 a
LSD	11.31	20.17	10.09	7.747	5.654	3.812
cv%	31.46	25.51	22.45	35.98	57.21	424.26

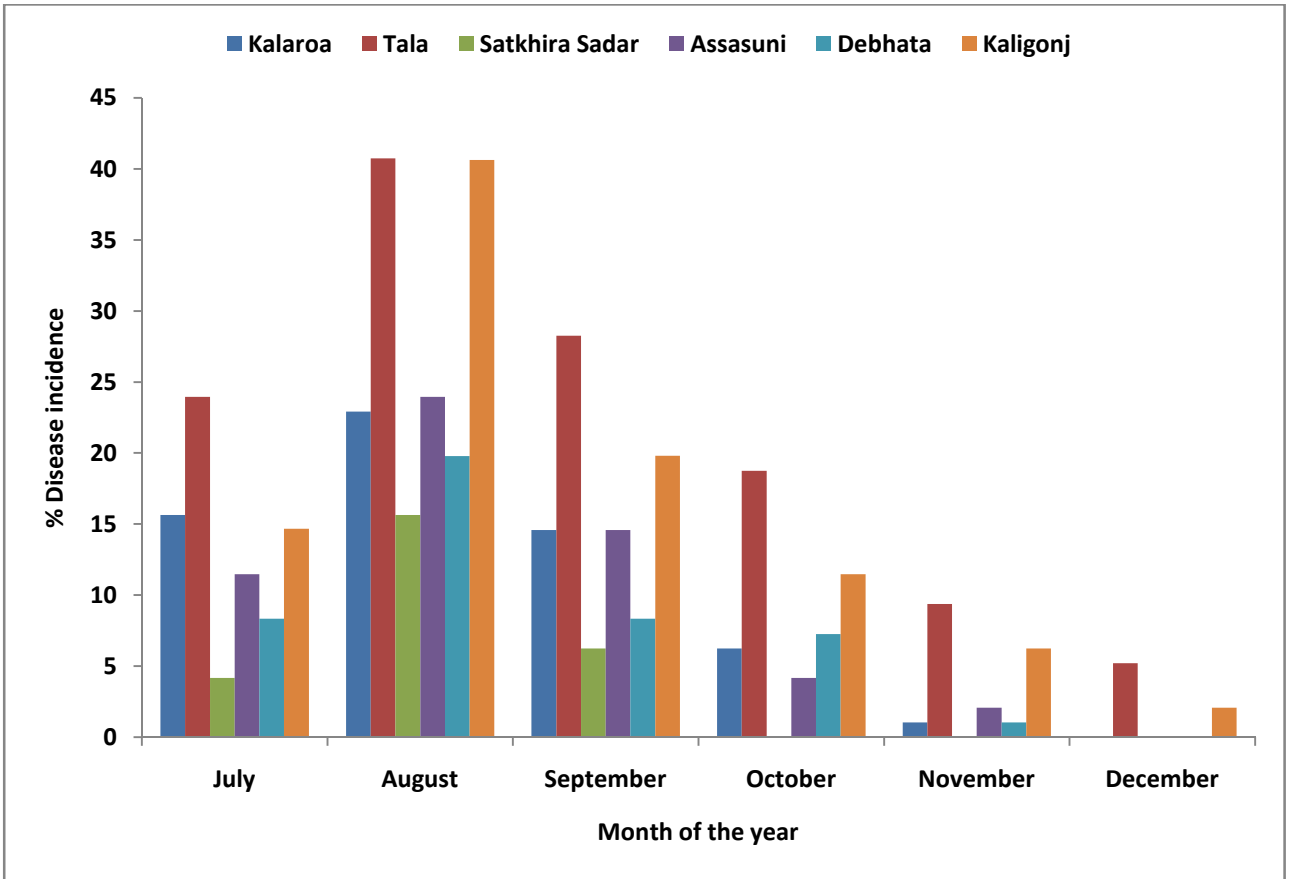


Figure 3: Mean disease incidence of foot & root rot of betel vine in different upazillas of Satkhira district in 2010 and 2011.



Plate 5. Field view of infected betel vine



Plate 6. Foot rot disease of betel vine caused by *Sclerotium rolfsii*.



Plate 7. Root rot disease of betel vine.



Plate 8. Pure culture of *Sclerotium rolfsii*.



Plate 9. Mycelial growth of *S. rolfsii*.



Plate 10. Sclerotia formation by *S. rolfsii*.

4.9. Effect of weather factors on disease incidence and severity of foot and root rot and leaf rot of betel vine

Weather factors found to have profound effect on disease development in epidemic form. Temperature, Relative humidity and Rainfall played an important role in the development of the diseases.

4.9.1. Effect of temperature on disease incidence and disease severity of leaf rot of betel vine:

Temperature played an important role in development of disease in respect of time. Disease incidence and disease severity of leaf rot of betel vine were significantly varied from one counting to another (graph1). When temperature laid around 29 °C the disease incidence and severity was the highest in August. The disease incidence and severity gradually decreased with the decrease of atmospheric temperature and it was the lowest at 18 °C in December in both of the year.

4.9.2. Effect of relative humidity on disease incidence and disease severity of leaf rot of betel vine:

Humidity played a vital role in the disease development in respect of time. Disease incidence and disease severity of leaf rot of betel vine in Satkhira district were varried from one counting to another (graph2). When relative humidity was the highest than disease progress was the highest, when relative humidity was the lowest than disease progress was the lowest. Maximum disease incidence and disease severity of leaf rot of betel vine was recorded at 85% R_H in August and minimum disease incidence and disease severity of leaf rot of betel vine was recorded at 78% R_H in December in 2010 and 2011.

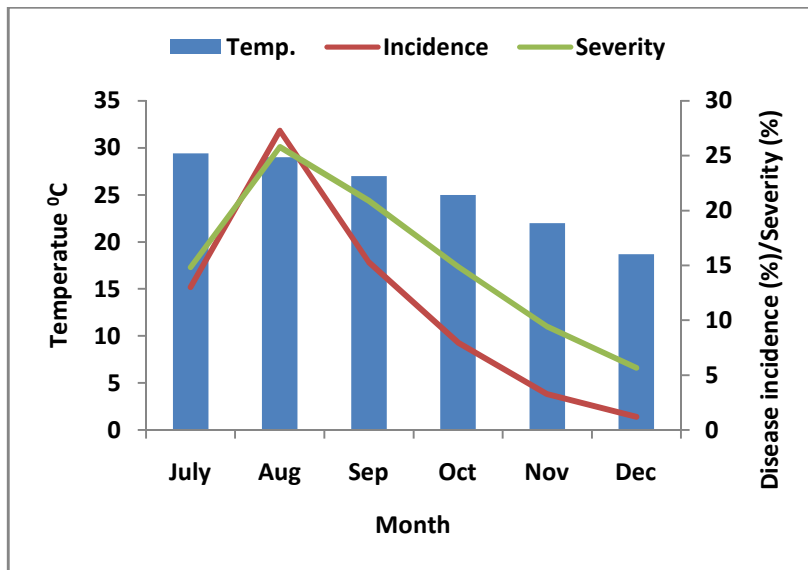


Figure 4: Effect of temperature on disease incidence and disease severity of leaf rot of betel vine in Satkhira district.

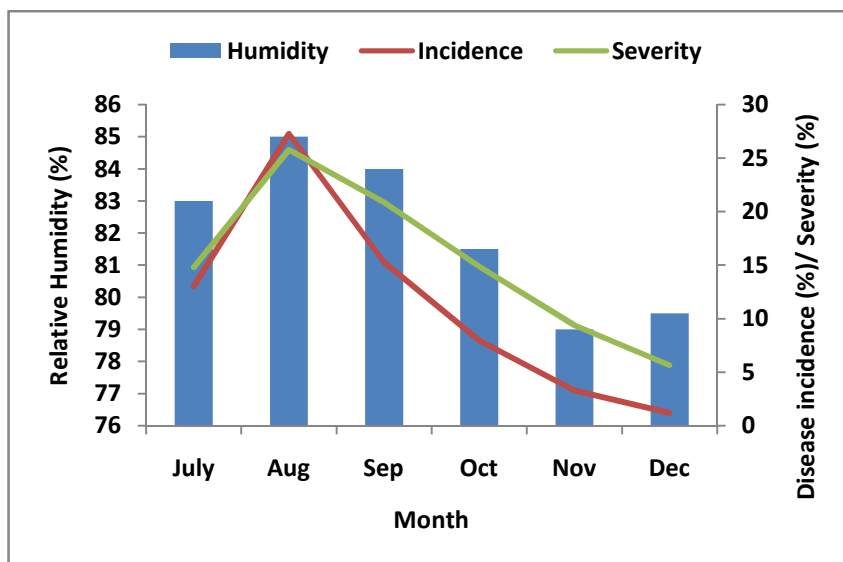


Figure 5: Effect of humidity on disease incidence and disease severity of leaf rot of betel vine in Satkhira district

4.9.3. Effect of rainfall on disease incidence and disease severity of leaf rot of betel vine

Rainfall was another factor that play an important role in disease development in respect of time. Disease incidence and disease severity of leaf rot of betel vine varied from one month to another (graph3). When rainfall was the highest, the disease was relatively higher, when rainfall was the lowest then disease was relatively lower. Maximum disease incidence and disease severity of leaf rot of betel vine was recorded at 396.5 mm rainfall in August and minimum disease incidence and disease severity of leaf rot of betel vine was recorded at 7.5 mm rainfall in December.

4.9.4. Effect of temperature on disease incidence of foot and root rot of betel vine

Disease incidence of foot and root rot of betel vine in Satkhira district were found to vary significantly in respect of different temperature (graph4). When temperature was the highest than disease progress was the highest, when temperature was the lowest than disease was the lowest. Maximum disease incidence of foot and root rot of betel vine was recorded at 29 °C in August and minimum disease incidence of foot and root rot of betel vine was recorded at 18.7 °C in December.

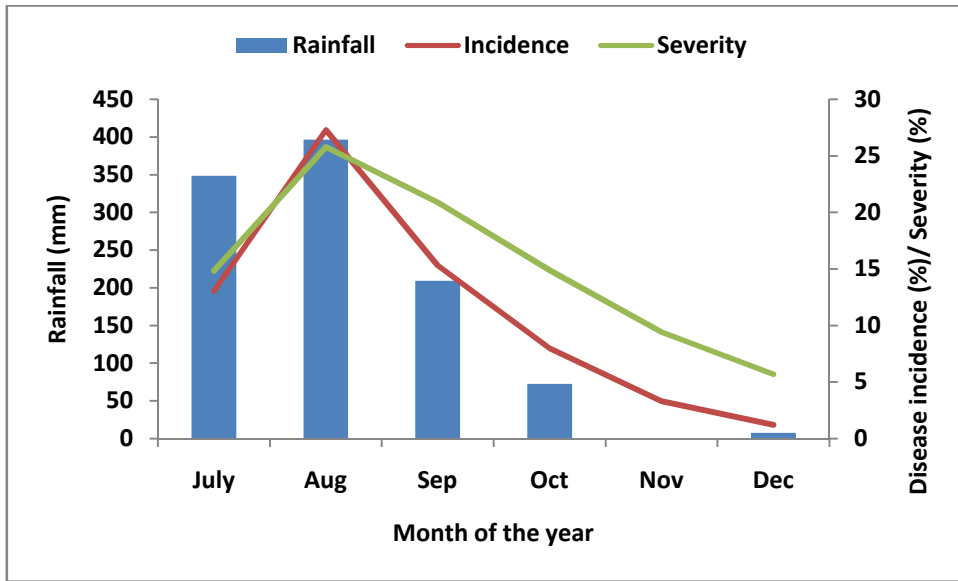


Fig. 6: Effect of rainfall on disease incidence and disease severity of leaf rot of betel vine in Satkhira district.

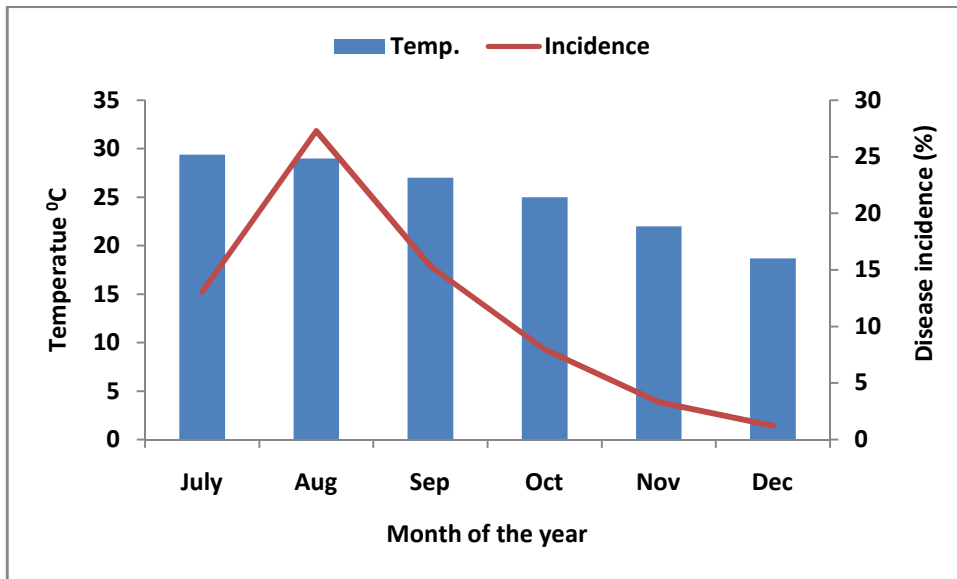


Fig. 7: Effect of temperature on disease incidence of foot and root rot of betel vine in Satkhira district.

4.9.5. Effect of relative humidity on disease incidence of foot and root rot of betel vine

Disease incidence of foot and root rot of betel vine in Satkhira district were found to vary from one season to another (Fig. 9). When relative humidity was the highest then disease progress was the highest, when relative humidity was the lowest then disease was the lowest. Maximum disease incidence of foot and root rot of betel vine was recorded at 85% R_H in August and minimum disease incidence of foot and root rot of betel vine was recorded at 78% R_H in December.

4.9.6. Effect of rainfall on disease incidence and disease severity of foot and root rot of betel vine

Disease incidence of foot and root rot of betel vine in Satkhira district were significantly varied in respect to amount of rainfall (Fig. 10). When rainfall was the highest than disease progress was higher, when rainfall was the lowest than disease progress was lower. Maximum disease incidence of foot and root rot of betel vine was recorded at 396.5 mm rainfall in August and minimum disease incidence of foot and root rot of betel vine was recorded at 7.5 mm rainfall in December.

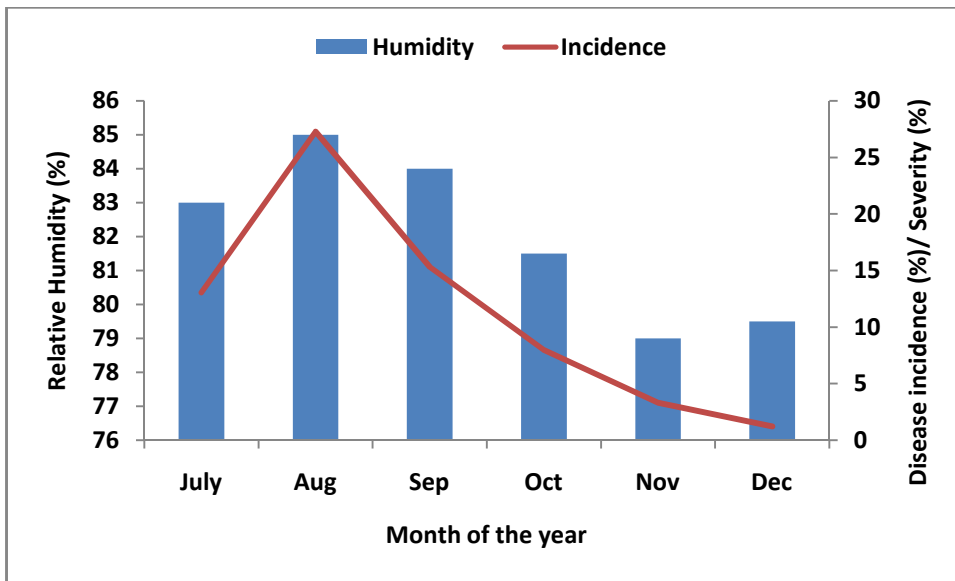


Fig. 8: Effect of humidity on disease incidence of foot and root rot of betel vine in Satkhira district.

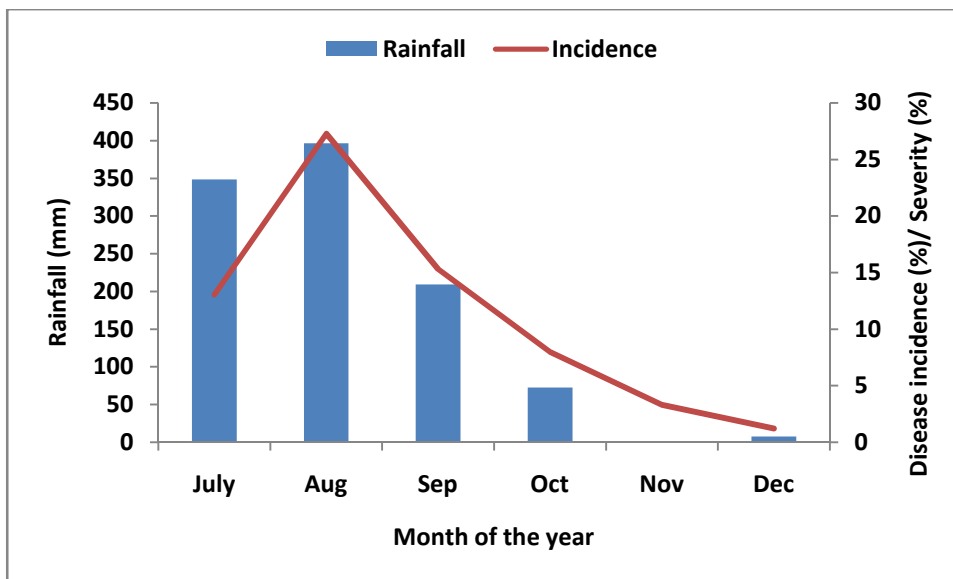


Fig. 9: Effect of rainfall on disease incidence of foot and root rot of betel vine in Satkhira district.

CHAPTER V

DISCUSSION

Betel vine (*Piper betle* L.) is an important cash crop grown on a commercial scale in Satkhira district. The major constraint to cultivation of betel vine is its diseases that severely damage foot, stem, root and foliage. Plants of betel vine are cultivated in conservatories under shady and humid conditions that also favours the development of many diseases (Chattopadhyay and Maiti, 1990). Interestingly, a small “Boroj” of even 10-15 decimals may provide considerable net profit for maintaining a small family of five members (Jana, 1995; SDAMM, 1996). Such a “Boroj” may be termed as a household bank since the leaves can be plucked and sold straight in the market as and when hard cash is required and this may continue for 10-30 years or more (Chattopadhyay, 1981; Jana, 1995). Further, since the leaves mature within 15-30 days (Jana, 1995) therefore, 1-4 harvestings are normally done every month (Guha and Jain, 1997). Thus, cultivation of betel vines provide a continuous source of income to the farming family unlike the major crops, which provide income only once in a year or so. Betel vine is cultivated mainly under an artificially erected structure, known as “Boroj”, “Bareja” or “Bheet”, which is a kind of hut whose sides and roof are made of jute slaths or straw on a light framework of bamboo. Two diseases viz. leaf rot and foot and root rot of betel vine were recorded during the investigation of 2010-2011. Leaf rot of betel vine disease found in all the locations under the survey areas viz. Kalaroa, Tala, Satkhira Sadar, Assasuni, Debhata and Kaligonj in Satkhira district.

Leaf rot of betel vine was recorded as a common disease in all the growing areas. Regarding locations of survey, higher number of disease incidence (46.94%) and disease severity (34.16%) of leaf rot diseases of betel vine were found in August at Tala upazilla having average temperature 29 °C, relative

humidity (85%) and rainfall 396.5 mm. On the contrary lower amount of disease incidence (3.16%) and disease severity (2.05%) of leaf rot diseases of betel vine was found in December at Satkhira Sadar upazilla having average temperature 18.7 °C, relative humidity (79.5%) and rainfall 7.5 mm in Satkhira district. On the other hand higher disease incidence (40.75%) of foot and root rot diseases of betel vine were found in August at Tala upazilla having average temperature 29 °C, relative humidity (85%) and rainfall 396.5 mm. No disease incidence (0%) of foot and root rot diseases of betel vine were found in December at Satkhira Sadar upazilla having average temperature 18.7 °C, relative humidity (79.5%) and rainfall 7.5 mm. Currently, there is a very little information regarding the presence, prevalence, epidemiology and management of diseases of betel vine in Bangladesh. As the diseases pose a potential threat to betel vine causing enormous loss in leaf quality and disruption of production schedules, it is imperative to investigate upazillas to get information on the identity, epidemiology and management of the pathogens that cause diseases. The growth and development of leaf rot of betel vine is influenced by temperature, relative humidity and rainfall. There was great variation of leaf rot incidence and severity of betel vine considering the location and growing time. On the other hand foot and root rot of betel vine disease was found in all the locations under survey areas viz. Kalaroa, Tala, Satkhira Sadar, Assasuni, Debhata and Kaligonj in Satkhira district. The incidence and severity of the diseases were found to vary from month to month, year to year as well as location to location.

The climate of Bangladesh harbors plant pathogens and provide luxuriant environment for the growth and reproduction of pathogens which cause hundreds of different diseases of crops (Fakir, 2001).

CHAPTER VI

SUMMARY AND CONCLUSION

The leaves of betel vine (*Piper betle* L.) have been traditionally used for chewing in our country. Chewing of betel leaves produce a sense of well-being, increased alertness, sweating, salivation, hot sensation and energetic feeling with exhilaration. On account of its immense medicinal, social, religious and export value betel vine is a cash crop of economic importance and is extensively grown on large scale in different parts of Bangladesh. Satkhira is a leading district in betel vine production and in export. Therefore the present study has been designed to survey the diseases of betel vine in selected district of Satkhira. In Satkhira district six upazillas viz. Kalaroa, Tala, Satkhira sadar, Assasuni, Debhata and Kaligonj were surveyed. The disease incidence and severity of leaf rot and foot and root rot varied significantly from location to location and month to month. In Kalaroa, disease incidence and severity of leaf rot of betel vine ranged from 4.16 to 34.49% and 6 to 30.66% respectively where the maximum disease was recorded in August and the minimum was in December. In case of foot and root rot of betel vine in Kalaroa, disease incidence ranged from 0 to 22.91% where the highest and the lowest count were recorded in August and December, respectively. In Tala, disease incidence and severity of leaf rot of betel vine ranged from 12.66 to 46.93% and 11.83 to 34.16%, respectively where maximum disease was recorded in August and the minimum was in December. In case of foot and root rot of betel vine in Tala, the disease incidence ranged from 5.20 to 40.75% where maximum and minimum diseases were recorded in August and December, respectively. In Satkhira sadar, disease incidence and severity of leaf rot of betel vine ranged from 3.16 to 27.37% and 2.05 to 15.33%, respectively where the maximum disease was recorded in August and the minimum in December. In case of foot and root rot of betel vine in Satkhira sadar ,disease incidence ranged from 00 to

15.62% respectively where maximum diseases were recorded in August and minimum diseases were recorded in October, November and December. In Assasuni, disease incidence and severity of leaf rot of betel vine ranged from 3.66 to 35.5% and 7.33 to 26.33% where the maximum disease was recorded in August and the minimum in December. In case of foot and root rot of betel vine in Assasuni, disease incidence ranged from 00 to 23.96% where the maximum disease was recorded in August and the minimum in December. In Debhata, disease incidence and severity of leaf rot of betel vine ranged from 3.83 to 33.33% and 3.66 to 19.67% where the maximum disease was recorded in August and the minimum in December respectively. In case of foot and root rot of betel vine in Debhata, disease incidence ranged from 0 to 19.79% where the maximum disease was recorded in August and the minimum in December respectively. In Kaligonj, disease incidence and severity of leaf rot of betel vine ranged from 8.49 to 40.5% and 3.167 to 28.65% where the maximum disease was recorded in August and the minimum in December respectively. In case of foot and root rot of betel vine in Kaligonj, disease incidence ranged from 2.08 to 40.62% where the maximum disease was recorded in August and the minimum disease was recorded in December. Temperature and humidity play an important role in development of leaf rot and foot and root rot of betel vine. In 29 °C and 85% R_H, the disease incidence and severity of leaf rot and foot and root rot of betel vine was the highest and with the decrease of temperature and humidity the incidence and severity gradually decreased and was the lowest when the temperature laid around 18.7 °C and the R_H laid around 75%.

From the findings of the present study it may be concluded that leaf rot and foot and root rot of betel vine are two most prevalent diseases in different upazillas of Satkhira district and there prevalence was higher in August and lower in December irrespective of the different betel vine growing areas of Satkhira

district. However further investigations are need to be carried out to ascertain the present findings for consecutive years.

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Appendix 1: Month wise air temperature ($^{\circ}\text{C}$), relative humidity (%) and rainfall (mm) from January to December 2010, in Satkhira district .

Month	Average air temperature ($^{\circ}\text{C}$)			Average relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum	Average		
January	24.1	11.2	16.7	76	0
February	29.2	16.4	22.2	73	3
March	34.6	23.5	28.3	70	1
April	36.1	27.0	30.7	73	25
May	35.1	26.1	30.1	78	214
June	34.3	26.9	30.1	84	318
July	33.2	27.0	29.5	84	269
August	33.5	26.8	29.4	84	155
September	32.6	26.2	28.8	85	202
October	32.4	24.6	27.8	84	92
November	30.6	20.3	24.6	80	1
December	25.6	13.3	18.4	78	15

Source: Bangladesh Abohawha Odidoptor Agargaoan, Sher-e-Bangla Nagar, Dhaka-1216.

Appendix 02: Month wise air temperature ($^{\circ}\text{C}$), relative humidity (%) and rainfall (mm) from January to December 2011, in Satkhira district .

Month	Average air temperature ($^{\circ}\text{C}$)			Average relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum	Average		
January	24.3	11.6	17.1	76	0
February	28.7	15.7	21.5	71	1
March	32.3	20.6	26.0	70	58
April	34.2	23.4	28.2	73	58
May	34.7	25.4	29.8	76	218
June	33.6	26.8	29.6	82	450
July	32.3	26.7	29.3	82	428
August	31.0	26.4	28.6	86	638
September	31.9	26.2	28.7	85	217
October	32.8	25.0	28.3	79	53
November	29.7	19.2	23.7	78	0
December	25	14.7	19.0	81	0

Source: Bangladesh Abohawha Odidoptor Agargaoan, Sher-e-Bangla Nagar, Dhaka-1216.

Appendix 3: Map showing the location of experimental site

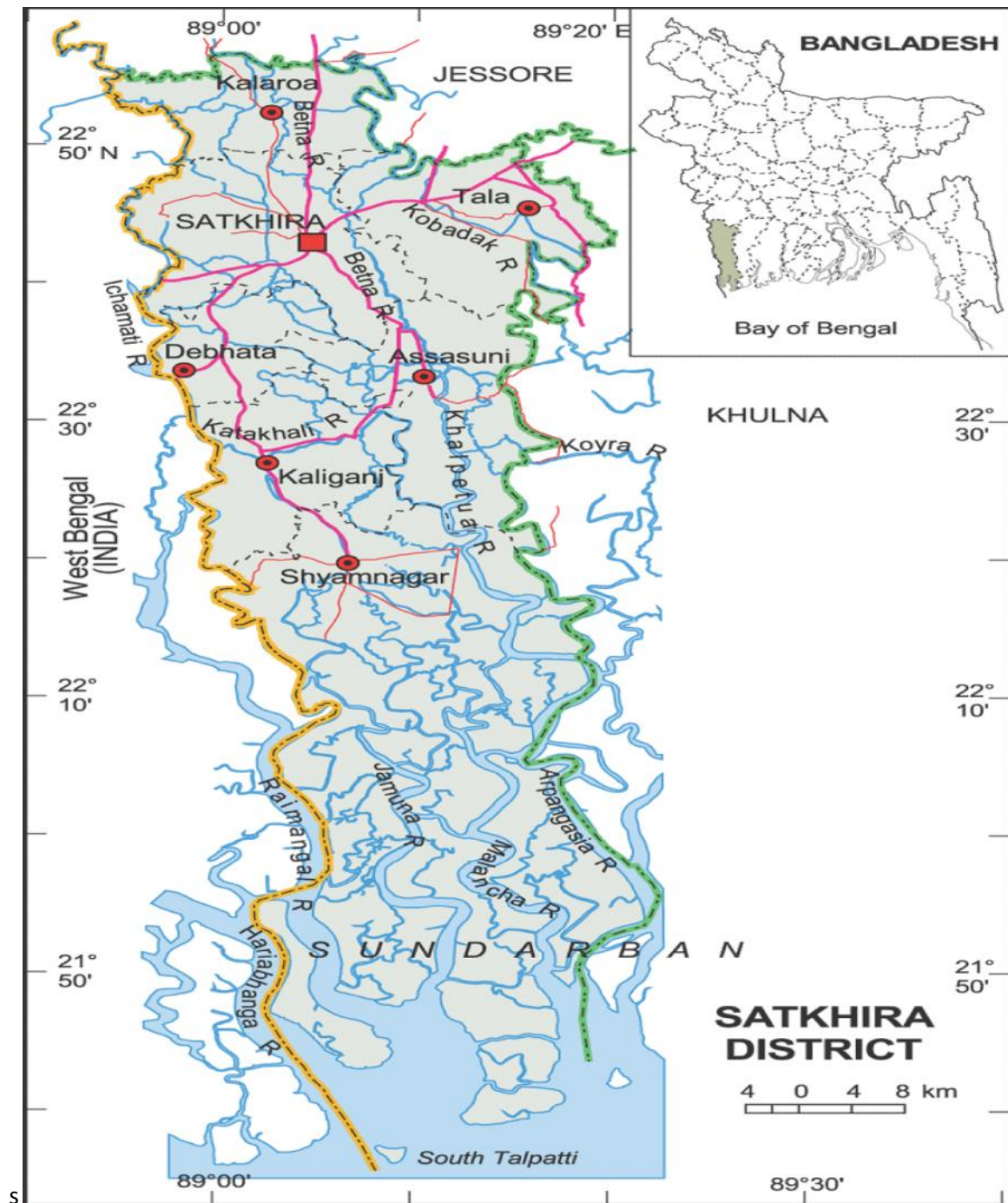


Figure : Satkhira district

