INTEGRATED PEST AND DISEASE CONTROL

Pests and diseases are biotic stresses that can reduce yields and even cause crop failure. Therefore, in order to obtain optimum yields, in rice cultivation, it is necessary to control pests and diseases. Integrated Pest Management (IPM) is a pest control system in relation to 1) population dynamics and the environment of a pest species, using 2) various compatible control techniques to keep 3) pest population below the threshold that causes economic damage (FAO Expert Panel, FAO, 1965). The main pests and diseases in irrigated rice fields were brown planthoppers, stem borer, rats, bacterial leaf blight, blast, tungro, and dwarf virus diseases.

A. Common Pest in Paddy Field

1. Brown planthopper (BPH)

The brown planthopper (BHP) (*Nilaparvata lugens* (Stal)), has been one of the main pests of rice in Indonesia since the mid-1970s. This is a consequence of the application of a rice intensification system (high yielding varieties, high doses of N fertilization, application of IP>200, etc.). The use of pesticides that violate the principles of integrated pest control (right type, right dose, and timely application) also triggers the brown planthopper explosion. Depending on the level of damage, brown planthopper attack can increase rice yield losses from only a few quintals of grain to puso (harvest failure). In addition, BPH is also a vector of dwarf virus (grassy stunt and ragged stunt).

By sucking fluid from the transport tissue of rice plants, BPH can cause mild to severe damage in almost all growth phases, from the seedling, tillering, until the milk ripening phase (filling). Symptoms of BPH in individual clumps can be seen from the yellowing of the leaves, then the plant dries quickly (like burning). This symptom is known as hopperburn. In an overlay, the hopperburn symptom is seen as a circle, which shows a pattern of BPH distribution starting from one point, and then spreading in all directions in a circle. In such circumstances, the BPH population is usually already very high.

Figure 1. Brown planthopper and the hopperburn symptom

Brown planthopper control

Brown planthoppers can be controlled by combining various control techniques including:

1. Plant rice simultaneously in a large area

Simultaneous rice cultivation is an attempt to limit food sources for brown planthoppers.

2. Use resistant varieties

   The use of resistant varieties must be adapted to the presence of brown planthopper biotypes in the field. Currently, the biotype of brown planthopper that develops in the field is dominated by biotype 3 and in some places there is already a biotype 4, so it requires a new high yielding variety (VUB) that has resistance to that biotype. ICRR has provided several new high yielding varieties that are resistant to these biotypes, namely Inpari 13, Inpari 31, Inpari 33, and Inpari 47.

3. Use of light traps

   Light traps can serve as a tool to monitor the presence of immigrant brown planthoppers who come to rice plantations. The light trap also functions as a physical and mechanical controller for the brown planthopper caught in the light trap. The catch in the light trap should be observed every day, because the catch in the light trap can be used to determine when to seed rice and when to apply chemical insecticides.

   a. Determination of rice seedling time based on catch on light trap

      Seeding time is determined by the peak of the immigrant brown planthopper caught in the light trap. If the arrival of immigrant brown planthoppers does not overlap between generations, then seeding should be done 15 days after the peak of immigrants. When the brown planthopper comes from overlapping generations, there will be two peaks. Under these conditions, seeding should take place 15 days after the 2nd immigrant peak.

   b. Appropriate timing of chemical insecticide application based on catch on light trap

      The peak population of early immigrant brown planthoppers (macropterous) based on light trap catches was recorded as generation zero (G0). At 25-30 days later, the zero generation (G0) of this brown planthopper will become the imago of the 1st generation brown planthopper. At 25-30 days later, the 1st generation will become the 2nd generation brown planthopper imago, and 25-30 days later, this 2nd generation will become the 3rd generation brown planthopper imago (Figure 2).

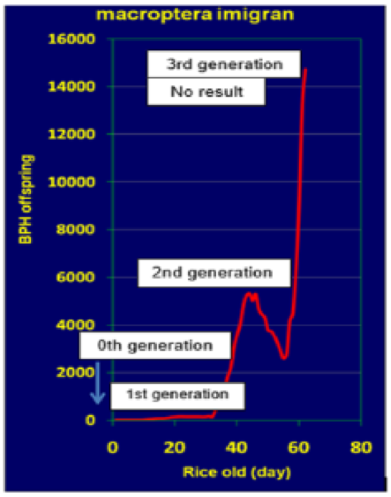

Figure 2. Brown planthopper generation

4. Observation of brown planthopper in the plantation

   Observations or monitoring of brown planthoppers are carried out once every 1-2 weeks. If the observations show that the brown planthopper population has reached the economic threshold, control measures must be taken immediately. The economic threshold for brown planthoppers in rice plants aged less than 40 days after planting is 3 individual, and in rice plants aged more than 40 days after planting is 5 individual.

2. Rice Stem Borer

Scirpophaga incertulas (Walker) (Yellow rice stem borer), *S. innotata* (Walker) (White rice stem borer), *Chilo suppressalis* (Walker) (Striped rice stem borer), and *Sesamia inferens* (Walker) (Pink rice stem borer) are among the most important pests of rice plants which often cause heavy damage and high yield losses (Figure 4). In the field, the presence of this pest is indicated by the presence of moths, death of rice shoots (dead heart), death of panicles (white head), and stem borer caterpillars (larvae). Each species of rice stem borer has different characteristics in distribution and bioecology, but is almost the same in how to attack or bore rice plants and the damage it causes.

This pest can damage plants at all stages of growth, both at the time of the nursery, going phase, and flowering phase. If the attack occurs in the nursery until the tiller stage, this pest is called deadheart and if it occurs during flowering, it is called whitehead (Figure 3).

Yield loss due to rice stem borer attack at the vegetative stage is not too large because the plant can still compensate by forming new tillers. Based on the simulation at the vegetative stage, the plant was still able to compensate for the damage caused by the rice stem borer up to 30%. Attacks at the generative stage cause the panicles to appear white and hollow called whiteheads. Yield losses caused by each percent of the outflow symptoms ranged from 1-3% or an average of 1.2%. Big losses occur when the flight of the rice stem borer moth coincides with the booting stage of rice plant.

Figure 3. The rice stem borer moth

Figure 4. Symptoms of rice stem borer attack

Rice stem borer control

Rice stem borer can be controlled by combining various control techniques including:

A. Endemic attack area

1. Cropping pattern settings
    - Simultaneous planting is carried out, so that the availability of food sources for rice stem borer can be limited.
    - Crop rotation with non-rice crops so as to break the life cycle of pests.
    - Nursery grouping is intended to facilitate efforts to collect rice stem borer eggs in bulk.
    - Timing of planting is based on flight of moths. Planting should not coincide with the peak of the moth's flight. Planting can be done before or after the peak of the moth flight.
2. Physical and mechanical control

- Cutting plants as low as possible to ground level at harvest. This effort can also be followed by flooding as high as 10 cm so that the straw or the base of the straw rots quickly so that the larvae or pupae die.
- Using a singkal tool when tilling the soil.
- Using a net cover in the nursery.
- Collecting egg masses of rice stem borer in nurseries and in plantations.
- Catching rice stem borer moths using light traps.

3. Biological control
   - Utilization of natural enemies by releasing egg parasitoids such as *Trichogramma japonicum*.

4. Chemical control
   - If needed as an alternative, the use of insecticides can be done. Insecticides were applied 4 days after the flight of the rice stem borer moth based on light trap monitoring, or the observation found that the egg masses averaged more than one egg masses / 3 m^2, or the average attack intensity was >5%. If the level of parasitizing of the egg masses in the early vegetative stage is >50%, there is no need for insecticide application.
   - The use of granular insecticide in the nursery is carried out if around the planting there is land that is being or nearing harvest one day before planting. In planting, granular insecticides are given mainly at the vegetative stage. In the generative stage, the application is sprayed with insecticide (liquid).
   - The recommended granular insecticide is an insecticide containing the active ingredient carbofuran.
   - The recommended spray (liquid) insecticides are containing the active ingredients Spinoteram (effectiveness: 70-80%), Chlorantraniliprole (effectiveness: 50-60%), and Dimehipo (effectiveness: 40-50%).

B. Sporadic attack area

1. Control methods other than using insecticides that can be applied according to local conditions.
2. Spraying with insecticides 4 days after the rice stem borer moth flight based on light trap monitoring, or observations found that the egg masses averaged more than one egg masses / 3 m^2, or the average attack intensity was >5%, no later than at least three weeks before harvest.

C. Other information

As a preventive measure in controlling the rice stem borer, it is necessary to monitor fluctuations in the population of the rice stem borer on a regular basis. To monitor population fluctuations of rice stem borer originating from migration from outside the area, light traps can be used.

3. Rat (*Rattus argentiventer* (*Rob. & Kloss*)

Rice field rats are the main pests causing damage to rice in Indonesia. Average damage rate rice crop reaches 20% per year. Rats damage rice plants at all stages of growth from seedling to harvest, even storage. Severe damage occurs if mice attack rice in the generative phase, because the plants are no longer able to form new tillers. In heavy attack, rats damage rice plants starting from the center of the plot, extending towards the edge, leaving 1-2 rows of rice at the edge of the plot.

Rats attack rice at night. During the day, rats hide in their nests in irrigation embankments, rice fields, embankments, and in rural areas near rice fields. In the fallow period, most of the rats migrated to the village areas near the rice fields and will return to the rice fields after rice planting approached generative. The presence of rats in rice fields can be detected by monitoring the presence of footprints, runways, faces, active potholes, and signs of attack. Rats breed very quickly and only occur in the generative period of rice. In one growing season, one female rat can give birth to 80 cubs (Figure 5).

Figure 5. Rice rat

Rat control

Rat control is carried out through the IRPC (Integrated Rat Pest Control) approach. These control based on the biology and ecology of rats, carried out jointly by farmers from an early age (before planting), intensively and continuously, utilizing various available control technologies, and within the target area of large-scale control.

At the beginning of the season, rat control was emphasized to suppress the initial population of rats, which was carried out through mass grouping, habitat sanitation, installation of TBS (Trap Barrier System) and Linear Trap Barrier System (LTBS), installation of traps in nurseries. TBS application is a rice crop that planted 3 weeks earlier, minimum size (20x20) m, fenced with plastic as high as 60 cm which is enforced with bamboo stakes at every 1 m distance, has trap traps on each side of the plastic fence with holes facing out, and equipped with a narrow embankment as an entrance for rats. TBS is surrounded by a 50 cm wide trench which is always flooded to prevent rats from digging or perforating the plastic fence. The working principle of TBS is to attract rats from the surrounding rice fields (up to a radius of 200 m) because the rats are attracted to the rice planted earlier and are pregnant first, so as to reduce the rat population throughout the plantation. LTBS is a stretch of plastic fence > 100 m long, equipped with traps on both sides alternately to be able to catch mice from two directions (habitat and rice fields). Installation of LTBS is carried out near rat habitats such as the edge of the village, along irrigation embankments, and large embankments/embankments. LTBS is also effective in catching migratory rats, namely by installing LTBS on the migration path through which rats pass so that rats can be directed into trap traps. Fumigation is most effective in the generative phase, when most of the mice are in the hole for reproduction. This method is effective in killing mice and their young in their holes. Rodenticides should only be used when the rat population is very high, and are only effective in the fallow period and the early vegetative phase.

B. Common Disease in Paddy Field

1. Bacterial Leaf Blight (BLB)

Bacterial leaf blight (BLB) is one of the main rice diseases in rice producing countries. This disease can be found in irrigated, dry land, rain-fed, and swamps rice agroecosystems. The cause of the disease belongs to the group of bacteria, namely *Xanthomonas oryzae* pv. *oryzae* (Xoo). Pathogens can infects rice plants in the early stages on seedling in the seedbed/nursery or late stages of plant growth, e.g. at about flowering.

BLB has 2 types of symptoms based on the plant growth stage affected, namely *kresek* (early phases) and blight (late/generative phases). However, the disease generally found at late stage of plant. On seedling stages, the disease symptom usually observed 1-2 weeks after transplanting. Younger plants (less than 21 days old) are the most susceptible. The first symptom appears as tiny water-soaked spots at the margin of fully developed lower leave. As the spots enlarge, the leaves turn yellow dry rapidly and wither. Besides these typical symptoms, the leaves sometimes roll/curled, so it is like a plant that has been attacked by stem borer. Meanwhile, blight is the most common symptoms found in the late stages/generative phases of plant growth (primordia to flowering stages). On leaf blades, lesions usually begin at the margin, a few cm from the tips, as water-soaked stripe with greyish in color. In its development, the symptoms will expand to be blights covered the entire blade and eventually the leaves dry up. In humid conditions (especially in the morning), groups of bacteria (ooze), in the form of golden yellow granules, can be easily found on leaves that show symptoms of blight. The mass of bacteria will be spread to leave or other plant by wind, friction between leaves, and splashes of rain (Figure 6).

Figure 6. Symptoms of rice leaf blight with ooze which is a mass of *X. oryzae* pv. *oryzae* (Source: Ratna Sari Dewi, 2021 and Ani Widarwati, 2018)

X. *oryzae* pv. *oryzae* has a variety of pathotypes (strains) based on differential varieties responses. In Indonesia there are 12 pathotypes (I-XII) and III, IV and VIII are known to be the dominant pathotypes. Each of these pathotype/strains has a different both virulence or distribution in rice field area.

The disease can cause yield losses up to 80% of total rice production. The disease occurs in the rainy season or wet dry season, especially in paddy fields that are always flooded. High fertilizer input condition especially nitrogen can induce the disease development. Irrigation water is considered to contribute the spread of BLB disease, as it carries the bacterial ooze that drop in the rice field water. The pathogen can survive around 15 days in the field water.

Bacterial Leaf Blight Disease Control

Bacterial leaf blight disease can be control by several approaches e. g. the use of resistant varieties, cultivation method, natural control, and the application of pesticides.

1. Resistant varieties

   Resistant varieties are the most effective to BLB control, but its use must be adjusted to the distribution of the pathotype in the area. Here are the rice varieties with resistance character to the dominant pathotype of Xoo.

   Table 1. Rice resistant variety to bacterial leaf blight based on type of *Xanthomonas oryzae* pv. *oryzae* pathotypes

No.	Variety	Year of release	Resistances type to Xoo		
			III	IV	VIII
1.	Inpari 23 Bantul	2012	R	MR	MR
2.	Inpari 25 Opak Jaya	2012	R	MR	MR
3.	Inpari 31	2013	R	MR	MR
4.	Inpari 32 HDB	2013	R	MR	MR
5.	Inpari 43 Agritan GSR	2016	R	MR	MR
6.	Munawacita Agritan	2017	R	MR	MR
7.	Mustaban Agritan	2017	R	MR	MR
8.	Baroma	2019	MR	R	R
9.	Pamelen	2019	MR	MR	MR
10.	Pamera	2019	R	MR	R
11.	Paketih	2019	R	R	R
12.	Jeliteng	2019	MR	R	MR
13.	Inpari 45 Dirgahayu	2019	R	MS	R

14.	Mantap	2019	R	MS	R
15.	Inpari 46 GSR TDH	2019	R	MR	MR
16.	Inpari Digdaya	2019	MR	MR	-
17.	Inpari Arumba	2020	R	MR	MR
18.	Inpari 47 WBC	2020	S	MR	MR
19	Inpari Gemah	2020	MR	MR	MR
20.	Hipa 3	2004	-	MR	MR
21.	Hipa 4	2004	-	MR	MR
22.	Hipa 5	2007	-	MR	MR
23.	Hipa 8	2009	-	MS	MR
24.	Hipa 18	2013	MS	MR	MR
25.	Hipa 20	2019	-	MR	MR
26.	Hipa 21	2019	-	MS	R
27.	Inpara 6	2010	-	MR	-
28.	Inpara 8	2014	R	MR	MR
29.	Inpara 9	2014	R	-	-
30.	Purwa (padi rawa)	2018	R	MS	MS
31.	Inpara 10 BLB	2018	MR	MS	MS

R: Resistant, MR: moderate resistant, MS: moderate susceptible, S: susceptible

2. Use a healthy seeds and seedlings

   Xanthomonas oryzae pv. *oryzae* that caused BLB disease are known to be seed-borne and have the potential to be a source of disease inoculum. Therefore, it is highly recommended that seeds from plants infected with HDB are not used as seeds. Seed treatment with bactericide by soaking in bactericides solution or hot water can be done. Soaking or washing the seeds can be done to reduce the Xoo population in the seeds. Soaking rice seeds in hot water at 50 ^{o}C for 20 minutes generally can reduce pathogens on the surface of the seeds. In addition, considering that this pathogen can be enter to the plant through wounds, cutting the tips of the leaves of seedlings before planting is not recommended.

3. Cropping pattern

   Legowo system with the intermittent irrigation system can be used for environmental manipulation. This system will reduce humidity around the crop (micro-climate) that can reduces the occurrence of dew and guttation water and leaf contact between plants as a medium for transmission of pathogens

4. Fertilization Management

   Nitrogen fertilizer was positively correlated with the severity of HDB disease. This means that plants that are fertilized with high doses of Nitrogen cause plants to become more susceptible and have higher disease severity. On the other hand, potassium fertilizer causes plants to become more resistant to bacterial leaf blight. Therefore, in order to suppress disease development and obtain high production, it is recommended to use balanced N and K fertilizers by avoiding too high N fertilization.

5. Sanitation

   Xantomonas oryzae pv. *oryzae* bacteria can survive on alternative hosts which are generally from weed groups, such as *Leersia sayanuka*, *L. japonica*, *Zezania latifolia*, and *Leptochloa chinensis*. These bacteria can also survive on plant debris. Therefore, sanitation of the rice field environment by maintaining the cleanliness of the fields from weeds and cleaning the remains of infected plants is a highly recommended.

6. Biological control

   Biological control agent e.g. *Paenibacillus polymyx*a and Pseudomonas fluorescens are known to suppress the development of HDB disease.

7. Chemical control

   Synthetic bactericide can also be used to control the disease. The recommended bactericides are containing the active ingredients oxytetracycline, tebukonazol, trifloksistrobin diphenoconazole, propiconazole, mancozeb, benomyl, copper hydroxide, propineb, fluopicolide, azoksistrobin.

2. Blast Disease

Blast disease is one of the constraint in rice production worldwide. In Indonesia, blast disease is generally a major constraint on dry land in an effort to increase upland rice productivity. Currently, blast disease has been found in swamp rice, rainfed rice and irrigated rice agroecosystems. In lowland rice is a serious problem because of the increasing incidence of neck blast.

Blast disease is caused by the fungus of *Pyricularia oryzae* (Cooke) Sacc. Morphologically the fungus of *P. oryzae* has conidia that are round, oval, translucent and partitioned two (3 rooms) (Figure 9). The fungus of *P. oryzae* can be pathogenic to several other important crops, such as wheat, sorghum and other cereals, and more than 40 species of weeds.

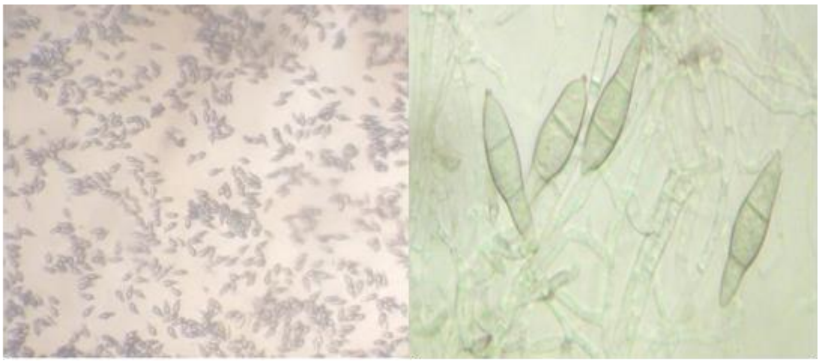

Figure 7. The conidia of the fungus of *P. oryzae*

Blast disease can attack all parts of the rice plant from the seedling stage, the vegetative stage by infecting the leaves and the generative stage by attacking the neck, panicle branches and rice grains. In susceptible varieties and environmental conditions that support the development of fungus can cause to fail to harvest. The fungus of *P. oryzae* can form symptoms on rice leaves, stem nodes, panicle necks, panicle branches, rice grains and leaf collars (Figure 8). Symptom on the leaf sheath are rare.

The typical shape of leaf blast spots is a rhombus with two more or less pointed ends. The symptoms have developed, the edges are brown and the center is grayish white. The symptoms start small, dark green, grayish. These symptoms continue to grow in susceptible varieties. Symptoms on susceptible leaves do not form clear edges. The symptoms are surrounded by a yellow color (halo area), especially in a conducive environment, such as humid and shaded conditions. The symptoms will not develop and remain as tiny dots on resistant varieties. This is because the process of conidia development of the fungus of *P. oryzae* in the host tissue is inhibited. The symptoms will develop to several millimeters round or elliptical with brown edges in varieties with moderate reactions.

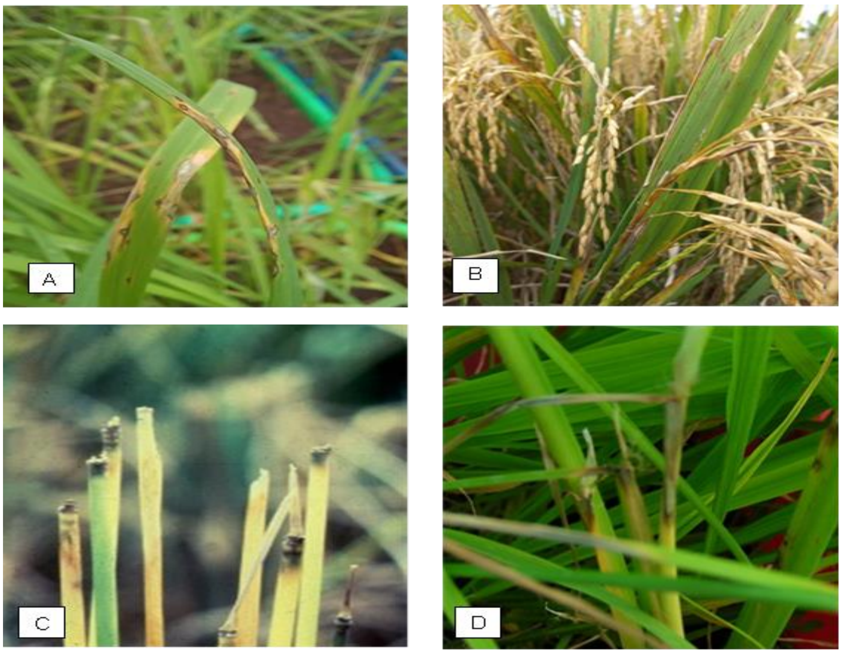

Figure 8. The disease symptoms of leaf blast (A), neck blast (B), node blast (C) and collar blast (D)

Infection of the stem node causes brown or black spots, broken and complete death of the upper stem of the infected. *P. oryzae* attack on the collar of the leaf, which is the border area between the leaf and the sheath, causes brown and gray-colored. Collar blast that occurs on the flag leaf can have a significant effect on rice production.

Spore dispersal occurs not only by wind but also by seeds and straw. The fungus of *P. oryzae* is able to survive in infected straw and seeds. In dry conditions and at room temperature, spores can survive for up to one year, while mycelia can survive for more than 3 years. The primary inoculum source in the field is generally infected straw. Inoculum sources derived from seeds generally show early symptoms in the seedling. For the tropics, sources of inoculation are always available throughout the year, due to the presence of spores in the air and host plants other than rice.

The fungus of *P. oryzae* has high genetic diversity. The *P. oryzae* population consists of racial individuals with different virulence characteristics. *P. oryzae* races can change and form new races quickly if the plant population or plant resistance changes.

Monitoring of blast pathogen populations conducted in upland rice areas in Lampung showed that at least 13-17 races were present in each growing season. A total of 26 races were identified during 5 years of monitoring and 7 races namely races 001, 023, 033, 073, 101, 133 and 173 were always present in each growing season.

In rice production areas in West Java, 30 races were identified, namely races 001, 003, 011, 013, 021, 023, 031, 033, 061, 073, 100, 101, 133, 141, 173, 201, 211, 233, 241, 243, 263, 273, 301, 333, 341, 343, 353, 361, 371 and 373. Races 301, 333, 341, 343, 353, 361, 371 and 373 are new races identified and more virulent than previously races. Race dominance in one region is very different from another, so it is possible that the variety (genotype) in one region is resistant but susceptible in another region.

Blast Disease Control

Control of blast disease can be done using resistant varieties, plant cultivation technology and chemical approaches.

1. Variety Resistance

   Resistant varieties as the main component in integrated blast disease control. The use of resistant varieties is a very effective and efficient to control blast disease. However, this technology is weakness by the presence of very diverse virulence of pathogens and the ability of pathogens to form new races with different virulence so that the resistance properties of varieties are easily broken. Therefore, it is not recommended to plant one variety in a large area continuously because it will accelerate the formation of new races which will break the resistance of the variety.

   To control of diseases caused by pathogens capable of forming new races such as blast disease, the strategies of rotating resistant varieties is need to be carefully. This strategies requires the support of various data, especially those related to the composition and distribution of pathotypes or races in an ecosystem and the resistance of a variety to be planted. The suitability of planting resistant varieties with the composition of pathogenic races in the field has an impact on increasing the effectiveness of blast disease control, so that disease transmission can be suppressed. Information on the distribution of blast races can be used as a reference for farmers in controlling of blast disease by planting resistant varieties according to the races in each location.

   Some varieties that resistant to blast disease are Situ Patenggang, Inpago 10, Inpago 12, and Inpari 48.

2. Plant Cultivation Approaches

   - Using the healthy seeds and seedlings

     Blast disease pathogens can be infected through seeds, so it is recommended that grain harvests from plantations infected with blast disease are not used as seeds.

   - Use of straw as compost

     The fungus of *P. oryzae* can survive on rce debris or straw and seeds from previous rice plantations, so that the source of inoculum is always available from season to season. Indonesia has a tropical climate which does not have a very favorable winter for blast pathogens. Without over winter and dry conditions, mycelia and spores can survive for one year. Embedding straw in the soil as compost can cause mycelia and spores to die due to rising temperatures during the decomposition process.

- Use of nitrogen fertilizers with recommended doses and Si fertilizers

  In general, the effect of N on epidermal cells is an increase in water permeability and a decrease in silica levels, so that fungi penetrate easily. The dose of N fertilizer correlated positively with the intensity of blast disease, the higher the dose of N fertilizer the higher the intensity of blast disease.

  The role of silica fertilizer has been widely studied, the effect of silica is mainly emphasized on physical resistance, especially epidermal cells. Appresoria was unable to penetrate some resistant varieties due to silicate deposition on the epidermal cell walls. Observations using an electron microscope showed that a silicate layer was found under the cuticle of the epidermal cell walls of rice leaves.

- Planting methods

  Planting that is too tight will create environmental conditions, especially temperature, humidity, and aeration that are more favorable for disease development. Tight planting will make it easier for infection and transmission from one plant to another. To provide environmental conditions that do not support the development of blast disease, it is recommended to plant a spacing with jajar legowo, which. Will reduce humidity around the canopy of the plant, reduce the occurrence of dew and water guttation and leaf friction between plants as a medium for pathogen transmission.

- Environment sanitation

  Pathogens can survive on alternative hosts in the form of grass and plant debris, so sanitation of the rice field environment by keeping the fields clean from weeds and infected plant remains is a recommended effort.

- The right planting time

  In Indonesia, the humidity factor needs to be considered to deal with blast neck disease. The period of time when there is a lot of dew at the beginning of flowering, both night, morning and day gives an opportunity for neck disease to occur. Temperature is not a limiting factor, because at a temperature of 30-32 ^{o}C neck infection is still severe as long as the air is moist and dewy. Setting the planting period to avoid "heading" when a lot of dew needs to be cultivated. Therefore, it is necessary to have supporting data for neck blast on each planting date.

- Chemical Approach

  Seed treatment. Blast disease control will be effective if implemented as early as possible, this is because blast disease can be transmitted through seeds. Seed treatment can be done with the use of systemic fungicides such as pyroquilon (5-10 g/kg seed).

  Soaking methods. The seeds were soaked in a fungicide solution for 24 hours and during this period the solution was stirred evenly every 6 hours. The ratio of seed weight and water volume is 1: 2 (1 kg of seed: 2 liters of water). The soaked seeds are aired at room temperature on newsprint and left until the seeds are spread in upland fields. In lowland rice soaking in a fungicide solution is carried out before curing.

Coating methods. This method is more effective than the first method and is more suitable for dry land (upland). The seeds are moistened by soaking for a few hours then drained until the water is no longer dripping. The fungicide used in a certain dose is mixed with 1 kg of wet seeds and shaken until evenly distributed, the seeds are dried in the same way as the previous method and then ready for planting.

Plant spraying. The efficacy of fungicides for seed treatment only lasts 6 weeks and then it is necessary to spray plants. The application of spraying to suppress the attack of neck blast disease is twice, namely at the time of maximum tillers and early flowering (heading 5%). Fungicides that can be used for blast spraying are the active ingredients edifenphos, tetrachlorophthalide, kasugamycin, pyroquilon, benomyl, isoprothiolane and methyl thiophanate.

3. Tungro

A) Status

Tungro is a major diseases of rice plants caused by bacilliform and spherical viruses. Yield loss due to tungro disease varies depending on the time of infection, planting location, point of infection, growing season, and type of variety.

In Indonesia, tungro was initially limited to certain areas in South Sulawesi, South Kalimantan, West Nusa Tenggara, and North Sulawesi, but later expanded to East Java, Central Java, and Yogyakarta. In 1972/1973 there was a tungro explosion in South Sulawesi and in 1998/1999 there were heavy attacks in Central Lombok and East Lombok covering an area of 10,000-15,000 ha. The explosion of tungro disease also occurred at the end of 1995 in Surakarta which resulted in around 12,340 ha of puso rice fields or equivalent to Rp. 25 billion.

The tungro disease has spread to almost all of Indonesia, especially in the areas of national rice production centers such as on Java, Bali, West Nusa Tenggara, Sulawesi, and South Kalimantan. According to the Directorate of Food Crop Protection, the area of infected plants annually reaches an average of 16,477 ha, and total damage (puso) is 1,027 ha during 1996-2002. With an estimated yield loss of an average of 20% of infected plants and 90% of puso plants, the price of grain is Rp. 1200/kg losses due to tungro disease reached Rp. 14.1 Billion. In the event of an explosion attack, the value of the loss can exceed the calculation above.

The tungro explosion also occurred in Klaten Regency in 1995 with an area of 12,340 ha affected, and in West Nusa Tenggara in 1998 with an attack area of 15,000 ha. Besides that, the spread of tungro in West Java, especially in the lowlands of Subang Regency on the North Coast Line (Pantura Line) is increasingly widespread.

B) Symptom

Tungro disease has long been known in Indonesia by various names such as mentek, habang disease (Kalimantan), cellapance (South Sulawesi), or kebebeng (Bali). In general, the expanse of rice fields infected with tungro looks yellow and the plant height is uneven, stunted plant spots are seen. The main symptoms in plants infected with tungro disease appear in the discoloration of the young leaves to yellow-orange, the yellow leaves appearing slightly twisted, stunted plants, and a decrease in the number of tillers. Leaves, especially young leaves, may show *mottle* and chlorosis between the veins (Figure 9).

Figure 9. Rice plants infected with tungro disease (A); and green leafhopper tungro-transmitting vector (B).

C) Biology and Ecology

Tungro disease is caused by two types of viruses, namely rod-shaped virus (RTBV: *rice tungro bacilliform virus*) and round form (RTSV: *rice tungro spherical virus*) which can only be transmitted by leafhoppers, especially the green leafhopper species *Nephotettix virescens* Distant. Green planthoppers can pick up the two viruses from stump, voluntary seeds (sprayed grain during the growing harvest), puzzles, and water hyacinth.

Green leafhopper *N. virescens* has dominated the composition of green leafhopper species in Java, Bali, and West Nusa Tenggara. *N. virescens* populations rarely reach high population densities so they do not cause direct damage. There is a habit of dispersal of imago, especially in the planting area is not uniform, although the population is low if there is a source of effective inoculum to spread tungro.

Yield loss will be high or even not produced at all if the two viruses infect sensitive plants and occur at the beginning of the vegetative phase of the plant. Yield loss occurred due to the small number of tillers and the disruption of photosynthesis due to the lack of chlorophyll yellow leaves so that the grain filling was not perfect. Round virus in terms of tungro spread is very important because stem viruses can only be spread by green leafhoppers when green leafhoppers have acquired round viruses. Round viruses are usually found to first infect plants and green leafhoppers. There were 2 peaks plus infected plants in one period of rice plant growth. The first peak occurs when the plant is one month after planting and the second peak occurs when the plant is two months after planting. The first cycle of infection is carried out by green leafhoppers immigrants from the vicinity, while the second cycle is carried out by their offspring that develop in that location.

D) Control

It is recommended that tungro disease control be carried out by combining control techniques that have a synergistic effect to strengthen natural control mechanisms, in an integrated plant management system, which is introduced/applied gradually according to the stages of cultivation. The application of insecticides to quickly kill green leafhoppers to be efficient and have the least impact on the environment should be carried out based on observations about the condition of the threat of tungro.

Control of tungro disease is carried out early (sensitive young plants) by implementing an integrated disease control system, namely eradication of sources of infection (diseased plants, stump, volunteer and host grasses), use of resistant varieties, cultivation of healthy plants and control of infectious insects.

1) Plan to plant concurrently in an expanse of at least 40 ha, based on the reach of one inoculum source.
2) Plan the planting time by estimating when the peak population density of green leafhoppers and the presence of tungro occurs, the plant has passed the vegetative phase.
3) Clean sources of tungro inoculum such as stump, seeds that grow from scattered grain, nut grass and water before making a nursery. Green leafhoppers get the virus from these inoculum sources.
4) Plant tungro resistant varieties:
    - Inpari 7 Lanrang
    - Inpari 8
    - Inpari 9 Elo
    - Inpari 36 Lanrang
    - Inpari 37 Lanrang
5) Observe the population of green leafhoppers in the nursery with insect nets 10 swings. Test for virus infection with iodine test from 20 leaves. If the multiplication result between the number of green leafhoppers and the percentage of infected leaves is equal to or more than 75 then the plant is threatened. Antifeedant application with the active ingredient imidacloprid, thiametoxam or other active ingredients in the nursery or when the plants are 1 week old after planting to inhibit the acquisition and transmission. If you are unable to observe the population and infected plants in the nursery, observe the symptoms of tungro when the plants are 3 weeks old.
6) Plant in a 2 row or 4 row legowo way. The scattering of green leafhoppers was reduced in the distribution pattern of the hosts planted in legowo.
7) When the plant is 3 weeks old, if from a natural plot with an area of approximately 100 m^2 found 2 clumps of plants with tungro symptoms, the plant is threatened. Apply as soon as possible the application of dual-function insecticides, namely insecticides that can kill green leafhoppers and at low residues are antifeedant, such as insecticides with active ingredients imidacloprid or thiamethoxam or others to inhibit virus acquisition and transmission.
8) Do not dry the rice fields, try at least in water conditions. Dry rice fields stimulate the spread of green leafhoppers which can expand transmission.

4. Dwarf virus

A) Grassy stunt

1) Symptoms and Status

Grassy stunt disease is caused by a virus, namely Rice Grassy Stunt Virus (RGSV) which is a member of Tenuivirus. These virus particles are filamentous. There are two types of Grassy stunt disease. Grassy Stunt disease type 1 has symptoms: very stunted plants with many tillers, plant growth is very upright, many rosettes appear on the trunk and like grass, leaves are short, narrow, yellowish green, sometimes on the leaves there are spots small rust. Leaves of infected plants may turn green when nitrogen fertilizer is added. Affected clumps do not produce panicles (Figure 10a).

Type 2 grassy stunt disease has different symptoms from type 1. In plants infected with grassy stunt virus type 2 at the beginning of the stadia, the plants were slightly stunted, yellowed on the lower leaves, and the leaf blades were narrowed. On the lower leaves sometimes appear irregular rust spots. Infected plants at the age of 30 days or more show symptoms similar to tungro disease, one clump that is attacked sometimes only a few tillers or even symptoms only on a few leaves, yellow symptoms sometimes only occur on lower leaves/old leaves, infected plants in the adult stage, showed yellow-orange leaves but normal leaf width, number of tillers and plant height were the same as healthy plants (Figure 10b).

Figure 10. Symptoms of grassy stunt disease type 1 (a) (left), and symptoms of grassy stunt disease type 2 (b) (right)

2) Biology and ecology

Grass stunt virus transmitted by insect vectors: Brown planthopper *Nilaparvata lugens* Stal., *Nilaparvata bakeri* Muir and *N. muiri* China. The interaction between grass stunt virus and its vector was persistent without transovarial (not passed on to offspring through eggs). The acquisition feeding period required for the planthopper to acquire the virus is about 30 minutes. The inoculation feeding period to transmit the virus to healthy plants is approximately 9 minutes. The incubation period for the virus in insects to be transmitted to healthy plants is 5-28 days (average 11 days). While the incubation period in plants until the appearance of symptoms is 10-19 days. After feeding on RGSV-infected plants, about 5%-60% brown planthopper *N. lugens* becomes infective, and about 50% of the vector-borne brown leafhoppers that carry RGSV can transmit it. During life the brown planthopper remains viruliferous and can transmit the virus to healthy plants.

The main hosts of RGSV are rice plants: *Oryza sativa*, *O. rufipogon* , and *O. glaberrima.*While the secondary hosts of RGSV were reported to be several weeds such as: *Cynodon dactylon, Cyperus rotundus, Echibochloa colona, Leersia hexadra,* and *Monochoria vaginalis*.

3) Control

Control of grass stunt disease can be done by using virus-resistant cultivars or brown planthopper-resistant varieties. Source of resistance to RGSV type 1 virus is *Oryza nivara* Sharma & Shastry (wild rice species), but not resistant to RGSV type 2.

Control of brown planthoppers, with resistant varieties, chemicals, or other methods has been reported to reduce disease development. Technical culture to reduce the brown planthopper population can reduce the source of virus inoculum, among others by: crop rotation with secondary crops, immediately destroying stumps and ratoons after harvesting, flooding for several days, and spacing that is not too tight.

B) Ragged stunt

1) Symptoms and Status

Ragged stunt disease is a disease caused by a virus. The disease became known in Indonesia in 1977. The ragged stunt disease is found in Java, Sumatra, Bali, Sulawesi, and Lombok. In 1999, this disease was reported to attack rice plants in West Java covering an area of 49,917 ha. Infection causes crop yields to decrease or even not produce seeds. In Indonesia, yield loss reaches 53-82% if 34-76% of the plants are infected.

Symptoms of ragged stunt disease include shortened plants, twisted flag leaves, and panicles that do not come out or partially come out. From the panicle that partially emerges, the grain is usually empty. Plants form branching tillers and swelling occurs along the leaf bones. The color of infected leaves does not differ from that of healthy plants, and often leaves remain green even after flowering. Plant height reduced by 40% - 50% varies depending on the variety. Affected plants produce empty grain (Figure 11).

Figure 11. Symptoms of ragged stunt disease and brown planthopper as a vector of the disease

2) Biology and ecology

Ragged stunt virus can only be transmitted by the brown planthopper *Nilaparvata lugens*. The virus is transmitted by the brown planthopper persistently. The latent period in the insect body ranges from 5-11 days after sucking sick plants with an average of 9-10 days. The feeding period to acquire the virus is between 3-5 hours, and the minimum inoculation feeding period is 1 hour. After ingesting the virus, the insect can infect healthy plants for a period of its life. But the virus is not passed on to offspring through eggs. The empty dwarf virus is not transmitted through water, soil, seeds, or by mechanical friction.

3) Control

The recommended control is planting brown planthopper resistant varieties, and rotating varieties. Until now there is no information about varieties resistant to this hollow dwarf disease. Selective eradication of diseased plants was carried out to remove the source of inoculum. In addition, by controlling the vector, namely the brown planthopper.

C. *Beauveria bassiana* as a Biocontrol Agent, Propagation, and Application Methods

In agricultural activities, biological control is one of several strategies used to control pests to avoid economic damage on crop plants. This strategy can suppress resistance and resurgence. Biological control defined as the use of living organisms to suppress the population density or impact of a specific pest organism, making it less abundant or less damaging than it would otherwise be.

Based on the target of pest, biological control is divided into: 1) biological control of invertebrate pests such as insect groups, 2) weed control, and 3) biological control of plant pathogens. Biological control for invertebrate such as insect group can using predators, parasitoids or micro-organism that are pathogenic (entomopathogens). Biological control of weeds using herbivores and pathogens. Meanwhile for plant diseases, biological control of plant pathogens can using antagonistic micro-organisms.

There are four strategies in biological control, namely: 1) classical biological control, 2) inoculation, 3) inundation, and 4) conservation biological control. The classical biological control is done by introducing natural enemies/biological control agents from outside (exotic) and are expected survived permanently and long-term pests control. Inoculation is the intentional release of a living organism as a biological control agent with the expectation that it will multiply and control the pest for an extended period. Inundation biological control done by release of biological control agent with large numbers with the aim the biological control agents can reduce the pest population to a level that are not harmful. Meanwhile conservation can be done by modification of the environment or existing practices to protect and enhance specific natural enemies/biological control agents or other organisms to reduce the effect of pests.

In the biological control especially for insect pests can using entomopathogens. Entomopathogens are types of biological agents that infect insects and can damage the metabolic system which has an impact on changes in insect body structure. Entomopathogens can secrete compounds in the form of secondary metabolites, certain enzymes and toxins that can damage body tissues, disrupt organelles and cell function. Insects infected with entomopathogens will experience morphologically and anatomically changes due to disruption of the metabolic system.

Entomopathogenic agents can be derived from groups of bacteria (entomopathogenic bacteria), fungus (entomopathogenic fungi), viruses, nematodes, or protozoa. Biological control agents against rice pests are quite diverse, including *Beauveria bassiana*, *Metarhizium anisopliae*, and *Serratia marcescens.*

Beauveria bassiana is one type of entomopathogenic fungi which is widely developed as a biological agent to control various types of pests. This fungi has a fairly wide host range including the Order: Homoptera, Hemiptera, Orthoptera, Coleoptera, Lepidoptera, Diptera, Isoptera, and Hymenoptera and this agents does not cause resistance to target insects. The entomopathogenic fungi *B. bassiana* is parasitic in killing its host, but can develop saprophytically in natural media or in nature if it does not find a suitable host.

Beauveria bassiana can be propagated on rice, corn, husks, sawdust media. The rice is washed and soaked for 10-15 minutes. Then the water is removed and the rice is drained in room temperature for 3 minutes. The rice is put in a heat-resistant plastic or Erlenmeyer then given a piece of bamboo/pipe with holes as the mouth and covered with cotton and paper. Each plastic bag/Erlenmeyer contained 100 grams of rice (Figure 12). The rice was then sterilized using an autoclave for 15 minutes at 1.5 Atm. The rice medium was removed from the autoclave and allowed to stand for 24 hours. The *B. bassiana* isolate was then infested/inoculated on rice media aseptically and incubated at room temperature (25 ^{o}C) for 10-15 days and was ready for use or application.

The application dose is 10 g/liter or to make 10 liters of spray solution requires 100 grams of *B. bassiana* culture. The spray solution is made by harvesting the spores or conidia from the culture media. The culture was add into a container, adding water and stirring so that the spores in the rice media are released and then filtered. The rice media can be rinsed again with water to ensure that all spores have been harvested. The filtrate are then added with water until it reaches 10 liters and is ready to be applied. Applications should be carried out in the afternoon to minimize the stress of solar radiation which can cause the death of biological agents.

Figure 12. *Beauveria bassiana* propagation