The chapter describes about the raw knowledge base of rice plant diseases and their symptoms. Details of the rice plant diseases - fungal, bacterial and virus; its symptoms, predisposing factors and control measures are covered in this chapter.
Raw Knowledgebase: Rice Plant Diseases and Their Symptoms

3.1. Rice Plant

Since 8,000 to 10,000 years ago, worldwide, rice has supported a greater number of people for a longer period of time than any other crops. Approximately 50% people in the world eat rice as their staple food. In Asia, majority (90%) of the world are of rice-based production. Roughly 900 million of the world's deprived depend on rice as producers or as consumers. With the longest history of cultivation, rice was considered as the world's single most important economic activity and more than 2.5 billion of poorest people depend on it as their daily food requirement [37].

Rice continues to hold the key to sustained food security in the country, so even if rice production areas stabilize or register, negative growth, future rice production targets must be achieved exclusively. Recently, throughout worldwide it had seen that 23% (approx) of the global planting area was grain crops, of which 29 % (approx) was the output. It is well known that the green revolution in rice cultivation was most successful in irrigated ecosystems. Rice occupies an important position in the agricultural development, history, and
civilizations of Asian nations. Thus, rice is the cornerstone of cultural, social, and economic development in Asia [38].

In the world, India is the seventh largest country by area, with 329 million hectares and became the second-most populous country. By 2012, India’s population will reach 1.2 billion as per the demographer’s indicator. But, still India is running the lowest rice yields production among the countries. Out of 414 rice-growing districts, after the advent of high yield technology only seventy percent report yields which lower than the national average.

Rice a member of the family Poaceae, one of the three leading crops in the world mainly grown in rain fed areas that receive heavy annual rainfall. Rice is grown throughout the country by resource poor rural farmers and landless agricultural labourers on small farms averaging only 2.3 ha in size. Although a shift to high yielding rice varieties in the 1980s was meant to increase production, average grain yields have stagnated at around 3.0 ton per ha. Rice seeds are planted in September. It flourishes comfortably in hot and humid climate. Rice crops are grown in 5-25cm of water depending on growing conditions. Once harvested, the rice is commonly named paddy rice. This is the name given to unfilled rice with its protective husk in place [39].
Rice grows in rain fed areas where heavy annual rainfall receives. The seeds of the rice are usually planted in the month September. Throughout the country the cultivation are done by poor rural farmers and landless agricultural labourers on small farms with 2.3 ha in size and average grain yields have stagnated at around 3.0 ton per ha. Commonly once harvested it is named paddy rice, the name given to unmilled rice with its protective husk in place.

In looking towards the future, scientists start using high technique to maximize year-round production of the crop on a given plot of land so as to increase rice yields. With an annual population growth rate of 2%, an increase in rice yield has become a vital to both matching the rising caloric demand for this staple and to contribute to the income of the rural poor. Before improving the production, the most critical factors affecting that production must be revealed.

In the north eastern corner of India, a state with natural beauty and splendour, a precious little valley, Manipur encircled by mountain ranges on all sides has an area of about 1,850 sq.km, constituting only 8% of the total geographical area of the state. Majority of the people based on agriculture as source of livelihood. Rice based agriculture and allied services, provided direct employment to about 70% of the total working population of the state according to 1991
population census. Out of the total cultivated area 2.1 lakh hectares in the state, the area under main rice crop during kharif is 1.95 lakh hectares, which is about 93% of the net cultivated area. Studies have shown that State Domestic Product which is commonly known as "State Income" of Manipur of the agricultural sector with rice being predominant contribute about 53% of the total SDP but it fluctuate from year to year according to the success or failure of rice crop depends almost entirely on the capricious rainfall. Rice based agriculture plays a very crucial role in the state’s economy of Manipur as from the viewpoint of employment and income [5].

3.2. Diagnosis of Rice Diseases

Yields and production efficiency of the rice plant are usually increased by adopting modern techniques in cultivating of rice and use of high yielding nitrogen (N) fertilizers. But it had been seen that this adoption improvised new fungicides and start developing resistances which help to enter diseases. Microorganisms such as fungi, bacteria and viruses are the known causes of plant diseases that limit health, quality and production potential of crop plants. Functional biodiversity is mainly based on principles of using cultivar with diversified functions to limit the expansion of diseases [29]. Several factors determine the incidence and severity of a specific disease in the rice field. Diseases of rice plant are easily recognized
by the presence of symptoms and visible changes occurred [30]. Symptoms may vary according to time, environment, host variety, and race of the pathogen present. The three main principal elements that present for the occurrence of a plant disease are: a susceptible host, a pathogen, and favourable environmental conditions for disease development. As a result, rice diseases remain a major cause of yield loss and decrease in production. The diagnosis of rice plant-fungal diseases, bacterial diseases and virus diseases with their symptoms and related parameters are briefly described in the following.

3.2.1. **Fungal Diseases**

Fungi are microscopic vegetative body having cell walls and a true nucleus but lacks of chlorophyll. It consists of threadlike structure (hyphae), usually aggregated into branches-mycelia. Fungus which reproduces mainly by spores consists of one or more cell and it may be formed asexually or sexually by arising from modified mycelial portions (like buds on a twig) or through the fusion of unlike cells (gametes). Fungi are of two structures - asexual *(anamorph)* and sexual *(teleomorph)*. Teleomorph are rarely encountered or observed, and then anamorph. Ascospores are sexual spores within a saclike zygote cell (ascus), contained in a fruiting body called perithecium. Basidiospores are sexual spores of other
fungi; develop outside the club like zygote cell, the basidium. Conidiophore, asexual spore deriving from terminal or lateral cells cut off called conidia. Fungus such as spores, sclerotia initiates infection and germinate by producing a germ tube at the tip forming an aspersorium, through which it penetrates into the plant cell wall. Once it invades to the plant cell, the fungus continuously grows by producing more hyphae and intruding until the plant exhibits symptoms.

3.2.1.1. Rice Blast

The rice plant diseases caused by the fungus *Pyricularia oryzae* is called Rice blast [40, 41]. The epidemic of rice diseases became extremely high due to wide distribution and destructiveness. Under favourable conditions, disease development increases by thick stands and high nitrogen rates resulting in higher moisture levels of the areas. Severities of the diseases are seen more in areas of under upland or drained environment. Other conditions which favour rice blast are sandy soils and fields lined with trees. Pathologically, it infect at different growth stages such as: leaf, collar, node, internode, base, or neck, panicle, and also sometimes the leaf sheath [42].
3.2.1.1. Types and Its Symptoms

a. Leaf blast: Leaf blast lesions are also one of the rice plant diseases which are almost similar to brown spot lesions. The characteristics seen on a rice leaf are: gray colour at the center with dark border, and spindle-shaped which spread larger in the middle part and tapers toward the end (Fig. 1a).

b. Collar blast: Collar blast usually develops a reddish brown collar lesion (Fig. 1b) and slowly it may slaughter to the entire attached leaf. In some upland varieties the internodal infection were also occurs at the base of the plant. Nodal infection is more commonly seen than internodal infection. Similarly white panicles also causes to that induced by yellow stem borer or water deficit.

c. Node blast: In case of node blast, the rice plant turns blackish in colour especially at the node parts (Fig. 1c) and it breaks easily. The infected part of the nodes became crack and gets open while drying dead tissues and the parts above the infected node dry off. As a result sterile panicles were produce.

d. Neck blast: Neck blast which is the most destructive one result in a girdled neck with grayish brown lesions (Fig. 1d). Neck blast may sometime be confused with "whiteheads" caused by stem borer injuries which results in empty, erect, white gray and conspicuously injured panicles. However, the entire stem can be
pulled out readily and causes the injury only at the neck region of the plant which normally does not extend further into the leaf sheath.

Figure 3.1: Blast Disease of Rice Plant- Leaf (a), Node (b), Collar(c), Neck (d)

3.2.1.1.2. Predisposing Factors of Rice Blast Disease

The predisposing factors that favour rice blast disease are exposure of the diseased plants in long dew period (10hrs or more);
Relative humidity above 90%; Lower night temperature i.e. 20°C or below.

3.2.1.1.3. Control Measures

Blast disease can be controlled by an integrated management system using a variety of methods based on the information from disease forecasting systems. The following are the measures for controlling of the rice blast diseases:

3.2.1.1.3.1. Cultural Systems

Plant varieties are resistant to blast and should be planted as early as possible within the recommended planting period to avoid it. For leaf blast, re-flood the field if it has been drained. Maintain flood at 4 - 6 inches above it ensuring that the soil are covered.

3.2.1.1.3.2. Fertilizer Management

The amount and type of fertilizer for the rice blast diseases must be carefully decided according to the cultivator used, soil condition, climatic conditions and disease risk. The field should not be over fertilizing with nitrogen (N). Application of fungicide must be done as per necessary.
3.2.1.3.3. Chemical Control

Systemic fungicides are widely used to protect blast by seedling application and also protect against panicle blast by applying more than 20 days before heading. The composition, amount, timing and application method of fungicide depends on forecastor level of disease present. Seed treatments are done with tricyclazole at the rate of 4gm/kg seed by increasing the dose of the potassium over the recommended level. Spraying by fungicides such as tricyclazole @0.6gm/l or Carbendazium 1gm/l; Kitazin @1ml/l also control the diseases.

3.2.1.2. Brown Spot

Brown Spot is also one of the rice plant diseases caused by the fungus Cochilobolus miyabeaus Helminthosporium (asexual) oryzae and Bipolaris oryzae (sexual) which is distributed worldwide and reported in all rice-growing countries in Asia, America, and Africa. Within short duration of plantation leaf spots appears and continue to develop until the rice plant maturity. More prevalent are seen in rain fed lowlands and uplands areas or other situations with abnormal or poor soil conditions. The significant development of brown spot is often indicative of poor soil fertility, resulting in reduction of grains per panicle and kernel weight. Severely infected seeds may fail to
germinate. These cause the yield losses of 40-90% of rice production [43, 44].

3.2.1.2.1. Symptoms

The symptoms mostly seen are Coleoptic and become infected from diseased seeds. The colour of smaller spots are dark brown which change to reddish brown and larger spots have a dark brown margin and reddish brown to gray centres on susceptible varieties and may reach 1cm or more in length. Leaf spots vary in size, typically 1/8 inch in diameter, and shape may vary from circular to oval.

Figure 3.2: Brown Spot Disease of Rice Plant

3.2.1.2.2. Predisposing Factors:

The predisposing factor of Brown spot is usually the indicator of potash deficiency. Infection can occur at the temperature level
between 16 and 36°C; optimum temperatures are reported to lie between 20 to 30°C. Infections is favoured by free water on plant surfaces but have been reported to occur in situations without free water at relative humidifies above 89%. Partial shading before, during and after inoculation increases infection. Water stress also increases the host susceptibility. At the same time High and low levels of nitrogen have been reported to increase susceptibility of disease to the rice plants.

3.2.1.2.3. Control Measures

Brown spot may be reduced with balanced fertilization, crop rotation, and by using high quality planting seed which will leads to resistant to the disease. Adding muriate of potash helps to correct the potash deficiency in the soil. Foliar fungicides are not economical for controlling brown leaf spot on most commercial long grain varieties. But 3 to 4 sprays with 0.2% zinels or Mancozeb 75%WP at an interval of 10-12 days just before the appearance of initial symptoms of the diseases may control the diseases.

3.2.1.3. Narrow Brown Spot

Narrow brown leaf spot is generally a minor disease of rice caused by the fungus *Cercospora janseana* [45, 46]. The fungus is airborne and probably survives between crops in residue and on seed.
It develops late in the season and causes little or no yield or quality loss. Affected sheath lesions are irregularly shaped and can be several inches long. Lastly, the fungus can infect the node area just below the panicle or tissue just above the node causing a dark brown discoloration. Some spikelet’s and individual flowers may be blanked by this disease, especially in no-till fields or in years with repeated light rainfall or other moisture during heading. Narrow brown leaf spot is and can infect leaves, sheaths and panicles.

3.2.1.3.1. Symptoms

The spots appear are short, narrow, and elliptical to linear brown lesions usually on leaf blades but may also occur on leaf sheaths, pedicels and glumes or rice hulls. Lesions are narrower, shorter and darker brown on resistant varieties. But they are wider and lighter brown with gray necrotic centres on susceptible varieties.

Figure 3.3: Narrow Brown Spot Disease of Rice Plant
3.2.1.3.2. Predisposing Factors

At 25°C, a R.H. of over 89% is required for successful inoculation by conidia. Free water on leaf surface favoured infection. Partial shading before, during and after inoculation increased infection. H. oryzae is a weak pathogen. So, it prefers physiologically weak plants. Brown spot is an indicator of potash deficiency.

3.2.1.3.3. Control Measures

Cultural practices, such as the use of potassium and phosphorus fertilizers, and planting of maturing cultivars early in the growing season, are recommended to manage the narrow brown leaf spot. Growing in good nutritional condition will leads to resistant to the disease. Adding muriate of potash will help to correct the potash deficiency in the soil. Give 3 to 4 sprays with 0.2% zinels or Mancozeb 75%WP at an interval of 10-12 days just before the appearance of initial symptoms of the diseases.

3.2.1.4. Leaf Scald

The Leaf Scald disease are caused by fungi of Microdochium oryzae or Rhynchosporium oryzae , mainly affecting the more on matured leaves, panicles and seedlings, starting from the tip of the leaf, edges of leaf blades. It looks yellow or golden in colour from far end. The pathogens are seed-borne and survive between crops on
infected seeds [47]. Panicle infestations of the disease usually cause a uniform light to dark, reddish-brown discoloration of the florets of developing grain. It develops in the late season, can cause sterility or abortion of developing kernels.

3.2.1.4.1. Symptoms

The lesion usually is yellow to gold, having indistinct, mottled pattern. Zonate lesions of alternating chevron pattern light tan and dark brown starts from leaf tips or edges. Individual lesions 1-5cm long and 0.5-1cm wide or may almost cover the entire leaf. Affected leaves areas dry out giving the leaf a scalded appearance and translucent at the diseased leaf tips and margins. In case of strong wind, it splits the leaf tips near the mid rib.

![Figure 3.4: Leaf Scald Disease of Rice Plant](image)

3.2.1.4.2. Predisposing Factors

The disease is favourable when High relative humidity for sporulation – 83% & above. Below 75%R.H. fungus fails to produce
conidia. Disease incidence increases with an increase in host age. Positive correlation between closed spacing & level of scald infection; Disease increased with the increase of nitrogen (N) in the soil.

3.2.1.4.3. Control Measures

The control measures of the Leaf Scald disease are discussed as below:

3.2.1.4.3.1. Cultural Practices

Using of seeds for sowing should be free from disease. Fertilizers are not to be of high nitrogen (N) content.

3.2.1.4.3.1. Chemical Practices

The chemical practices of leaf scald diseases are the sowing seed to be treated with Carbendazim or Benomyl or Thiophanate methyl. The affected field must be Sprayed with – 0.1% Carbendazium solution or 2gm mancozeb or 2.25gm Zineb/litre

3.2.1.5. Bakanae

The seed borne disease which internally infects by *Fusarium fujikuroi Nirenberg* through the roots or crown of the rice plant is called Bakanae [48]. This fungus contaminates outside of the seed coat and produces growth hormones (gibberellins) and a fusaric acid,
causing the plant elongated and stunt. Residue of the fungus in crop or the soil makes the survival of disease cycle. By limiting the amount of inoculum carrying over to the next crop provide the benefits by destruction of crop residue infested with the pathogen.

3.2.1.5.1. Symptoms

Affected Rice plant may be of abnormal elongation in the seedbed and stunting or normal growth. If they survive to maturity, they produce no panicle or of empty panicles field - thin plants with yellowish green leaves. Reduced tillering and drying of leaves at late infection - dying seedlings at early tillering. Partially filled grains, sterile, or empty grains for surviving plant at maturity.

Figure 3.5: Bakanae Disease of Rice Plant
3.2.1.5.2. Predisposing Factors

Presence of infected seeds; soil borne pathogens; high nitrogen application; temperature ranging from 30 to 35° C; presence of wind or water that carries the spores from one plant to another; seedling and tillering stages of the rice crop are the predisposing factor which leads to diseases.

3.2.1.5.3. Control Measures

Bakenae diseases may be reduce by using clean seeds, salt water to separate lightweight, infected seeds from seed lots and thereby reduce seedborne inoculum. Seed treatment using fungicides such as thiram, thiophanate-methyl, or benomyl is effective before planting.

3.2.1.6. False Smut

In almost all rice producing countries, false smut rice diseases have been found, cause by Ustilaginoidea virens (Cooke) Takahashi [49, 50]. These diseases survive in the soil or contaminated rice grain as spore balls and replace the developing rice kernel. It germinates lately at the time of growing season and release spores into the air. The primary infection occurs when the spores reaches the soil and develop rapidly in infected flowers. The mature spore balls starts releasing a tiny airborne spore when it disturbed. The first sign
appears as silvery-white structures and later as orange smoke/dust, when infected later develops panicles. The disease cycle continues late into the growing season and has caused the loss of direct yield so far [42].

### 3.2.1.6.1. Symptoms

The symptoms seen is that individual rice grain transformed into a mass of yellow fruiting bodies. When mature, the spore balls are 1/4 to 1/2 inch in diameter and are orange and turn yellowish green or greenish black. Growth of velvety spores that enclose floral parts. The immature spores are slightly flattened, smooth, yellow, and covered by a membrane. Only few grains in a panicle are usually infected and the rest are normal.

![Figure 3.6: False Smut Disease of Rice Plant](image-url)
3.2.1.6.2. Predisposing Factors

Disease favours when there is presence of rain and high humidity; soils with high nitrogen content; presence of wind for dissemination of the spores from plant to plant; presence of overwintering fungus as sclerotia and chlamydospores; flowering stage of the rice crop.

3.2.1.6.3. Control Measures

No special control measures are necessary. There are varieties that are found to be resistant or tolerant against the disease. Among the cultural control, destruction of straw and stubble from infected plants is recommended to reduce the disease.

3.2.1.7. Sheath Blight

Sheath blight is the rice plant diseases cause by fungi *Rhizoctonia solani Kuhn* that survive in infected straw of rice and in other crop residue which does not last long. [51]. The fungi, sclerotia float around the field with irrigation water and infect the early reproductive growth stages of the rice. Under favourable conditions, it grows in the rice tissue as threads like microscopic structure called hyphae. During the latter half of the rice-growing season, the fungus forms sclerotia on dying or dead tissue. The continuation of the
fungus in field occurs when sclerotia fall off the straw before or during the time of rice harvesting [42].

3.2.1.7.1. Symptoms

Initial lesions on leaf sheaths near are water-soaked to greenish gray and later become grayish white with brown margin, presence of sclerotia; lesions may coalesce to form bigger lesions which lead to death of the whole leaf. It filled or empty grains, especially those on the lower portion of the panicles

![Figure 3.7: Sheath Blight Disease of Rice Plant](image)

3.2.1.7.2. Predisposing Factors

Presence of the disease in the soil; presence of sclerotia or infection bodies floating on the water; relative humidity from 96 to 100%; temperature from 28-32 °C; high levels of nitrogen fertilizer;
presence of irrigation water; growing of high yielding improved varieties; late tillering or early internodes elongation growth stages leads to sheath blight diseases of rice plant.

### 3.2.1.7.3. Control Measures

The least susceptible production of diseases can be the selection of rice plants which are high-yielding varieties, seed plantation to a stand of 15 to 20 plants per square foot. Plantation to be done at the optimum time for a specific variety. Avoid extremely early planting. Timely applications of nitrogen 30 pounds or less are applied at internode elongation (IE). Scout fields for symptoms from IE to a few days before heading and use a labelled fungicide when the incidence of sheath blight has reached a threshold level.

### 3.2.1.8. Sheath Rot

Sheath rot caused by the fungus *Sarocladium oryzae*, is one of the most severe diseases which infects the young panicle of the rice plant especially during the boot stage. It is seen mainly on the uppermost part of leaf sheaths that may affect the panicles and emerged severely [52, 53]. This diseases increase when insect or mite damage to the boot or leaf sheaths. Usually, it affects only the scattered tillers in a field and plants along the leaves. However, significantly large areas of a field may have damage.
3.2.1.8.1. Symptoms

Mostly the rice plants are seen with irregular spots or lesions, dark reddish brown margins and gray centre; there is discoloration in the sheath. Lesions enlarge and often coalesce and may cover the entire leaf sheath and a whitish powdery growth inside the affected sheaths and young panicles are observed infected panicles sterile, shrivelled, or with partially filled grain. Severe infection causes entire or parts of young panicles to remain within the sheath, unmerged panicles rot and florets turn red-brown to dark brown.

Figure 3.8: Sheath Rot Disease of Rice Plant

3.2.1.8.2. Predisposing Factors:

The predisposing factors of sheath rot disease is associated with insect injury; presence of entry points. It favour in the field with
high amount of nitrogen; high relative humidity; dense crop growth; temperature from 20 to 28°C - heading to maturity rice crop stages.

### 3.2.1.8.3. Control Measures

Removal of infected stubbles after harvest and optimum plant spacing are among the cultural practices that can reduce the disease. Application of potash at tillering stage is also recommended. Foliar spray of calcium sulphate and zinc sulphate was found to control sheath rot. At booting stage, seed treatment and foliar spraying with carbendazim, edifenphos, or mancozeb was found to reduce sheath rot. Foliar spraying with benomyl and copper oxychloride were also found to be effective.

### 3.2.1.9. Stem Rot

Stem rot, rice plant diseases infected by fungi, *Sclerotium oryzae* Cattaneo is mostly noticeable at the latter stages of rice plant maturity causing premature death and lodging of the plants. It occurs in circular to irregular areas in fields. The disease attacks nearby the water line during late tillering or early reproductive stages of growth of the rice plant [54]. Approaching towards the maturity of the rice plant, the stems injury increases and reaches its peak at harvesting periods. It makes the stalks of the plant weak and breaks easily making harvest difficult. Plants infected early yield poorly. In many of
the areas Ratoon cropping became impractical because the percentage of plants killed by the disease rises up. [42].

3.2.1.9.1. Symptoms

Stem rot are of small and irregular black lesions on the outer leaf sheath near water level, tiny white and black sclerotia and mycelium inside the infected culms and caused unfilled panicles and chalky grain, Infected Culm lodges, Death of tiller.

![Figure 3.9: Stem Rot Disease of Rice Plant](image)

3.2.1.9.2. Predisposing Factors

Presence of infection bodies or sclerotia in the upper soil layer or on irrigation water; presence of wounds as entry points of the fungus; panicle moisture content; nitrogen fertilizer; presence of the
white tip nematode, which has synergistic effect with the disease; from milking to ripening stages of the crop

3.2.1.9.3. Control Measures

Among the cultural control practices, burning straw and stubble or any crop residue after harvest or letting the straw decompose and draining the field can reduce sclerotia in the field. A balanced use of fertilizer or split application with high potash and lime to increase soil pH reduces stem rot infection and increases yield. The use of resistant cultivars may be the best control measure for stem rot. Chemicals such as fentin hydroxide sprayed at the mid-tillering stage, thiophanate-methyl sprayed at the time of disease initiation can reduce stem rot incidence in the rice field. The use of other fungicides such as Ferimzone and validamycin A also show effectiveness against the fungus.

3.2.1.10. Leaf Smut

Leaf smut is a rice plant disease which often observed on the upper part of the rice leaves especially in the field which is over-fertilized with Nitrogen [55, 56]. It is caused by the fungus *Entyloma oryzae*. It infects the endosperm of the plant. Partially or completely it replaces with masses of dark spores that ooze out of the seed when there is moist environment. Therefore, like the same factors that
favour kernel smut, it also increased the infection and often the two diseases were noticed on the same plants.

### 3.2.1.10.1. Symptoms

Rice plant may be pale green or yellow with stunted growth including root growth, with erect and stiff blades infected stem rots. Occurrence of yellow-green streaks parallel to the veins that may turn gray. Occurrence of black dusty spores followed by browning. Leaves may splits and curl from the tips downward.

![Figure 3.10: Leaf Smut Disease of Rice Plant](image)

### 3.2.1.10.2. Predisposing Factors

Acidic soils with excess thatch and low moisture. With optimum temperature 50-68 degrees F (10-20 degrees C) favours for the leaf smut diseases.
3.2.1.10.3. Control Measures

3.2.1.10.3.1. Cultural Management

Only smut-free seed and sod should be used to establish new lawns. A few infected plants are easy to overlook, and smut is usually not discovered until infections are more extensive in older lawns. In established lawns, smut will be worse with excess thatch, soil pH below 6.0, frequent watering and excess nitrogen fertilizers. These same factors encourage other diseases as well and should be avoided. After infected plants die out during summer stress, reseed in the fall with a blend of resistant cultivars.

3.2.1.10.3.2. Chemical Management

Only penetrate /systemic fungicides are useful against smut fungi. They are expensive and usually must be applied more than once. Fungicide applications are not economical or practical for most lawn situations compared to reseeding damaged areas.

3.2.1.11. Stack Burn

The rice disease which is caused by the staining known as stack-burn and flecking and decay of the grain in the shock and in storage leads to poor germination of the seed. Stack Burn seed injury was associated with a leaf spot and seedling blight of rice. The leaf
spot is caused by the small sclerotial fungus *Alternaria padwickii* [57, 58]. The sclerotial fungus, forms sclerotia in the glumes and on the surface of the kernels. Latter become both shrivelled and brittle under very humid conditions, much enlarged, irregular in shape, and black in colour. In the presence of the other fungi mentioned, the kernels have brown flecks and the decayed tissue is of a uniform brownish colour.

### 3.2.1.11.1. Symptoms

Stack burn spots caused by the disease typically are large (0.5 to 1 centimetre in diameter), oval or circular, with a dark brown margin or a ring around the spot. The centre of the spot is initially tan and eventually becomes white or nearly white. Mature spots have small, dark or black dots in the centre. These are sclerotia of the fungus.

![Figure 3.11: Stack Burn Disease of Rice Plant](image.png)
3.2.1.11.2. **Predisposing Factors**

The development of the disease is favoured by the humid atmosphere and high temperatures. An optimum temperature of 26-28°C has been reported for the development of disease symptoms on Coleoptic of rice; the inoculated plants remained free from any visible symptom of stack burn diseases till harvest.

3.2.1.11.3. **Control Measures**

No specific control recommendations are available, but seed-protectant fungicides will help reduce the seedling blight caused by this pathogen and will reduce the number of spores available to cause leaf infections.

3.2.2. **Bacterial Diseases**

Bacteria are a serious agricultural problem for growth of rice plants seedlings. Depending upon the species, host-parasite, relationship and environment the bacterial disease produces different types of symptoms on the rice plant.

3.2.2.1. **Bacterial Blight**

The oldest known diseases, Bacterial leaf blight was first notice at Japan, caused by bacteria *Xanthomonas oryzae pv. Oryzae* occur in epidemic proportions incurring 50% severe crop loss. It reduces
the grain yield at varying levels, depending on the stage, degree of cultivar susceptibility and to a great extent, the conduciveness of the environment in which it occurs. Recent research has provided considerable evidence that the deployment of bacterial antagonists to \( Xoo \) might be an effective strategy, bringing about disease suppression by biological control. The various strategies that may prove effective in reducing disease severity and consequently in improving rice production in India and elsewhere [59, 60].

3.2.2.1.1. Symptoms

The symptoms mostly associated with water-soaked to yellowish stripes on leaf blades or starting at leaf tips then later increase in length and width with a wavy margin. Appearance of bacterial ooze that looks like a milky or opaque dewdrop on young lesions early in the morning. Lesions turn yellow to white as the disease advances later become greyish from growth of various saprophytic fungi. Severely infected leaves tend to dry quickly.
3.2.2.1.2. Predisposing Factors

It is mainly with the presence of weeds, rice stubbles and ratoons of infected plants. Presence of bacteria in the rice paddy and irrigation canals also leads to infections. Warm temperature, high humidity, rain and deep water, over fertilization & handling of seedlings at transplanting are also the factors that favour bacterial leaf blight diseases.

3.2.2.1.3. Control Measures

Practicing field sanitation such as removing weed hosts, rice straws, ratoons, and volunteer seedlings is important to avoid infection caused by this disease.
3.2.2.2. Bacterial Leaf Streak

Bacterial leaf streak is caused by virus *Xanthomonas oryzae pv. Oryzae* were pathogens penetrate the leaves through natural-openings of the plants (stomata and hydathodes). Developments of the disease occur at any stages between the veins of the leaves in the parenchyma cells but the peak infection starts during wet seasons where high rates of nitrogen (N) are used, wherein leaf stomata are fully opened and multiplies in the substomatal cavity. Significantly, reduction of the rice yield is less in unfertile soils, especially when low nitrogen (N) rates are applied. Potential sources of bacterial inoculum include infected planting materials, volunteer rice plants, infected straws, and weed hosts. Once the diseases enter the vascular system, the bacterium multiplies and starts spreading in both directions [61].

3.2.2.2.1. Symptoms

Initial symptoms are dark-green and water-soaked streaks on interveins from tillering to booting stage. Streaks later enlarge to become yellowish gray and translucent. Bacterial exudates on surface of lesions. Lesions turn brown to greyish white then dry. Browning and drying of entire leaves.
3.2.2.2.2. Predisposing Factors

It can result in yield losses through the reduction in thousand grain-weights depending on the rice variety, plant age, and climatic conditions. Presence of the bacteria on leaves and in the water or those surviving in the debris left after harvest. High temperature and high humidity. Early stage of planting from maximum tillering to panicle initiation.

3.2.2.2.3. Control Measures

The disease can be controlled by proper application of fertilizers and proper planting spacing, the use of resistant varieties, and hot water treated seeds.
3.2.3. **Virus Diseases**

Virus diseases constitute a serious threat to increased rice production. Since then, virus diseases have been increasingly recognized in most rice growing districts and they could develop into epidemic proportions, particularly under conditions of high fertilization, cultivation of susceptible varieties, multiple cropping and haphazard cultural practice.

3.2.3.1. **Tungro**

Tungro is the rice diseases caused by a viral complex, *Rice tungro bacilliform virus* (RTBV) and *rice tungro spherical virus* (RTSV), with outbreaks affecting thousands of hectares (ha) which are mostly seen in Southeast Asia. It is considered as one of the most economically important viral disease of rice. Naturally, rice tungro disease are the RNA and a DNA virus complex which spread with the help of an insect vector such as- leathoppers, particularly the green leafhopper (GLH) and Nephotettix viriscens (Distant) [62].

3.2.3.1.1. **Symptoms**

Discoloration begins from leaf tip and extends down to the blade or the lower leaf portion. Infected leaves may also show mottled or striped appearance – stunting and reduced tillering. It delayed flowering, which may delay maturity - panicles small and not
completely exerted. Most panicles sterile or partially filled grains and covered with dark brown blotches.

![Figure 3.14: Tungro Disease of Rice Plant](image)

**Figure 3.14: Tungro Disease of Rice Plant**

### 3.2.3.1.2. Predisposing Factors

Synchronization of the presence of the virus sources and vector, age and susceptibility of host plants are the factors. All growth stages of the rice plant specifically the vegetative stage leads to tungro diseases.

### 3.2.3.1.3. Control Measures

Planting of resistant varieties against tungro virus disease is the most economical means of managing the disease.
3.2.3.2. Grassy Stunt

Grassy stunt are the rice plant diseases caused by the virus, Rice grassy stunt virus (RGSV). The virus flies from affected fields to a newly planted rice fields. In the tropical countries, grassy stunt and BPH are generally an endemic where rice is planted throughout the year. During the winter season, brown plant hopper (BPH) migrates annually from the endemic areas. The migrant brown plant hopper (BPH) travels overseas carrying the infected rice stubble and volunteer rice plants also serve as a source of the virus [63].

3.2.3.2.1. Symptoms

Symptoms of grassy stunt are rice plants are stunting with excessive tillering and very upright growth habit. It’s grassy and rosette appearance, Leaves short, narrow, and yellowish green with numerous. Threadlike filaments 6-8 nm in diameter and small isometric particles 18-20 nm in diameter were observed in extracts of rice plants. The symptom develops 10-20 days after infection. Small rusty spots or patches, which form blotches. Infected plants usually survive until maturity, but produce no panicles.
3.2.3.2.2. Predisposing Factors

The virus is transmitted by the brown plant hopper (*Nilaparvata lugens*) in a persistent manner and has an incubation period in the insect ranging from 5 to 21 days availability of the vector. All growth stages especially the tillering stage of the rice crop.

3.2.3.2.3. Control Measures

A single dominant gene governs resistance. A strain of wild rice, *Oryza nivara* Sharma & Shastry, was found to be resistant to the pathogen. The control of brown plant hopper, either with chemical, resistant varieties, or other control measures, result in the control of RGSV.
3.2.3.3. Ragged Stunt

Ragged stunt are rice plants disease which is infected by virus, *Rice ragged stunt virus (RRSV)*. Rice plants yields productions are greatly reduced due to delay flowering, incomplete panicle emergence, and unfilled grains. Though several resistant varieties are available, most of the rice plants are susceptible to RRSV. It have been seen that though the attempts are made to prevent RRSV infections often opposite effect of facilitate RRSV outbreaks which is due to a disproportionate effect of insecticides on the natural enemies of BPH. With increase in BPH populations, the incidence of RRSV also increases within a field and they transform into long-winged migratory forms spread RRSV to fields up to hundreds of kilometres away [64].

3.2.3.3.1. Symptoms

Rice is stunting during early growth stages of the crop. Leaves became short and dark green with serrated edges. The leaf blades twisted at the apex or base. Leaf edges are uneven and the twisting give the leaves a ragged appearance and colour changes from yellow to yellow-brown. Vein swellings pale yellow or white to dark brown are develop on the leaf blades and sheaths. Flag leaves twisted, malformed, and shortened at booting stage. Incomplete panicle
emergence. Nodal branches produced at upper nodes. Partially exerted panicles and unfilled grains.

![Ragged Stunt Disease of Rice Plant](image)

**Figure 3.16: Ragged Stunt Disease of Rice Plant**

### 3.2.3.3.2. Predisposing Factors

Presence of the vector and the host. Tillering, reproductive, and maturity growth stages of the rice plant are the predisposing factors of ragged stunt diseases of the rice plant.

### 3.2.3.3.3. Control Measures

There are no specific control measures for the ragged virus disease except for the use of resistant varieties. Because some rice varieties are resistant to the brown plant hopper, to the virus, and to both.