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**A STUDY ON MASS MORTALITY OF RAIN TREE
(*Albizia saman* Jacq.) AT KHULNA BYPASS ROAD**



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**FORESTRY AND WOOD TECHNOLOGY DISCIPLINE
SCHOOL OF LIFE SCIENCE
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Dedicated

To

My Beloved Parents and Brothers

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ABSTRACT

Rain tree (*Albizia saman* Jacq.) is one of the multipurpose tree species grown in village woodlot, embankments and road sides in Bangladesh. It is a large tree mostly grown in southern and northern part of Bangladesh. It is one of the most important species in Barisal and Khulna districts. It is a fast growing tree which obtains a large size. Its timber is very suitable for cabinet and furniture making. On account of its great strength, elasticity and durability, Rain tree is valued as a good construction and utility timber. It is most common as a pasture, shade or ornamental tree, but has numerous uses.

This project work has been performed to observe the present status of Rain tree plantation, extend of mortality of Rain tree at Khulna bypass road, Khulna. The survey has revealed that, the Rain tree is decreasing day-by-day from the Khulna bypass road, Khulna.

2005-2006 was the plantation year. From then growth performance was good. Rain tree have been raised with Babla (*Acacia nilotica*), Arjun (*Terminalia arjuna*), Amloki (*Phyllanthus emblica*), Khaya babla (*Pithecellobium dulce*), Neem (*Azadirachta indica*), Ghora neem (*Melia azadirachta*). But from 2013 to 2014 a number of rain trees are decreasing and now most of the Rain trees are dead in Khulna bypass road, Khulna. Department used mono-culture in some part and mixed-culture in other part along the roadside. Through the data collection it was found that around 52% were dead, 32% was dying and 16% of Rain tree was healthy at Khulna bypass road. Dead trees are fully total leaf loss. About 30% of rain tree was total leaf loss. About 32% was bark drew out and 22% of rain tree exhibited top debarked. Top debarked tree has green leaves in the main, secondary and tertiary branches. Dead trees were attacked by insect also. Some insect holes were also seen in the trees. That condition was seen both in mono-culture and mixed-culture plantation at Khulna bypass road. The survivablity of Rain trees in mixed-culture was better than -culture. *Albizia saman* at Khulna bypass road, Khulna now facing an unknown disease. Apparently, the above symptom is very similar to that of 'Die-Back' disease. Unfortunately any definite control measures or proper management of that disease is not found. For this reason, authority has become discouraged to raise Rain trees plantation in the study area.

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LIST OF ABBREVIATIONS AND SYMBOLS

dia	Diameter
et al.	With Other
ha	Hectare
i.e.	That is
mm	Millimeter(s)
NGOs	Non- Government Organizations
pH	Negative Lgarithm of Hydrogen ion Concentration
Sp.	Species
&	And
%	Percentage.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Rain tree (*Albizia saman* Jacq.) belongs to the Fabaceae (Mimosoaceae), legume family, sub-family Mimosoideae. Leguminosae is the third largest family of the flowering plants having approximately 650 genera and 18,000 species distributed throughout the world (Sanjappa, 1992). *Albizia saman* (Jacq.) is a medium-sized or large tree of potentially great size, often reaching 25-30 m tall, occasionally 45 m, with a short stout bole to 2-3 m dbh and a wide, low, spreading crown, often twice as wide as the tree is high (Amara & Mansaray, 1989). Rain tree is a native of Central America and parts of South America. Though Rain tree is a native of South America, it has been planted along road sides in some of the warmer parts of India and particularly in lower Burma where it is one of the commonest road side trees. It grows best in moist climate. Soil and humidity determine the shape and size of the trees, like low branches exhibit in poor soil (Luna, 1996). *Albizia saman* (Jacq.) was one of the first roadside exotic trees to be widely planted in many tropical countries and it is now so widely cultivated, particularly in South-East and south Asia, that it is often mistaken as native to that area and are found all over Pakistan (Ali, 1972).

Bangladesh is a country with a very large population and a limited land resource. As a general rule 25 % of total land of a country should have forest cover for maintaining ecological balance. *Albizia saman* (Jacq.) is extensively cultivated by the farmers in South of the country as a small-scale farm forestry or woodlot plantation ranging from 0.5 to few hectars (Agarwal and Nirmal, 1998). The public sectors e.g. Forest Department, Roads and Highways, Bangladesh Railways etc. have planted this tree extensively. NGO's have also planted rain tree under participatory forestry approach. Probably farmers choose the tree because of faster growth, well suited for those lands unsuitable for rice production, multipurpose uses and good market value of timber. Farmers took this plantation approach as their risk-management strategy in a sustainable manner (Shikder, 2004).

But Mortality of rain trees have been observed in areas of Chattagong, Khulna districts and also other areas of the South of the country. Rain tree is very important tree species in agro forestry and social forestry in Bangladesh, particularly in the north and south districts of the country. The farmers are however, very disappointed and frustrated because of the disease of

rain tree. *Albizia saman* (Jacq.) is an important species in Bangladesh but research work and investigation regarding its pathology is poorly developed. *Albizia saman* (Jacq.) is subjected to various pest and diseases in both nursery and plantation stage. Die-back disease is very significant in Indian sub-continent among the plantation disease (Shikder, 2004).

1.2 Background of this study

Albizia saman (Jacq.) is a medium-sized or large tree of potentially great size, often reaching 25-30 m tall, occasionally 45 m, with a short stout bole to 2-3 m dbh and a wide, low, spreading crown, often twice as wide as the tree is high. Rain tree is a native of Central America and parts of South America. Though rain tree is a native of South America, it has been planted along road sides in some of the warmer parts of India and particularly in lower Burma where it is one of the commonest road side trees (Luna, 1996). In its native places, the species grows mostly on open country but also on riversides in forest. It is widely distributed in the forests of tropical Asia (Zabala, 1990). It was introduced in 1880 in west Bengal, Tamil Nadu, Kerala and Karnataka for shade in plantation and roadside avenues and also for pastures. It was planted to a lesser extent in Gujrat, Bihar and Utter Pradesh (Luna, 1996). It has been largely planted along roadsides and avenues in some warmer Indian region and in Bangladesh as well as for easy transplanting of seedlings (Zabala, 1990). In the delta districts of Burma, it is capable of growing in some of the wettest places, rapidly killing out of grasses with its broad crown (Bates, 1961).

Most of the studies about the diseases of rain tree have been conducted in Kerala, India and only a few from Philippines. The most important and extensively studied problem of rain tree in India is a die-back disease which is caused by *Botryodiplodia theobromae*. Though the amount of information available on the diseases of *Albizia* spp. is unusually large, they are known to be attacked by relatively few fungal diseases of significant importance (Gibson, 1975). Diseases of seedlings and root diseases of young plants are relatively few but a number of root and stem pathogens are recorded from older trees. A total of 15 diseases have been recorded on *Alibizia* spp. Of these, eight diseases, namely *Botryodiplodia* root infection, violet root rot, *Aglaospora* root rot, *Fomes* stem canker, charcoal stump, *Phoma* die-back, *Macrophoma* stem infection and foliar necrosis have been reported exclusively from India. Diseases recorded commonly in India and elsewhere are charcoal stump rot, die-back (*Botryodiplodia theobromae*): pink disease, leaf cast and web blight. Though five diseases including those marked above with an asterisk and *Botryodiplodia* die-back, pink disease and leaf cast have been recorded on *Alibizia saman* precise details of these diseases are lacking

(Sharma, 1987). In most cases these reports include only occurrence and symptoms with either no mention of incidence/severity or it is described very vaguely; for some diseases even the symptoms are not described. Among the diseases recorded in India and elsewhere some account is available for pink disease and web blight. A high incidence of pink disease has been reported in 1-year-old trees from Assam. In the Philippines, (Eusebio, 1979) observed pink disease as the most serious disease of *A. falcataria*. An average of 76% trees were found infected with four or more infection points on stem in seven different localities. They indicated that if the disease is not contained it might affect the plantation development programme considerably. Web blight was also reported by (Agnihotrudu, 1962) in the same plantation in Assam where the pink disease occurred. A few diseases of other *Albizia* spp in India and other countries have also been recorded on *Albizia saman* (Jacq.).

Albizia saman (Jacq) has been planted in Bangladesh mainly along the roadsides and to some extent as avenue tree all over the country. It has also been successfully planted on raised coastal green belt. But the plantation of rain tree is facing a serious problem of plant diseases. There are die-back, top dying, wilting, half-dying and entire dead plants. The disease situation in Bangladesh is less similar with Philippine, India, Nepal and Pakistan. Many Scientists from different rain tree growing countries of the World has done a considerable amount of research on the die-back of Rain tree, a serious problem now, and they have given the details description of symptoms and/or the possible causal organisms of the diseases in their review and research papers. Unfortunately no one has given any definite control measures or proper management of the root diseases of rain tree (Mondal , 2011).

Rain tree is an important multi-purpose tree species. Its timber is very suitable for cabinet and furniture making. On account of its great strength, elasticity and durability, Rain tree is valued as a good construction and utility timber. Rain tree is a fast growing tree species. In about 10-15 years it attains a reasonable size and can fetch handsome return for its growers. Over last 10- 12 years Government of Bangladesh has been encouraging people for tree planting along highways, Upazila Parisad roads and Union Parisad roads, on embankment, on public and private marginal lands and on canal banks. It is, however, seen more commonly in the southwestern part of Bangladesh more abundantly as compared to that in other parts of the country (Davidson, 1985).

But the plantation of Rain tree in Bangladesh is facing a serious problem of plant diseases. There are top dying, wilting, half-dying and entire dead plants. The diseases are spreading

fast and causing wide spread damage at all kinds of localities / habitats and infecting the plants of all ages. Over past 4-5 years a problem of twig die-back followed by gradual death of major branches and ultimate death of the affected trees has been in different areas of Bagerhat, Khulna, Jessore, Kushtia, Pabna, Manikganj, Dhaka and Chittagong districts. Undoubtedly the disease has been on the gradual increase. This is simply a case of concern to those who think about tree resources of the country. Research is not available in Bangladesh. It is therefore considered necessary to find out the causal factors of the diseases and biology of the causal pathogen so that further attempt could be taken to prevent and/ or control the diseases to augment productivity of timber in Bangladesh (Hawladar, 1982).

Rain tree is a very important tree species in agroforestry and social forestry plantations and in village homesteads in the South of the country. During last 5-6 years, there has occurred large-scale mortality of rain tree of different ages in various parts of the country. This has caused serious concern among the growers and also in the Forest Department.

It is proposed that through the present project investigation would be made on the extent of the rain tree mortality in various parts of the country supporting rain tree plantations. The nature and extent of damage by the disease would be precisely described. The stages of symptom development would be recorded. The causal pathogen would be identified. Factors favoring epidemic development of Rain tree mortality would be determined. Suitable prevention and/or control measures would be worked out through laboratory studies. Best strategies for prevention and/or control of the disease will be demonstrated to the growers through field trials for motivation of the public to apply the prevention/control measures for safeguarding rain tree trees against mortality and thereby help in promoting the productivity of Rain tree timber in the country (Shikder, 2004).

1.3 Objectives of the study

The objective of the study is-

- To know the present status of *Albizia saman* (Jacq.) plantation in the study area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Local Names

English (saman tree, algarrabo, raintree, cow bean tree, cow tamarind, monkey pod, giant thibet, acacia); Filipino (acacia); French (gouannegoul,saman); Hindi (belati-siris, guango, nid-raganneru, majhamaram); Indonesian (slubin, kihujan, mungur, trembesi); Spanish (dormilón, delmonte, samán, guannegoul, carretonegro, raintree, algarrobo del país, algarrobo); Thai (cham cha, kam kram) (Rosherko, 1995).

2.2 Rain tree (*Albizia saman* Jacq.) – A General View

Taxonomic classification

Domain: Eukaryota

Kingdom: Plantae

Phylum: Spermatophyta

Subphylum: Angiospermae

Class: Dicotyledonae

Order: Fabales

Family: Fabaceae

Subfamily: Faboideae

Genus: *Albizia*

Species: *Albizia saman* (Barneby and Grimes, 1996).

2.3 General Description

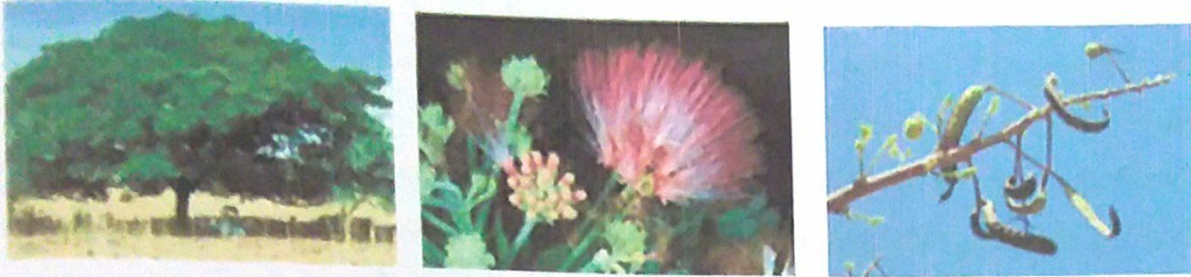


Fig: 2.1 A healthy Rain tree, flower, fruit

(Source: C. Elevitch 1965)

Albizia saman (Jacq.) is a medium-sized or large tree of potentially great size, often reaching 25-30 m tall, occasionally 45 m, with a short stout bole to 2-3 m dbh and a wide, low, spreading crown, often twice as wide as the tree is high. It is a stately tree, with heavy, nearly horizontal branches and an umbrella-shaped crown. One notable old *Albizia saman* tree near Government House in Trinidad was recorded to shade approximately a hectare, and reach 50 m in height, a stem 2.6 m in diameter, with a crown diameter of 60 m (Allen and Allen, 1981). The bark is grey-brown, rough and furrowed into ridges (Barneby and Grimes, 1996). Leaves are large, 6-25 mm long x 3-8 cm wide, bipinnate, with 3-6 pairs of pinnae per leaf, 6-9 pairs of leaflets per pinna and large leaflets, 24-62 mm long x 10-25 mm wide. Leaflets are unequal in size, becoming larger towards the distal end of the pinnae. The new growth and leaf rachis are covered in short, velvety, tawny pubescence. The leaflets are rhombic-oblong or elliptic in shape, unequal at the base, dark olive-green, glabrous and slightly glossy above, dull grey-green and hairy below. The flowers are arranged in loose umbelliform heads, which develop in groups of 2-5 in the axils of leaves on actively growing shoots. The terminal or central flower on each head is sessile and enlarged compared to the peripheral flowers. The exposed and conspicuous stamen filaments are bright or pale pink and showy. The fruits are broadly linear, compressed pods, 10-22 cm long x 1.5-2.2 cm wide x 0.5-1 cm thick. They are green and fleshy when unripe, and turn dark blackish-brown when ripe. The thick mesocarp is filled with dry pitch-like, sweet, nutritious pulp. The pods are indehiscent and contain 5-10 mature seeds, 8-11.5 mm long x 5-7.5 mm wide (Durr, 2001).

2.4 Phenology

2.4.1 Flowers

The tiny flowers (12–25 per head) are massed in pinkish heads 5–6 cm (2–2.4 in) across and about 4 cm (1.6 in) in height. The long, bicolored stamens (white in lower half and reddish above) give the whole inflorescence the appearance of a powder puff or feather duster held slightly above the foliage. Thousands of heads are borne at the same time, covering the tree in pinkish bloom. The central flower in each head is larger, stalkless, has more petals, and is capable of forming a fruit; this flower is a nectar-producing organ that attracts pollinators. Usually only one flower per head (rarely two) is pollinated and forms a fruit. (Flores, 2002).

2.4.2 Fruit

Mature pods are black-brown, oblong, lumpy, 10–20 cm long (4–8 in), 15–19 mm (0.6–0.8 in) wide, ca. 6 mm (0.25 in) thick, straight or slightly curved, not dehiscent but eventually cracking irregularly, and filled with a sticky, brownish pulp that is sweet and edible (Bawa and Buckley, 1989).

2.4.3 Seeds

Seeds are plumply oblong-ellipsoid, 8–11.5 mm (0.3–0.45 in) long, 5–7.5 mm (0.25–0.38 in) wide, slightly flattened from side to side, smooth, dark glossy brown with a slenderly U-shaped yellowish marking (pleurogram) on the flattened sides. There are 15–20 seeds per pod (often only 5–10 seeds per pod in the native range, where seed predation by insects accounts for the rest). One kilogram of seeds averages 4000–6000 seeds (1820–2730 seeds/lb). Seeds are readily dispersed by domestic livestock (cattle, hogs, goats) and to a much lesser extent by wild animals (peccary, tapir, and rodents in the presumed native range), whose feeding habits and digestive capacity permit very few seeds to pass through intact. It has been hypothesized that rain tree fruits evolved for dispersal by large mammals that became extinct in the Americas during the Pleistocene glaciations. Cattle and other herbivorous domestic animals efficiently fill the seed dispersal role today (Esuoso, 1996).

2.5 Climatic Condition

2.5.1 Climatic factors

Albizia saman (Jacq.) is globally distributed especially in the tropical region. Rain tree grows in tropical and sub-tropical climate. It can withstand extremes of climatic conditions, especially of temperature and rainfall, although in seedling stage, it is sensitive to the drought. It tolerates dry conditions and drought resistance up to 3-4 months, but grows well in the localities with high rainfall (Jama *et al.*, 1989).

2.5.2 Light requirements

Rain tree has high light requirements; it thrives in full sunlight.

2.5.3 Air Temperature

Parameter	Lower limit	Upper limit
Absolute minimum temperature (°C)	8	
Mean annual temperature (°C)	20	28
Mean maximum temperature of hottest month (°C)	24	35
Mean minimum temperature of coldest month (°C)	15	22

(Magnus and Seaforth, 1965.)

2.5.4 Rainfall

Parameter	Lower limit	Upper limit	Description
Dry season duration	0	6	number of consecutive months with <40 mm rainfall
Mean annual rainfall	600	3000	mm; lower/upper limits

(Magnus and Seaforth, 1965.)

2.5.5 Soil requirements

Albizia saman (Jacq.) is normally found on neutral to moderately acid soils and can grow on soil with pH as low as 4.6. It grows on light or heavy soils and tolerates infertile or waterlogged conditions. Young tree should be irrigated after planting until they are fully established. Where sidewalks or pavement surrounds the tree, supplemental irrigation is

beneficial; in open areas without obstruction to rainfall, normal precipitation is adequate for growth (Datta, 1997).

2.6 Edaphic Condition

It typically grows on alluvial ground in and along the beds of streams and rivers or on sand or gravel along the banks of rivers and on island. The tree avoids stiff clay, preferring a porous soil of sand, pebbles and boulders (Datta, 1997).

2.7 Reproductive Biology

There is a hermaphroditic reproductive system. Flowers are believed to be pollinated by large night-flying hawk and noctuid moths, the central, enlarged flower of the inflorescence providing nectar. Pollen is dispersed as large 32-grained polyads and the species is thought to be predominantly outcrossing (Bawa & Buckley, 1989). Flowering occurs towards the end of the dry season and the small immature pods persist for 8-10 months before expanding, ripening and falling nearly a year after flowering in the mid dry season. There are between 4,400 and 7,700 seeds/kg. The seed coat is hard.

2.8 Environmental Requirements

Albizia saman (Jacq.) is a truly tropical species, intolerant of frost. It thrives in both the seasonally dry and wet tropics (Allen and Allen, 1981) but is faster-growing where rainfall is >1000 mm (Booth & Jovanovic, 2000). The mean annual rainfall is estimated to be 600 - 3000mm, with a dry season duration of 0 - 6 months. *Albizia saman* needs well-drained alluvial, fertile, neutral to moderately acid (>pH 4.6) soils for best growth but can also tolerate heavy clays (vertisols) and infertile, or seasonally waterlogged soils. It grows from sea level of to 1500 m altitude (Booth and Jovanovic, 2000).

2.9 Pests and diseases

In most places, *Albizia saman* (Jacq.) is free from pests and diseases. A wound parasite, *Ganoderma lucidum* is reported from the Philippines. It may cause white soft rot in the lower part of the stem. A powdery mildew (*Erysiphe communis*) is very common in nurseries and may cause complete defoliation of seedlings. Two psyllid species attack *Albizia saman*, but rarely cause serious damage. The leucaena psyllid (*Heteropsylla cubana*) feeds on young shoots and in severe cases may cause defoliation, stunted shoot growth and eventually the death of the tree. *Psylla acacia-baileyanae* feeds on the shoots, causing leaves and shoots to curl. (Quiniones, 1981.)

2.10 Nursery diseases

2.10.1 Damping off

It is very important in our country as well as other parts of the world. It is caused by infection at root and collar region of the host fungi, i.e. *Pythium spp.*; *Fasarium spp.*; *Rhizoctoria solani* and other soil inhabiting fungi. If the disease rots seedlings at soil level, it is called post-emergence damping off. In post-emergence damping off the seedlings collapse at collar region, due to death of roots. If the germination of the seeds is prevented due to fungal attack then it is called pre-emergence damping off (Rahman, 1982).

2.10.1.1 Predisposing factors include

- High moisture content of soil.
- Alkaline conditions increase incidence and severity of damping-off.
- Water logging soil reduces root aeration and growth, and thus renders seedlings more susceptible to the disease.
- Too dense seedlings are more prone to damping-off.

2.10.1.2 Control Measures

- By ensuring good drainage of soil without organic manure, soil pH 5.0-6.0 and maintaining moderate density of seeding, damping-off can be prevented largely.
- Protective soil treatments probably not worthwhile unless regular pre-emergence losses are encountered to be quite high.
- Steam sterilization of nursery soil.
- Drenching with Formalin 1.0-1.5 gal. of Formalin per square yard.
- Range of the fungicide such as Tiram, Captan and Copper-oxochloride are also used. (Rahman, 1982)
- Topsin and Bavistin treatment were found to be effective measure against damping off caused *Fasarium palidoroseum* in Madhy Pradesh in India (Harsh, 1993)

2.10.2 Fungal disease

Occurrence: This disease was reported from Karnataka in India (Heremath, Sharma, & Swamy, 1991).

Cause: The identified was *Camptomeris aibizzicola*.

2.10.3 Seedling wilting

Cause: *Fasarium palidoroseum* (Sharma, 1987) and

Hendersonula toruloidea. (Giha, 1975).

2.10.4 Collar rot

Occurrence: A collar rot disease affected *Albizia saman* seedlings at Dharward in India. (Siddaramaiah, 1979).

Symptoms: The collar region appeared sunken and was discolored black by sclerotia under the bark. The leaves above were shed.

Control: *Rhioctonia bataticola* was responsible of the disease.

2.10.5 Root Gall

Albizia saman (Jacq.) seedling exhibited symptoms of wilting, stunted growth and numerous root galls in nursery soils.

Pathogen: The organism associated with the galls was identified as *Mincogita*. (Mahali, 1999).

2.10.6 Powdery mildew

Erysiphe communis was responsible of the disease (Quinione and Dayan, 1987).

2.10.7 Leaf spot

Occurred in India.

Pathogen: *Collectot richum*.

Plantation stage

2.10.8 Stem canker

Pathogen: The causative organism was *Fusarium semitectum*.

Control: The disease could be controlled by spraying with 0.2% Bavistin. (Dwdwal and Jamaluddin, 1991)

2.10.9 Bark eating caterpillar

Albizia saman (Jacq.) is affected by bark eating caterpillar *Indarbela quadrinotata* (Babu, et al., 2000).

2.11 Pests

2.11.1 Nematodes

Heavy nematode infestation was observed on *Albizia saman* (Jacq.). *Pammene theistis* is also found on *Albizia saman* (Jacq.)

The white grub, *holotricia fissa*, and Isoptera were also common pests on this species (Ghorpade and Patil, 1991).

2.12 Uses and products

Albizia saman (Jacq.) has been most widely planted as a shade, ornamental and roadside tree. Its canopy, with crowns of great diameter is unsurpassed for shade in silvo-pastoral systems, parks or roadsides. In addition, the pink flowers add to its value as an ornamental.

2.12.1 Fruit

The sticky, licorice-flavored fruit pulp is a minor food item for humans, mainly eaten by children. It is known as licorice tree in the English-speaking Caribbean. Although the pods have a nice flavor, they are too astringent to eat more than the pulp from a single pod (Chicco *et al.*, 1973).

2.12.2 Nut/seed

The seeds, once cleaned from the sticky fruit pulp, are used in making seed necklaces and other craft items.

2.12.3 Animal fodder

With 13–18% protein, the pods are edible and nutritious for livestock and make an excellent feed supplement (Flores, 2002). In Asia, rain tree is grown as a green fodder supplement for goats, sheep, and cattle. A 5-year-old tree can produce as much as 550 kg (1210 lb) of green forage. The pods are ground into a nutritious animal feed in part of the world.

2.12.4 Beverage/drink/tea

The fruit pulp is used to make a beverage (Chicco *et al.*, 1973).

2.12.5 Medicinal value

There are several folk remedies prepared from various parts of rain tree. The boiled bark is applied as a poultice to cure constipation. In the Philippines, a decoction of the inner bark and fresh leaves is used for diarrhea. In Venezuela, the roots are made into a hot bath for stomach cancer. In the West Indies, the seeds are chewed for sore throat (Esuoso, 1996).

2.12.6 Timber

The timber is valued for carvings, furniture, paneling, veneers, and is also used for turnery, posts, framing in boat building, plywood, boxes, and crates. The sapwood is narrow and white to light cinnamon. The heartwood is straight or cross grained with a medium to coarse texture. Air-dry specific gravity averages about 0.56. The wood requires careful drying because of shrinkage and moderate to severe warp. It is generally considered a durable wood and resistant to attack by dry wood termites (Longwood, 1971).

2.12.7 Fuelwood

In places where there is no demand for rain tree timber for construction or carving, the trunk and branches are used for firewood and charcoal. Although the wood makes good firewood, it burns with a lot of smoke even when very dry (Hossain *et al.*, 1992).

2.12.8 Fiber/weaving/clothing

The wood has the right fiber properties for making paper. Shavings made from the wood are made into hats (Longwood, 1971).

2.13 Service

2.13.1 Shade or shelter

The trees provide a microclimate effect for the plants growing under their canopies. At night and on cloudy days, branches hang down and the leaves fold down and inward, allowing rain to fall directly on the ground and promoting cooling through exposing the ground. The species is used as a shade for tea, coffee, cocoa, nutmeg and vanilla, and provides shade for pasture and grazing animals (Roshetko, 1995).

2.13.2 Nitrogen fixing

Albizia saman (Jacq.) forms nitrogen-fixing symbiotic relationships with many strains of Rhizobium, and root nodulation has been confirmed but no roots were found within the grass-root zone. This suggests that the deciduous habit of the tree is the main mechanism of fertility transfer (Troup and Joshi, 1983).

2.13.3 Soil improver

Pruned to yield nitrogen-rich green manure, and in pastures, *Albizia saman* (Jacq.) is prized for its shade, high quality, nutritious pods, and for promoting the health of the grass growing in its vicinity. This is because the soil under the tree has a higher nitrogen content than surrounding soil (Roshetko, 1995).

2.13.4 Beautiful/fragrant flowers

Rain tree has been introduced to many tropical places for the beautiful masses of pinkish flowers it bears for extended periods.

2.13.5 Ornamental

The attractive tree is one of the most commonly planted avenue and park trees in the tropics (Roshetko, 1995).

2.14 Description of study area

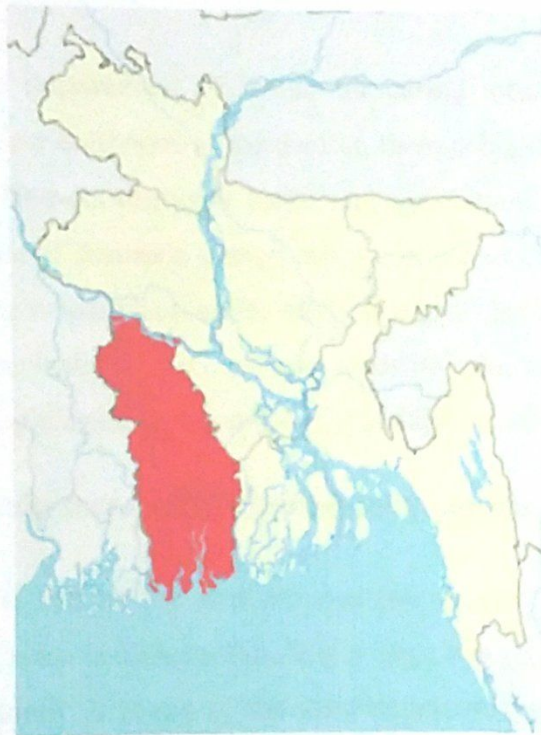


Fig: 2.2 Map of Khulna Division

(Source: Miah and Sajahan, 2012)

Khulna is located in south-western Bangladesh at $22^{\circ}49'0''\text{N}$ $89^{\circ}33'0''\text{E}$, on the banks of the Rupsha and Bhairab river. It covers a total area of 59.57 km^2 , while the district itself is about 4394.46 km^2 . It lies south of Jessore and Narail, East of Satkhira, West of Bagerhat and North of the Bay of Bengal. It is part of the largest delta in the world. In the southern part of the delta lies the Sundarban, the world's largest mangrove forest. The city of Khulna is in the northern part of the district, and is mainly an expansion of trade centers close to the Rupsha and Bhairab rivers. The Mayur River forms the western boundary of the metropolitan area.

Khulna is humid during summer and pleasant in winter. Khulna has an annual average temperature of 26.3 °C (79.3 °F) and monthly means varying between 12.4 °C (54.3 °F) in January and 34.3 °C (93.7 °F) in May. Annual average rainfall of Khulna is 1,809.4 millimetres (71.24 in). Approximately 87% of the annual average rainfall occurs between May and October.

Khulna Bypass road, Khulna, is an important part of Khulna Division. The structure of soil is sandy, loomy, Sandy-loomy and clay. But most of the soil is sandy. Water supply is available in this area. All other factors are almost favourable for planting different tree species (Tapan, 2012).

In addition to domestic requirement of wood, for curing tobacco leaves and processing sugarcane which are widely cultivated in the district, there is big demand for fuelwood which is scarce in the region. Non-conventional fuels, e.g., agricultural wastes, cow dung, etc. are widely used as the source of domestic energy supply. In recent decade`s people, particularly large land holders raising woodlots on arable lands as it gives greater profit. Government and Non- government organizations are raising roadside plantations practicing cropland agroforestry through people`s participation (Miah and Sajahan, 2012).

2.15 Distribution of rain tree (*Albizia saman* Jacq.) in Bangladesh

Albizia saman (Jacq.) is one of the multipurpose tree species grown in village woodlot, embankments and road sides in Bangladesh. It is a large tree mostly grown in southern and northern part of Bangladesh. It is one of the most important species in Barisal and Khulna districts where it contributes some 19% of total volume (Anon, 1982). It is an exotic and a good fodder tree. Village people use its stem as timber. They also use its branches as fuel wood frequently because of its excellent coppicing behavior (Latif *et.al.*, 2000).

2.16 Description of the study area

Albizia saman (Jacq.) trees suffering with the infection have been found widely across Khulna region and it was firstly noticed by the authority of Roads and Highways department, reported that dying of this trees in large numbers in this year.

Rain trees along both sides of the road were affected and died by unknown disease. The death of trees started from the top and gradually dying. The non-affected healthy trees were devoid of all the aforesaid characters.

CHAPTER THREE

METHODOLOGY

The study was carried out in the roadside plantations in Khulna bypass road. Primary observation of the area, sampling and data collection procedure in details have been described below:

3.1 Determination the condition of *Albizia saman* (Jacq.) in the study area



Fig: 3.2 Condition of *Albizia saman* in the study area

(Source: Kamona, 2015)

It was assumed that the total plantation of *Albizia saman* (Jacq.) in Khulna bypass road, Khulna is decreasing day by day due to an unknown plant disease. During data collection, the number of *Albizia saman* (Jacq.) planted and the area of plantation was recorded. This assumption was verified by comparing different plot of *Albizia saman* (Jacq.) plantation.

3.2 Sampling technique

Sampling area was roadside plantations in Rupsha Bridge bypass road, Khulna and it located from Zero-point to Khan Jahan Ali Bridge. For this purpose line-transect sampling was adapted. Each sample plot was 10m x 10m. Sample plot was taken by 30m interval in zigzag pattern.

3.3 Collection of data

Data were collected in August 2015. The present condition (dead, dying, healthy) of trees, physical appearance, physical condition of bark, leaves, soil condition, water condition etc. were recorded in the structured data sheet. Public opinion, which was relevant to the study, was also noted. Data were analyzed using appropriate statistical tools. Height and Diameter at breast height (DBH) were measured. Diameter tape and Haga Altimeter were used for measurement.

3.4 Data analysis

Data collection on various parameters from field survey was processed and summarized in suitably formatted tables while detailed data was provided in Appendices. Such data was analyzed by using appropriate computer programme such as Microsoft excels 13.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Determination the condition of plantation in the study area



Fig: 4.1 Plantation condition in the study area

(Source: Kamona, 2015)

The plantation is owned by Road and Highway Department Khulna, Bangladesh. They planted different species along the roadside during 2005-2006. They planted rain tree (*Albizia saman*), Babla (*Acacia nilotica*), Arjun (*Terminalia arjuna*), Amloki (*Phyllanthus emblica*), Khaya babla (*Pithecellobium dulce*), Neem (*Azadirachta indica*), Ghora neem (*Melia azedarach*). 2 year old seedlings were planted. Authority employed one person per kilometer for maintenance. These people maintained the plantation for first two year. Regular watering, fencing, take care were taken by them. Department used mono-culture in some portion but mostly used mixed-culture. But from 2013 to 2014, rain trees affected by an unknown diseases. Mono-plantation was affected more than mixed plantation (Md.Kutub-uddin, 2015).

4.2 Present status of plantation under study area

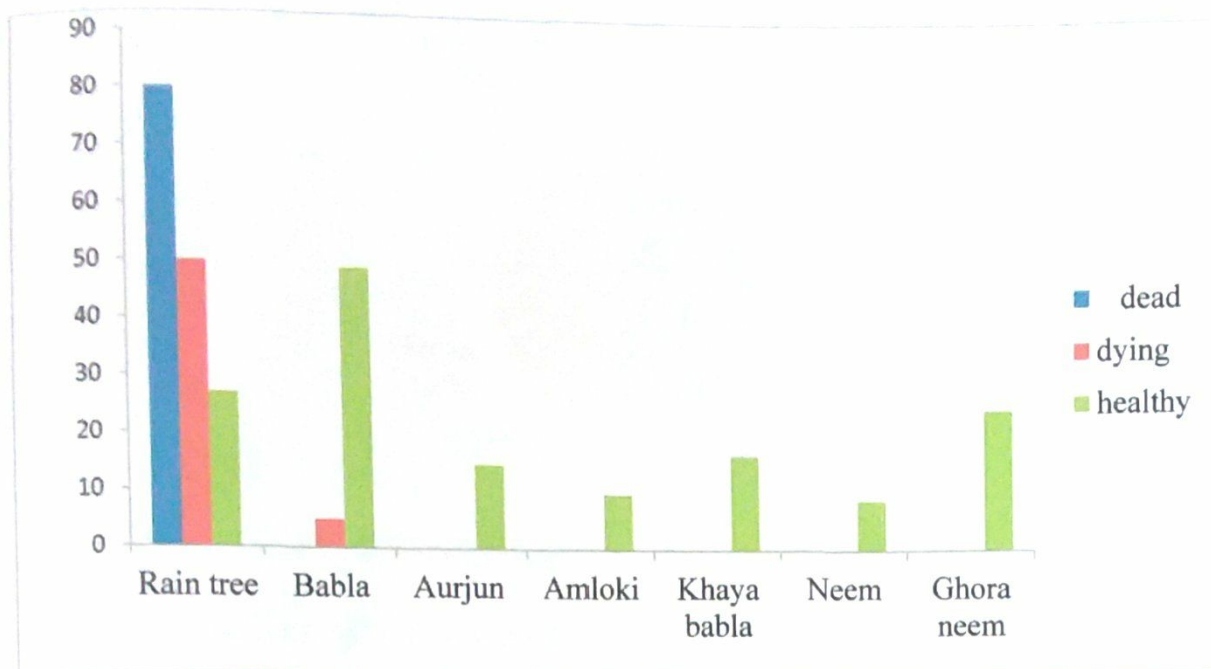


Fig: 4.2 Condition of roadside plantation

In the study area, it has been found that from 2005 to 2006 was the plantation year. Rain tree have been raised with Babla (*Acacia nilotica*), Arjun (*Terminalia arjuna*), Amloki (*Phyllanthus emblica*), Khaya babla (*Pithecellobium dulce*), Neem (*Azadirachta indica*), Ghora neem (*Melia azedarach*). 80 *Albizia saman* were dead, 50 were dying and 27 were healthy. Associate species like 15 *Terminalia arjuna*, 10 *Phyllanthus emblica*, 17 *Pithecellobium dulce*, 9 *Azadirachta indica*, 25 *Melia azedarach* were almost healthy. Only 5 *Acacia nilotica* were dying because of physical damage. Almost soil of the study area was sandy and water supply was available near the plantation.

4.3 Present status of *Albizia saman* (Jacq.) plantation under study area

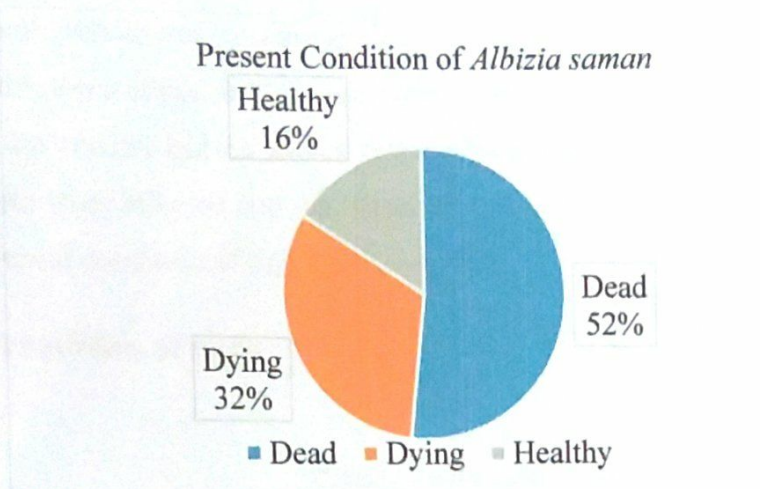


Fig: 4.3 Present Condition of *Albizia saman* (Jacq.)

In the study area, it has been found that from 2005 to 2006 was the plantation year. Rain tree have been raised with babla (*Acacia nilotica*), Arjun (*Terminalia arjuna*), Amloki (*Phyllanthus emblica*), Khaya babla (*Pithecellobium dulce*), Neem (*Azadirachta indica*), Ghora neem (*Melia azedarach*). After that from 2013 to 2014 the plantation was less but more from 2014 to 2015 most of the rain trees were dead. Through the data collection it was found that around 52 percent rain trees were dead, 32 percent rain trees were dying 16 percent rain trees were healthy. From the observation it was that, most of the trees are dead.

4.4 Leaves condition of Rain tree in the study area

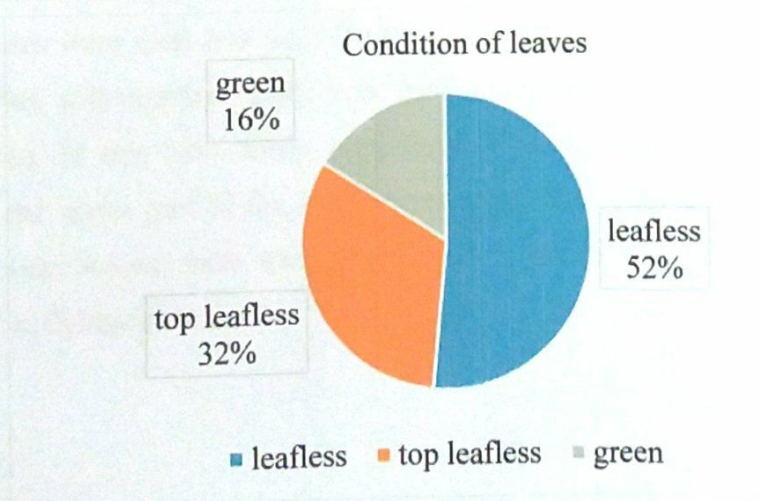


Fig: 4.4 Present leaves condition of *Albizia saman* (Jacq.)

Leaf condition is an important parameter to know condition of the trees. Through physical observation, it was seen that 52% trees were totally leafless. Leaf fall started first at the top of the tree. Gradually whole tree became leafless. Some trees had no leaves in the top portion. 32% trees exhibit top leafless. In this case, some trees had huge leaves in the lower and side branches. But top portion had no leaves and top bark started to dry. They also attacked by insect. That trees were affected and died gradually. Few trees were healthy and it was about 16%. So the present condition of rain tree is very bad.

4.5 Physical condition of bark

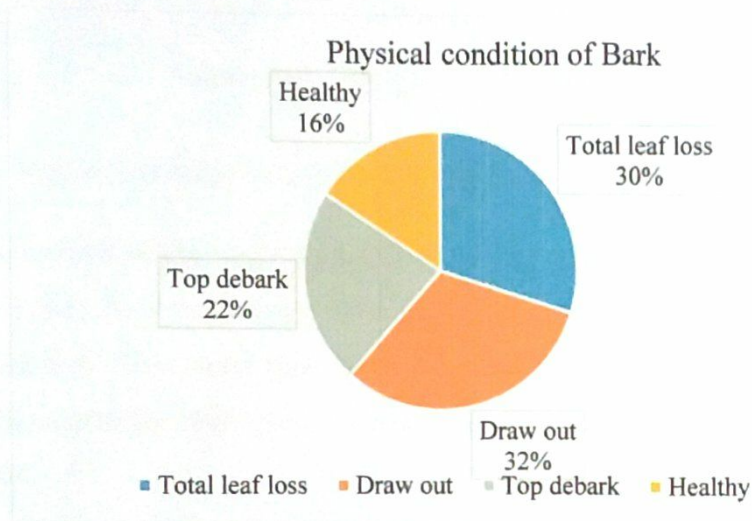


Fig: 4.5 Physical condition of bark of *Albizia saman* (Jacq.)

Almost all of the dead trees were total leaf loss. From the observation it was seen that about 30 percent trees were total leaf loss. It was known that local people drew out the bark for their daily fuel consumption. Bark was drew out about 32 percent of rain trees in the plantation area. In this case, lower portion of the trees were almost drew out and bark remained in the upper part of the trees. About 22 percent rain tree exhibited top debarked condition. Green leaves were seen other portion except top of the trees and it is the precondition of dying of the trees.

4.6 Parasite attack condition

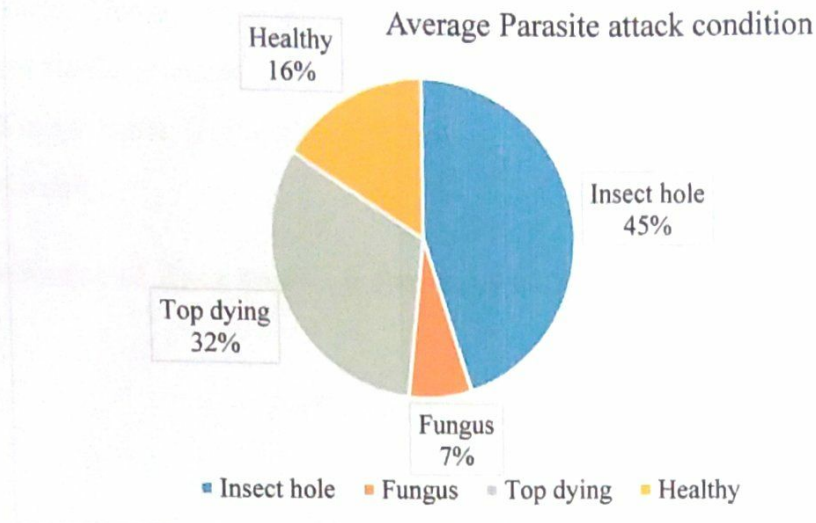


Fig: 4.6 Average parasite attack condition of *Albizia saman* (Jacq.)

Through observation of the study area, it is seen that most of the dead and dying trees were attacked by insect. They made hole in the wall of the tree. Insect holes were seen around 45 percent of the rain trees. Few trees were attacked by fungus. About 7 percent tree were attacked by fungus in the study area. Around 32 percent trees exhibited top dying condition in the study area.

4.7 Disease appearance of Rain tree in the study area

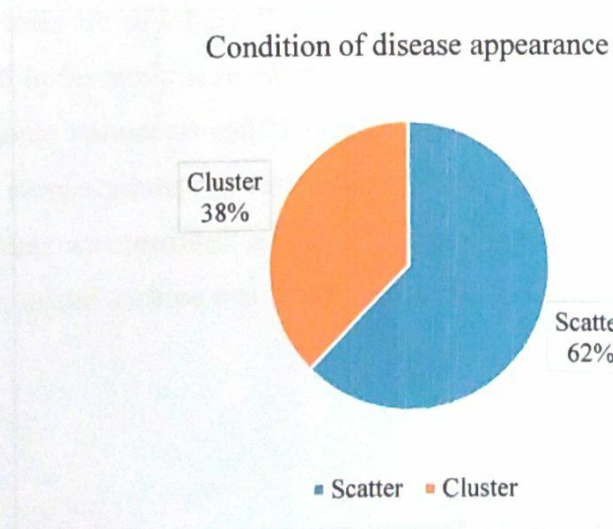


Fig: 4.7 Disease appearance of Rain tree

Disease are found in two forms- cluster and scatter. Clustery affected portion was occurred in mono plot. It was found in some mixed plots. Scatters affected portion were found in most of the mixed plots. Healthy trees are found here. Rain trees are associated with some other species like Babla (*Acacia nilotica*), Arjun (*Terminalia arjuna*), Amloki (*Phyllanthus emblica*), Khaya babla (*Pithecellobium dulce*), Neem (*Azadirachta indica*), Ghora neem (*Melia azedarach*).

4.8 Performance of Rain tree in mono-culture in the study area

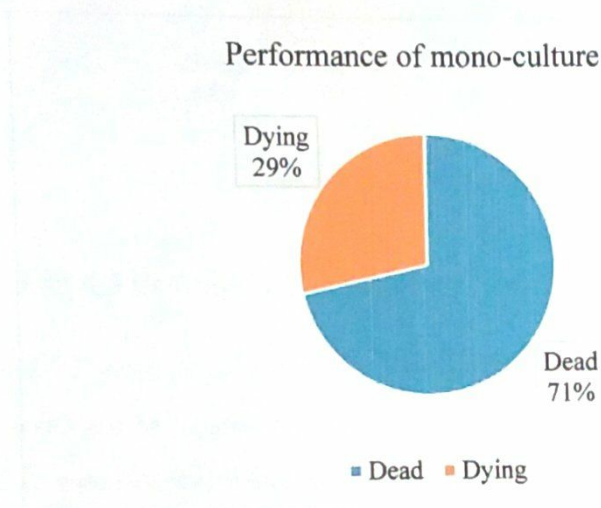


Fig: 4.8 Performance on mono-culture of *Albizia saman* (Jacq.)

From 2005 to 2013 more or less Rain tree plantations had been raised in the study area. But very few Rain trees are still there. Rain trees plantation either mono-culture or mixed- culture had been raised in the study area. Mono-cropping in the study area is less than mixed-culture cropping. In mono- culture around 71 percent trees were dead, 29 percent trees were dying. In the study area mono-culture was less than mixed-culture plot. Large-scale mortality of trees due to this disease was recorded usually in patches in plantations at mono-culture area. The survivability of mixed- culture was better than mono- culture.

4.9 Performance of Rain tree in mixed-culture in the study area

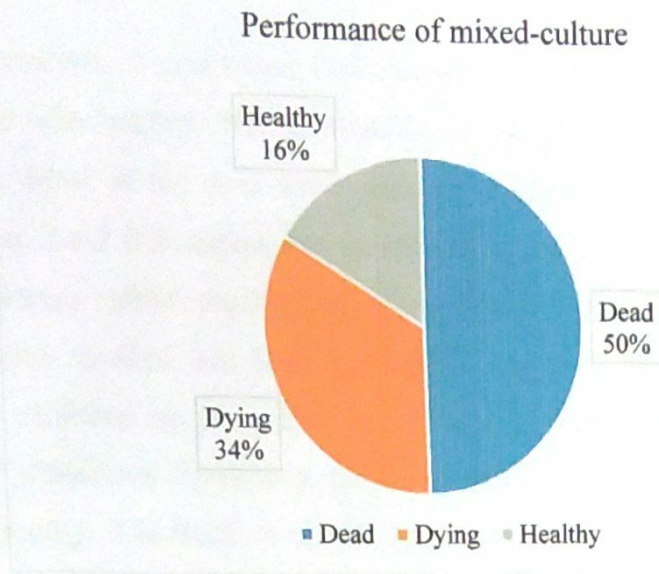


Fig: 4.9 Performance on mixed-culture of *Albizia saman* (Jacq.)

From 2005 to 2013 more or less rain tree plantations had been raised in the study area. But very few rain trees are still there. As most of the plots of the study area were mixed, through data analyzed it was observed that about 16 percent trees were live, 34 percent trees were dying, 50 percent trees were dead. In those plot rain trees were mostly associated with babla, khaya babla, neem, ghora neem etc. The survivability of Rain trees in mixed-culture were better than mono-culture.

4.10 DISCUSSION

Through the analysis, it was found that around 52% were dead, 32% were dying and only 16% rain trees were healthy. The survivability of rain trees in mixed-culture were better than mono-culture. Most of the trees were completely devoid of leaves. About 52% trees were totally leafless. Leaf fall started first at the top of the tree. Gradually whole tree became leafless. 32% trees exhibit top leafless. About 16% trees were healthy. Around 45% Insect holes were seen in dead rain trees. About 7% tree were attacked by fungus. Around 32 percent trees exhibited top dying condition. The non-affected healthy trees were devoid of all the aforesaid characters. Apparently, the above symptom is very similar to that of 'Die-Back' disease. Generally, 'Die-Back' is caused by a number of fungi of which the prominent are *Botryodiplodia theobromae*, *Nectria ditissima* etc. Dieback is a fungal disease which causes leaf loss, crown dieback and bark lesions in affected trees (Bagchee, 1945). When a tree is attacked by die-back disease, top part of the tree become leaf less and gradually dying the total tree. In the fully dead trees, leaves were fallen off, the main, secondary and tertiary branches were fully dead.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From this project work it has been found that the Rain tree plantation is decreasing day-by-day in the study area, the probable cause is mortality. From 2005 - 2006 was the plantation year but from 2013 - 2014 the number of Rain trees are decreasing and now most of the Rain trees are dead in the study area. Department used mono plantation in some part and mixed plantation in other part of the roadside. The survivality of Rain trees in mixed plantation were better than mono-plantation.

5.2 Recommendations

Albizia saman (Jacq.) become most popular among the people in our country within very short time due to fast growing and excellent quality of wood. But the popularity has been decreased among the people due to mortality. To rescue such high valuable species the following steps can be taken:

- On the national basis, a multi-disciplinary research team should be organized to study the rain trees forests in order to identify the causes of mortality and to recommended remedial measures.
- A long term monitoring is needed to study the causes and severity of damage.
- Immediate removal of affected trees (Dead trees should be removed immediately to avoid the infestation of healthy trees in the plantations).
- Identification of plus trees among selected provenances and land races should be selected from disease resistant of *Albizia saman* for raising permanent seed sources.
- Seed should be collected from vigorous plus trees not from affected, early ages and separate trees.
- Small or medium, vigorous seedlings should be planted instead of large and bare rooted seedlings.
- Seedlings should be planted in silt loamy soil in lieu of water logging land.
- Should ensure proper care viz. put fertilizer, weeding, thinning, and pruning.
- Mass propagation of superior genotypes by stem cuttings for direct planting.

- It is difficult to prescribe the control measure in this stage without identifying the causal organisms/ pathogen of the disease.
- Avoid monoculture plantations of Rain trees.
- Quality seedling should be used for planting.

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APPENDIX

Appendix -1

Field survey questionnaire

Survival status of Rain tree (*Albizia saman* Jacq.) in Khulna bypass road, Khulna district:-

1. Information on plantation of Rain tree

a). Location of the land

- Village
- Post
- Upazilla
- District

b). Total land area (Km/Hectare/Acre/Decimal)

c). Type of land area

- Arable land
- Homestead
- Roadside
- Embankments
- Others

d). Ownership status

- Private land
- Government Khas land
- Leased from Government by any Non- Government organization.

2. Purpose of growing trees

Fuel/ Cash/ Timber/ Construction material/ Soil fertility/ Protection against storm/ Control soil erosion/ fodder/ Beautification/ others.

3. Year of plantation

Year	Plantation

4. Type of plantation

- Monoculture
- Mixed

If mixed then

Species grown with rain tree:

- a)
- b)
- c)
- d)
- e)

5. Number of tree per area

- At the time of plantation:
- Existing number of tree:

6. Spacing

- a) Regular (specify):
- b) Irregular (range)

7. Availability of the seedlings

- Adequate
- Non- adequate
- Medium

8. Maintenance:

Measures	Yes	No
Protection		
Weeding		
Watering		
Fertilizing		
Pesticides		
Pruning		

9. Employ for per kilometer

- One person
- Two person

10. Soil Condition

- Sandy
- Loomy
- Sandy-loomy
- Clay

11. Water condition

- Water available
- Water scarcity

12. Physical appearance

- Insect attack
- Ooze appearance

13. Condition of leaves

- Fully leafless
- Top leafless
- Green

14. Condition of bark

- Bark dry
- Insect attack

15. Disease appearance

- Scatter
- Cluster

16. Number of healthy and disease affected trees

Type	Number
Healthy	
Moderately affected	
Severely affected	
Total	

Appendix -2

Basic information on the study area

Spp.	Total spp found	spp in plot	dead	dying	healthy
Rain tree	157	24	80	50	27
Babla	54	19	0	5	49
Aurjun	15	3	0	0	15
Amloki	10	2	0	0	10
Khaya babla	17	4	0	0	17
Neem	9	3	0	0	9
Ghora neem	25	4	0	0	25

Plot	Total Spp.	Mixed/Mono	Associated Spp.	% of associated Spp.
1	10	Mixed	Babla	20
2	9	Mixed	Babla	44.44
3	8	Mono	No	0
4	12	Mixed	Babla	25
5	11	Mixed	Babla	27.27
6	10	Mixed	Babla	10
7	7	Mono	No	0
8	7	Mixed	Babla	28.57
9	8	Mixed	Babla	25
10	10	Mixed	Babla	10
11	7	Mixed	Arjun, Amloke	71.43, 28.57
12	4	Mixed	Arjun, Amloke	25, 75
13	11	Mixed	Babla	54.55
14	14	Mixed	Babla	35.71
15	7	Mixed	Babla	57.14

16	6	Mixed	Babla	16.67
17	13	Mixed	Babla	46.15
18	6	Mono	No	0
19	5	Mixed	Babla	20
20	9	Mixed	Babla	22.22
21	10	Mixed	Babla	30
22	10	Mixed	Babla	30
23	10	Mixed	Arjun	10
24	14	Mixed	Khaya Babla, Babla	64.25, 35.71
25	10	Mixed	Neem, Bohara	40,40
26	9	Mixed	Ghora neem, neem	77.79, 22.22
27	9	Mixed	Babla, Neem	22.22, 11.11
28	13	Mixed	Ghora neem	38.46
29	11	Mixed	Ghora neem, Babla	54.55, 45.46
30	12	Mixed	Ghora neem, Babla	58.33, 16.67

4.10 Determination of height (m) and DBH (cm) of Rain tree in the study area

Plot	Plantation Type	Average height(m)	Average DBH(cm)
3	Mono	10.38	22.14
7	Mono	11.40	25.16
18	Mono	11.63	23.64
1	Mixed	11.43	26.64
2	Mixed	12.44	25.49
4	Mixed	12.19	28.98
5	Mixed	10.19	24.43
6	Mixed	12.49	26.80
8	Mixed	11.36	24.26
9	Mixed	12.69	26.63

10	Mixed	12.69	26.63
13	Mixed	11.07	21.81
14	Mixed	11.37	21.17
15	Mixed	9.88	17.02
16	Mixed	9.97	17.75
17	Mixed	10.94	22.19
19	Mixed	9.40	25.91
20	Mixed	11.78	24.84
21	Mixed	11.71	25.62
22	Mixed	9.48	19.41
23	Mixed	9.08	16.31
27	Mixed	11.98	29.40
28	Mixed	10.02	20.74
30	Mixed	11.94	27.98

Plantation status of Rain tree in the study area

Dead	Dying	Healthy
30.154	18.70233	9.353333

Leaves condition of Rain tree

Leafless	Top leafless	Green
51.592	32.49	15.92
74	54	29

Parasite attack condition of *Albizia saman* (Jacq.)

Insect hole	Fungus	Top dying	Healthy
44.58	6.64	31.84	15.92

Physical condition of bark of *Albizia saman* (Jacq.)

Debarked	Draw out	Top debark	Healthy
17.273	18.38621	13.121	9.153793

Disease appearance of Rain tree in the study area

Scatter	Cluster
62.5	37.5

Performance of Rain tree in mono-culture in the study area

Dead	Dying	Healthy
71.42	28.57	0

Performance of Rain tree in mixed-culture in the study area

Dead	Dying	Healthy
48.529	33.088	15.92