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# Review on integrated pest management of important disease and insect pest of rice (*Oryzae sativa* L.)

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**ABSTRACT**

Rice (*Oryzae sativa* L.) is one of important crops in the world and Ethiopia. Productivity of rice is decreasing due to different factors. It is second in production next to wheat in the world and almost half of world population and 90% of south Asia countries use rice. Disease like Rice blast and insect pests like stem borer are important pests for reduction of rice productivity. Integrated rice pest management (IPM) is the best method to solve problems of pests and it is combination of different methods to control pests in sound environmental management and cost effective way. Control methods like resistant cultivars, healthy seed, fertilizer management, cultural systems, burning or composting of diseased tissues and chemical control are commonly used.

***Keywords*:** Rice, Blast, Stem borer, Yield loss, Symptoms, *Oryzae sativa*, *Scirpophaga incertulas*

## 1. INTRODUCTION

Rice (*Oryzae sativa* L.) belongs to the family Poaceae, and is one of the main cereal food crops in most part of Africa. Rice is the principal food grain consumed by almost half of the world's population (Khush, 2005), making it the most important food crop currently produced. Rice is increasingly becoming a regular staple for the populations of sub-Saharan Africa (SSA). Rice availability and price impact directly on the welfare of the poorest consumers in the region, many of whom are resource of poor farmers depending on rice as

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both a staple food and a source of income. It is therefore not surprising that rice is a major component of the food security and poverty alleviation strategies of many SSA countries.

Against this background, any improvement in rice productivity will contribute significantly to achieving a higher level of regional and household food security, while responding to the needs of the poorest by enhancing their diet both quantitatively and qualitatively and by providing additional income opportunities (Seck *et al*., 2012).

Rice cultivation and utilization as a food crop in Ethiopia is very recent phenomenon (Abdu *et al.*, 2013). However, its importance is being well recognized in the country as the area coverage of 18,000 ha and total production of 42,000 tons in 2006 has increased in 2009 to 155,000 ha and 496, 000 tons, respectively. Rice cultivation in Ethiopia has begun at Fogera (Amhara Region) and Gambella plains in the early 1970's. It is reported that the potential rice production area in Ethiopia, which is estimated to be about thirty million hectares.

The rice average yield in Ethiopia is 2.7 tons/ha in upland rain-fed and 3.2 tons/ha in lowland areas. It is currently challenged by different biotic and abiotic factors. The biotic factors like fungi, bacteria, and virus and nematode diseases have been reported on rice crop in the world. Diseases are considered major constraints in rice production and responsible for losses in quantity and quality of harvested produce. Important diseases cause crop damage severe enough to make control measures an economic necessity. Estimated losses can range from 1-100% depending on the nature of the disease, stage of plant growth at infection, resistance of the variety, management and weather conditions. A susceptible host plant, a virulent pathogen and a favorable environment are the three factors composing the plant disease triangle (John and Fielding, 2014).

In Ethiopia, blast disease has been recorded on rice in Amhara Region, since 1985 and also in SNNPRS. This disease is one of the major constraints to intensification of rice cultivation. Despite the frequent occurrence of severe epidemics of the rice blast disease, there is no detailed information with regards to the rice blast disease intensity against *P. oryzae* pathogen in Ethiopia (Mebratu *et al*., 2015).

Insects are found in all types of environment and they occupy little more than two thirds of the known species of animals in the world. Insects affect human beings in a number of ways. Many of them fed on all kinds of plants including crop plants, forest trees, medicinal plants and weeds. They also infest the food and other stored products in bins, storage structures and packages causing huge amount of loss to the stored food and deterioration of food quality. Insects that cause less than 5 % damage are not considered as pests. The insects which cause damage between 5 - 10% are called minor pests and those that cause damage above 10% are considered as major pests. The objective of this paper is to asses integrated pest managements practicing on most important disease and insect pest of rice crop.

## 2. IMPORTANT DISEASE AND INSECT PEST OF RICE

The major problems in rice production around the world are biotic and abiotic stresses against rice crops. Blast disease, bacterial blight, brown spot, rice stem borer, rice leaf hopper and others are common biotic stress to rice crop (Jamal *et al.*, 2012). Panicle blast, leaf blast, rice yellow mottle virus (RYMV), bacterial panicle blight, brown spot, sheath blight, sheath spot and bacterial leaf strike on rice crop were identified as important diseases of rice in

Ethiopia. While rice blast causes most severe damage in upland rice, it also occurs in lowland production, because of its wide distribution and extent of destruction under favorable conditions capable of causing very severe losses of up to 100%. Most damage due to RYMV occurs in the Sahel, but it is also a problem in lowland, forest and savannah regions. Bacterial blight is distributed in forest, savannah and Sahel regions.

Insects that cause injury to plants and stored products are grouped into two major groups namely chewing insects and sucking insects. The former group chews off plant parts and swallow them thereby causing damage to the crops. Sucking insects pierce through the epidermis and suck the sap. Many of the sucking insects serve as vectors of plant diseases and also inject their salivary secretions containing toxins that cause severe damage to the crop.

Introduction of high yielding varieties, expansion in irrigation facilities and indiscriminate use of increased rates of agrochemicals such as fertilizers and pesticides in recent years with a view to increase productivity has resulted in heavy crop losses due to insect pests in certain crops. This situation has risen mainly due to elimination of natural enemies, resurgence of pests, and development of insecticide resistance and out-break of secondary pests. Rice is grown under different agro-climatic conditions and the crop is damaged by more than 100 species of insect pests and infested by varied diseases. These insect pests' cause enormous grain yields losses, which may vary from 20-50% if not managed in time (Krishi K., 2005).

Rice cultivation is commonly encountered by different biotic factors including insect pests: yellow stem borer, pink stem borer, leaf hopper, leaf folder, grass hopper, stem borer, aphid and jassid and diseases like brown spot disease rice blast, and bacterial leaf blight etc, which adversely affect its yield per unit area. Rice stem borer and termite are common insects of rice in Ethiopia. Though there are no written documents termites specially at harvesting stage of lowland rice and at any stage of upland rice are common in Ethiopia (PARC rice team, 2017).

## 2. 1. Rice Blast

Rice blast is caused by an ascomycete fungus *Magnaporthe oryzae* (anamorph: *Pyricularia oryzae*). The symptoms (elliptical grey-white lesions) appear on the aboveground organs of the rice plant: the most frequently described are leaf, panicle, node and neck blast. Neck blast is considered more destructive than leaf blast (Zhu *et al*., 2005). Rice blast has been widely and intensively studied both globally and in Africa, because the interaction between rice and the blast pathogen has both practical and theoretical interest. The practical interest is related to the importance of rice in human nutrition and the importance of unpredictable yields losses caused by blast worldwide (Jia *et al*., 2009).

Blast pathogen diversity at pathological level is usually analyzed by infecting 'differential' varieties with different isolates of the pathogen. However, in Africa, blast-trapping nurseries were developed and implemented, not only to identify efficient resistance genes, but also to characterize rice-growing areas (especially screening sites) in terms of the structure of their blast pathogen populations.

Blast is common in all the three main ecosystems in which rice is grown namely, irrigated, and rainfed uplands and lowlands although the incidence and severity is greater in upland situations.

### 2. 1. 1. Leaf blast

The lesions due to this disease appear on leaves. The tips of leaf lesions are typically spindle-shaped to diamond-shaped spots, wide in the center and pointed at the ends. Lesion size varies from small to large with the most commonly observed field lesions having a reddish brown border and off-white to tan center. Mostly common at vegetative stage of crop and blast spores need free moisture on the plant to cause infection, the disease is favored by long dew periods (9 plus hrs), increased by fog, shade or frequent light rain and become worse when temperature is slightly cooler (Liu *et al*., 2007).

### 2. 1. 2. Panicle blast

Lesions typically are spindle-to diamond-shaped. Single or several florets on a panicle branch turn light brown to straw colored; floret stem with brown lesion; grain stops developing and florets turns gray. In the early of infection spots were small and brown; and gradually increased into irregular-shaped and dark brown. The occurrence of the blast disease is favored by extended periods of free moisture on plant surfaces and temperatures at night between 63-73F with little or no wind and high relative humidity (RH). Conidia are produced and released under high RH with no spore production below 89% RH. Leaf wetness or free moisture from dew or other sources is required for infection to occur. Optimum temperature for germination, infection, lesion formation and sporulation are 77-82F (Yoboué, 2001). The disease leaf blast showed the highest prevalence, incidence as well as severity rate of 80.08, 75 and 5.2%, respectively at vegetative growth stage compared to other diseases. However, at head setting growth stage the disease panicle blast recorded the highest severity percentage (10.3%). Blast diseases become worse when temperature is slightly cooler and humidity becomes high.

From vegetative to heading stage diseases leaf blast, panicle blast and bacterial panicle blight were radically increased in prevalence, incidence and severity percentage; leaf blast recorded 80.08, 75, 5.2% at vegetative growth stage while 100, 96 and 7.21%, respectively at heading stage, panicle blast recorded 13.51, 11.15, 1.1% at vegetative while 100, 100 and 10.3%, respectively at heading and bacterial panicle blast was recorded 9.67, 13.46, 0.9% at vegetative while 21.2, 32.3 and 4.2%, respectively at heading stage. In vegetative to heading stage the temperature was become cooler and blast is favored by relatively cooler temperature and wet weather condition.

### 2. 1. 3. Life Cycle and Biology of Rice Blast

It is an infectious fungal disease, which is distributed worldwide and prevailing in more than 85 countries of the world (Jamal *et al.*, 2012) and also as one of the most important disease infecting rice plants in African countries. In Ethiopia, blast disease has been recorded on rice in Amhara Region, since 1985 and also in SNNPRS. This disease is one of the major constraints to intensification of rice cultivation.

A disease cycle begins when a blast spore infects and produces a lesion on the rice plant and ends when the fungus sporulates repeatedly for about 20 days and disperses many new airborne spores. Under favorable moisture and temperature conditions (long periods of plant surface wetness, high humidity, little or no wind at night and night temperatures between 12–32 °C) the infection cycle can continue. In the canopy of rice plants, newly developed leaves act as receptors for the spores. The maximum number of spores produced was 20,000 on one lesion on leaves and 60,000 on one spikelet in one night. Lesions on leaves become an inoculums source for panicles.

### 2. 1. 4. Damage and distribution

The rice blast is the most important and serious disease of rice. The disease is a significant problem in temperate regions including Ethiopia and can be found in areas such as irrigated lowland and upland. Blast can be found on the rice plant from the seedling stage to maturity. The leaf blast phase occurs between the seedling and late tillering stages (Couch and Kohn, 2002).

Rice blast causes economically significant crop losses annually and causes yield loss as high as 70–80% when pre-disposition factors favor epidemic development (Piotti *et al*., 2005). Several rice blast epidemics have occurred in different parts of the world, resulting in heavy yield losses in these areas ranging from 50 to 90 % of the expected crop (Jamal *et al* ., 2012). Spores are spread to and infect rice during periods of high humidity or moisture and relatively cool temperatures.

Rice straw refuse, weed hosts, seed, soil, rice at a distant location and artificial sources are common sources for primary infection and number of spores produced, environmental conditions affecting sporulation on lesions and latent period are sources for primary infection. Air (release, flight and landing process), water, mammals, birds, insects and humans are common distribution facilitator of blast.

### 2. 1. 5. Yield Loss

Severe outbreak of leaf blast causes stunting and the development of small panicles. Early infection of neck nodes causes white head and yield loss, y, expressed as $y = 1.45x$ to $y = 2.55x$ (where x is the percentage of white head), and $y = 0.31x$ to $y = 0.57x$ (where x is the percentage of diseased neck node); x is surveyed on the 30th day after heading. 15 years of data collected in Japan shows that y varies considerably under different circumstances from 1–100%.

### 2. 1. 6. Symptoms of Rice Blast

The fungus is able to infect and produce lesions on all organs of the rice plant except the root. When the fungus attacks a young leaf, purple spots can be observed after an incubation period, changing into a spindle shape which has a gray centre with a purple-to-brown border, and then surrounded by a yellow zone as time passes. Infection to the neck node produces triangular purplish lesions, followed by lesion elongation to both sides of the neck node symptoms which are very serious for grain development.

#### 2. 1. 6. 1. Integrated Management Tactics of Rice Blast

As rice scientists and farmers have gained experience in the cultivation of the modern varieties and the agronomic practices that have accompanied the "Green Revolution" there has been a shift from a primarily unilateral approach of disease control, with a strong reliance on pesticides, to a multilateral approach involving a mix of control tactics.

### 2. 1. 6. 2. Resistant cultivars

Race-specific and race-nonspecific resistant cultivars have been bred all over the world. Based on the information of distribution of races, these cultivars can be selected.

### 2. 1. 6. 3. Healthy seed

To obtain healthy seeds, the seeds must be collected from the field located under unfavorable conditions for the pathogen, and fungicide must be applied if necessary. Gravity separation methods for seeds are useful. Salt solution, 200 g $l^{-1}$, or ammonium sulfate solution, 230 g $l^{-1}$, is used to separate sufficiently matured seeds, followed by chemical treatment for seed disinfection against a range of pathogens.

### 2. 1. 6. 4. Fertilizer management

Nitrogen and phosphorus content in the plants affects disease proneness. Excess nitrogen fertilizer encourages disease development, while silica application reduces disease development. Therefore the amount and type of fertilizer must be carefully decided upon according to the cultivar used, soil condition, climatic conditions and disease risk.

### 2. 1. 6. 5. Cultural systems

Sowing into water eliminates disease transmission from seeds to seedlings because of the anaerobic condition that is unfavorable to the pathogen. On the contrary, sowing on wet soil allows seed transmission. Shade affects disease occurrence because of the longer wet condition.

### 2. 1. 6. 6. Chemical control

Many fungicides are used against blast disease, including benomyl, fthalide, edifenphos, iprobenfos, tricyclazole, isoprothiolane, probenazole, pyroquilon, felimzone (meferimzone), diclocymet, carpropamid, fenoxanil and metominostrobin, and antibiotics such as blasticidin and kasugamycin. Systemic fungicides are widely used to protect against leaf blast by seedling application and also to protect against panicle blast when applied more than 20 days before heading. The composition, amount, timing and application method of fungicide applied depends on the disease forecast or level of disease presents.

## 2. 2. Rice stem borer (*Scirpophaga incertulas*)

Several insects feed on rice, but stem borers are considered the most important rice pests, in particular *Scirpophaga incertulas* (Walker) and *S. innotata* (Walker) (Lepidoptera: Pyralidae). Stem borer *S. incertulas* usually comprised more than 90% of the borer population in rice. The onset of flooding and stem elongation provided a more favorable environment for *S. incertulas*.

The rice stem borer *S. incertulas*, infesting the plant from seedling to maturity, is one of the main problems and yields limiting factors in the rice fields (Sarwar, 2011). The yellow stem borer is widely spread across the country and is far more abundant than any other species.

### 2. 2. 1. Nature of damage

Larva feeds inside the stem causing drying of the central shoot called 'dead heart' in young plant or drying of the panicle called 'white ear' in older plants. October-December has been found conducive for the multiplication most of the insect.

### 2. 2. 2. Life Cycle and Biology of stem borer

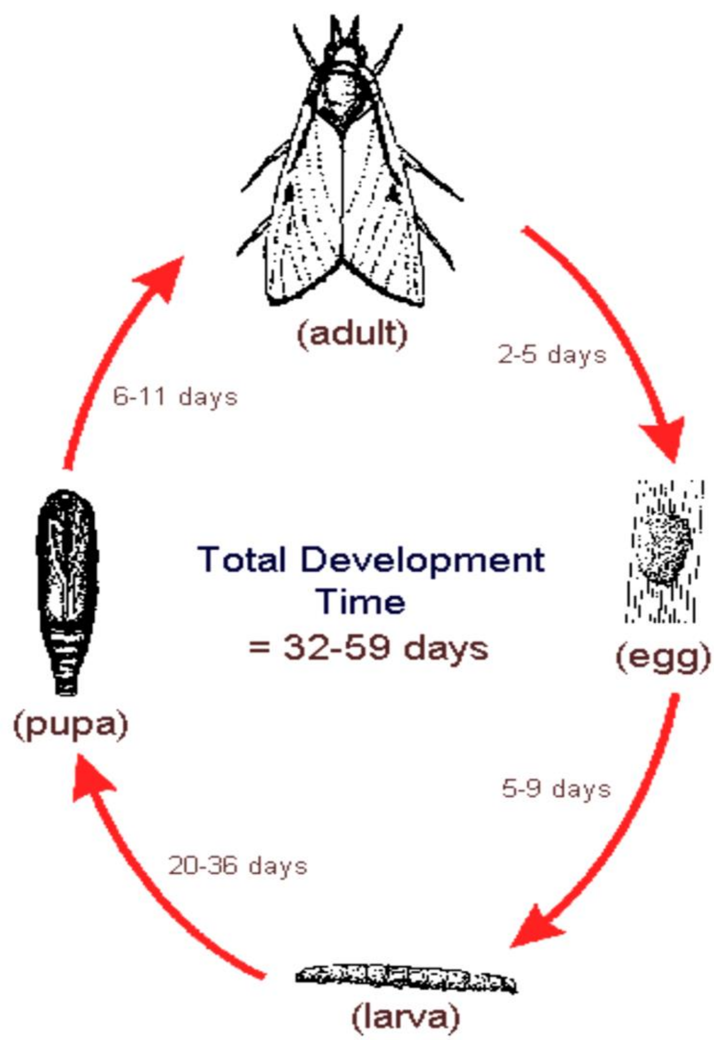


**Figure 1.** Life cycle of the rice stem borer, *Scirpophaga incertulas* (Walker, 1863)
(Source: IRRI Website)

Female lays 15 - 18 eggs in a mass near the tip on the upper surface of tender leaf blade and covers them with buff colored hairs and scales. A female lays about 2 - 3 egg masses and the incubation period ranges from 5 - 8 days. The newly hatched pale white larva enters the leaf sheath and feeds for 2 – 3 days and bores into the stem near the nodal region. Usually only one larva is found inside a stem but occasionally 2 - 4 larvae may also be noticed.

The larva becomes full grown in 33 - 41 days and measures about 20 mm long. It is white or yellowish white with a well developed prothoracic shield. Before pupation it covers the exit hole with thin webbing and then forms a white silken cocoon in which it pupates. The pupa is dark brown and measures 12 mm long. The pupal period varies from 6 -10 days and may get prolonged depending on the weather conditions. The entire life-cycle is completed in 50 - 70 days (www.knowledgebank.irri.org/).

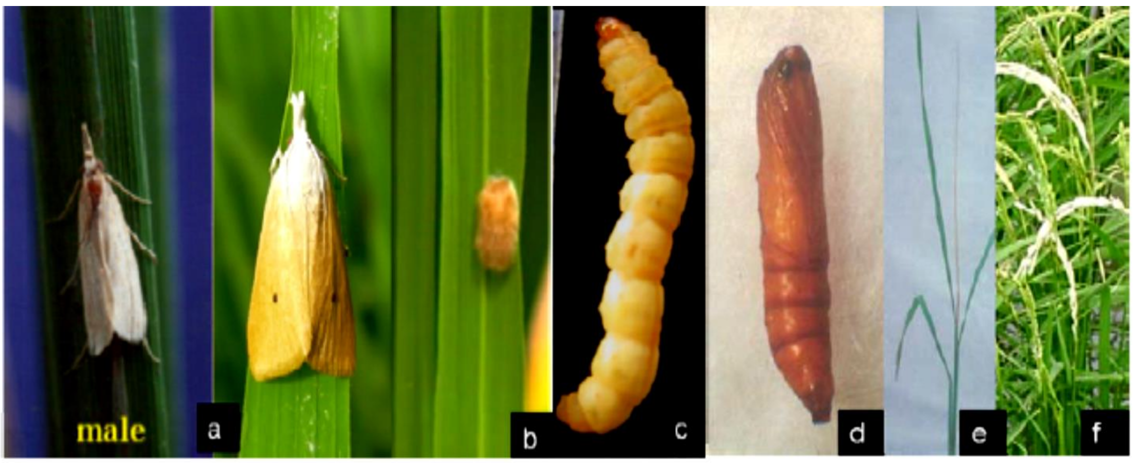


**Figure 2.** Different stage of rice stem borer

### 2. 2. 3. Integrated Management Tactics of stem borer

#### 2. 2. 3. 1. Cultural Practices

Cultural methods to control insects involve crop production practices that have a dual purpose of crop production and insect suppression. Farmers have developed these practices through many years of trial and error and these practices have been handed down through generations. Primary cultural control practices are those done specifically to control insects such as draining a field to control the aquatic caseworm larva or planting a trap crop for stem borers. Secondary practices are those that are specifically done for crop husbandry, such as land preparation and weeding, but which also happen to minimize pest buildup.

Rice culture has a rich source of folklore regarding indigenous cultural practices. Cultural control practices that offer potential control of rice insects includes (1) mixed cropping, (2) planting methods (transplanting vs direct seeding), (3) age of seedlings at time of transplanting, (4) water management, (5) fertilizer management, (6) crop rotation, (7) number of rice crops per year, (8) planting time, (9) synchronous vs asynchronous planting over a given area, (10) trap crop, (11) tillage, (12) weeding and (13) growth duration of the crop.

Closed plant spacing or direct seeding give a dense plant population, which does not reduce white stem borer infestation, but does help to reduce yield loss. Applying nitrogen fertilizer at the appropriate time may also reduce yield loss: tillers affected during the vegetative phase could recover and compensate for the damage. Under the same degree of *S. innotata* infestation, application of urea granules (slow release) gives a higher yield. Early flooding prior to wet-season planting also reduces infestation as diapause is ended out of synchronization with the availability of the host crop.

### 2. 2. 3. 2. Biological Control

The action of indigenous predators, parasitoids and insect pathogens forms the cornerstone for modern IPM programs on rice. Although hundreds of insect species feed on rice only 8% are considered as major pests. This indicates that over the thousands of years of rice cultivation a relatively stable association between rice insects and their natural enemies has evolved. When this stability is upset, as is the case in the destruction of predators by insecticides, insect outbreaks occur.

Classical and inundative biological control approaches tried so far have had little success in rice. However, research studies have shown that indigenous natural enemies have a strong impact on rice pest populations and their conservation is an essential part of rice IPM programs. Many species of predators, parasitoids and pathogens have been shown to attack rice insect pests. However, only one example of each will be mentioned (Management of Rice Insect Pests-Radcliffe's IPM World Textbook.htm). A wide range of predatory species attacks the eggs and small larvae of stem borers before they enter the stem of the rice plant. Some important predators are coccinellid beetles *Micraspis crocea* (Mulsant), *Harmonia octomaculata* (Fabricius), and carabid beetles such as *Ophionea* spp. Ants and a dozen other predators prey upon stem borer larvae (Roul K.2005). Natural control is by parasitoids and predators. Egg parasitoids are more important than larval or pupal parasitoids, and egg parasitism may reach up to 90% at harvest. In order for the populations of egg parasitoids to build up early in the season, early insecticide application should be avoided.

### 2. 2. 3. 3. Mechanical Control

Infestation may be reduced by cutting the stubble very low during harvest, destroying larvae before they move to the lower part for diapauses; however, at harvest 40-85% of larvae have already reached the lower part of the stem. Ploughing the stubble immediately after harvest could destroy the larvae; however this may not be economically feasible unless the field is to be planted again. Attracting the moth using lamps has also been suggested; but experiments show that mass trapping by petromax lamps is not effective as the majority of moths attracted had already laid eggs in the field, and it required many lamps to be effective (Aunu Rauf *et al*., 1992b).

### 2. 2. 3. 4. Chemical Control

When modern rice varieties were introduced in the 1960's, insecticides were one component in a package of technologies of the "Green Revolution" in Asia. Chlorinated hydrocarbons were first used and then phosphates, and recently the carbamates have been used. However, insecticides are often too expensive for resource-poor farmers to use. Even where farmers can afford insecticides the health hazards may outweigh the economic benefits. Studies in the Philippines have indicated that when the effect on farmers health and subsequent lost days of work, and the adverse effect on the environment are taken into consideration, the productivity increases obtained from the utilization of insecticides are minimal. Due to the variable regulations around registration of pesticides, there are many specific chemical control recommendations.

**Table 1.** Chemical insecticides to control rice stem borer
(Source: DOASL., 2002)

| Common (Generic) Name | Dilution | Rate of Application (product/ha) | Remarks- |
|---|---|---|---|
| Fipronil 0.3% GR | - | 16kg | Apply insecticides only when damage exceeds 10% dead hearts or 5% white heads. |
| Carbofuran 3% GR | - | 17-22kg | |
| Carbosulfan 200g/l EC/SC | 30ml/10 l | 1500ml | |
| Diazinon 5% GR | - | 17-22kg | |
| Chlorpyrifos 400g/l EC | 10-25ml/10 l | 500-1000ml | |
| Chlorpyrifos 200g/l EC | 20-50ml/10 l | 1000-2000ml | |
| Phenthoate 500g/l EC | 20ml/10 l | 800ml | |
| Quinalphos 250g/l EC | 30ml/10 l | 1500ml | |

#### 2. 2. 3. 5. Host-Plant Resistance

There are no cultivars available which are specifically resistant to *S. innotata*. In the field the degree of infestation is determined by the duration of the rice variety, the date of planting and the stem borer population (Sanusi Wityanara, 1994).

## 3. SUMMARY AND CONCLUSION

The major problems in rice production around the world are biotic and abiotic stresses against rice crops. Rice blast caused by fungus *Magnaporthe oryzae*, is considered as the most important disease of rice worldwide because of its extensive distribution and destructiveness under favourable conditions. Blast disease can be controlled by an integrated management system using a variety of methods – resistant cultivars, cultural practices and chemical application – based on the information from disease forecasting systems.

Here is clearly observed that when the growth stage increases, the host loses its potential against the pathogen and the pathogen becomes virulent against the host; consequently the symptoms of the pathogen were observed evidently.

Integrated rice pest management (IPM) is the combination of different methods to control pests in a cost effective way, based on sound environmental management. None of the methods can by itself ensure efficient and sustainable protection. The methods often combine varietal resistance, crop management techniques and modest use of chemicals.

Due to their cost, toxicity to man and the environment, the secondary pest problems caused such as the resurgence of the brown plant hopper, and because of the development of insecticide resistant populations, the recent trend in rice IPM has been toward the integration of insect resistant varieties with the conservation of natural control agents. Although there are cases where the judicious use of selective insecticides in rice is necessary, routine, calendar-ebased applications in a non-IPM context are no longer recommended.

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