SCREENING OF SOME HYBRID RICE VARIETIES FOR RESISTANCE AGAINST MAJOR INSECT PESTS

A THESIS

BY

MD. ABDUL MALEK

MASTER 0F SCIENCE

IN

ENTOMOLOGY

DEPARTMENT OF ENTOMOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA-1207, BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled**,** "**SCREENING OF SOME HYBRID RICE VARIETIES FOR RESISTANCE AGAINST MAJOR INSECT PESTS**" submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in ENTOMOLOGY** embodies the result of a piece of bona fide research work carried out by **Md. Abdul Malek,** Registration No**. 04-03174** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2010
Place: Dhaka, Bangladesh

Professor Jahanara Begum
Supervisor

Acknowledgement

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SCREENING OF SOME HYBRID RICE VARIETIES FOR RESISTANCE AGAINST MAJOR INSECT PESTS

ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from June to November 2009 to explore the resistance source(s) among different hybrid rice varieties against major insect pests. The study was conducted in randomized complete block design (RCBD) with three replications. Seven rice varieities were evaluated in the present study, among them six hybrid varieties viz. Hira-2, Taj-1, Aftaf-108, Krisan-2, Madhumati-2, Aloron and one check variety BR 11 popularly cultivated as HYV. The rice stem borer, rice hispa, rice bug, rice leaf roller, rice green leaf hopper, short horned grasshopper, long horned grasshopper were found as the major insect pests of rice and caused significant damages on all rice varieties. The check variety BR 11 performed best against all major insect pests among the varieties. The hybrid rice varity Hira-2 and Krisan-2 performed better against stem borer whereas susceptible found against rice hispa. Aloron found susceptible against stem borer followed by all other insect pests except short horned grass hopper. Considering yield and yield contributing characters, BR11 was superior to the others. The highest yield (4.376 ton/ha) was produced by BR11, where the lowest (1.946 ton/ha) was produced by Aftaf-108. Among hybrid varieties, the maximum yield (2.561 ton/ha) was produced by Aloron that was second highest of all varieties.

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CHAPTET I

INTRODUCTION

Rice, *Oryza sativa is* a cereal crop, belongs to the family Gramineae. It has one of the largest germplasm collections in the world. Human selection and adaptation to diverse environments have crested a large number of cultivars and it is estimated that about 1,20,000 varieties of rice exist in the world (Khush 1997). Rice is the world's most important food crop and a primary source of food for more than half of the world population. Moreover, it is the staple food for more than two billion people in Asia and for a few hundreds of million in Africa, Latin America and Caribbean regions (Pillayar 1988). Rice is now cultivated in 113 countries of the world and all continents except Antarctica. In 2004, more than 75 percent of the global rice harvested area, about 114 million out of 153 million hectare, come from the tropical region whose boundaries are formed by the tropic of cancer in the northern hemisphere and the tropic of Capricorn in the southern hemisphere. The world population is projected to increase from 6.13 billion in 2001 to 7.21 billion in 2015 and 8.27 billion in 2030, indicating a corresponding increase in rice demand from 680 million tons in 2015 to 771 million tons in 2032 (FAO, 2004). To meet the demand of food of mushroom growing population of the world, the United Nations General Assembly (UNGA) declared the International Year of Rice 2004 during its 57th session in December 2002. In addition, thirty eight years age in 1966, rice became the first ever agricultural commodity to be declared ‘Crop of the Year’ (FAO 2004). The dedication in an International Year to a single crop was unprecedented in UNGA's history. In declaring the Year, the General Assembly affirmed the need to focus world attention on the role that rice can play in providing food security and eradicating poverty. However, rice is the staple food for maximum population of the world, especially the poor in rural areas and urban centre in developing countries in Asia, Africa and Latin America (FAO 2005).

Rice is more nutrition's than any other cereal crops and is an ideal host for over 800 species of insect (Barr and Smith 1975). In tropical Asia, more than 100 species of insects are persistent to rice. Among them, only about 20 species are of major important and regular occurrence (Grist and Lever 1969). In Bangladesh, rice covers almost 84% of the total cultivable land and T. aman alone occupies 46.30% of rice cultivated land. The rest 26.85, 17.59 and 9.26 % of the lands are occupied by Boro, Aus and Sown Aman, respectively (BBS 2004). For rice about 175 insect pests are available in Bangladesh and 25 species of them are economically important (Karim 1986). Most of the insect pests from them were considered as minor pest which have recently become major pest such as stem borer, grasshoppers, green leafhoppers, etc. (Alam *et al*. 1985) and small rice grasshopper, *Oxya velox* Fabr. occupies 15th position. Major insect pests cause about 13, 24 and 28% yield loss to Boro, Aus and Aman crops, respectively (BRRI 1985). The estimated annual loss of rice in Bangladesh due to insect pests and diseases amounts to 1.5 to 2.0 million tons (Siddique 1992).

Among these insect pests, rice leaf folder, once considered to be a minor pest has now acquired the status of a major pest due to the widespread damage. It has caused to the rice crop in different parts of the world (Teng *et al*. 1993). It has now been established that several species of pyralids and gelechiid constitute the rice leaf folder complex (Khan *et al.* 1989). Rice leaf folder and case worm attack the rice plant by feeding on the leaves, directly reducing photosynthesis and ultimately yield which is dependent on plant age and rice variety. Almost all rice are susceptible to the rice bug which attacks rice plants at milking stage and causes considerable damage to grain. Grasshopper is one of the devastating insect pests of rice. It causes damage to rice leaf resulting in yield reduction. Generally, the leafhoppers feed on the leaves and upper parts of the plant, whereas the plant hoppers confine themselves to the basal parts. Besides these some minor pests cause damage in rice plant. All the insects inhabiting rice field are not harmful, only a very few are a potential threat.

Many of them are beneficial and include a wide range of natural enemies as predators and parasitoids that contribute to keeping the insect pest organisms in cheek. Although only a few pest species cause sufficient yield reductions for which intensive control measure is required. These pest species are frequently cited as major constrains to rice production. To overcome this situation, any unilateral measures, as is now mostly used by farmers with insecticides, may prove unsuccessful and create complications such as disruption of the ecological balance of pest and natural enemies, resurgence of treated population, outbreak of secondary pests and development of environmental pollution etc. 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 insect control, with a strong reliance on insecticides, to a multilateral approach involving number of control tactics. This approach, known as integrated pest management (IPM), in the simplest terms is referred to as a broad ecological approach combining several tactics including biological, chemical, and cultural control methods and insect resistant rice varieties, for the economic control and management of pest populations.

IPM programs have a significant impact on minimizing the adverse effects of insecticides, and increasing the profitability of rice production. It has been estimated that the cost savings from research leading to increase insect pest management efficiency on rice in South and Southeast Asia will be $973 million in insecticide saved by the year 2000. Resistant cultivars are sought as the major tactic in an integrated approach to rice insect control. Because of its unique advantages host plant resistance is sought after as a key tactic in the integrated control of rice insect pests in developing countries. The cornerstone of the rice IPM strategy is the use of multiple pest resistant varieties along with natural biological control and other control tactics.

In this approach, natural factors such as natural enemies that prevent a pest species from increasing are emphasized and resistant varieties are being successfully utilized in reducing the damage caused by various insect pests and diseases of rice (Khush 1997). Pesticides are used only as a last resort to bring abnormal pest densities down when crop loss is expected to exceed the cost of treatment. The introduction of hybrid rice varieties is the new innovation in Bangladesh to meet the present demand of rice production. Huge numbers of hybrid rice varieties are being cultivated in Bangladesh without testing their reactions against major insect pests. Considering the situation above, the present study was conducted to explore the resistance sources among different hybrid rice varieties against major insect pests.

Objectives

i. To study the incidence of major insect pests on hybrid rice varieties;
ii. To measure the intensity of attack by major insect pests and evaluate varietal performance of some hybrid rice;
iii. To find out the resistance or tolerant variety (ies) of hybrid rice against major insect pests.

CHAPTER II

REVIEW AND LITERATURE

About 800 to 1400 species of injurious insect pests of rice are known (Barr *et al.* 1975; Yasumatsu and Torii, 1968). So far, 175 species of insects have been recorded as rice pests (BRRI 1985), and species of parasites and 88 species of predators of rice insect pests have been recorded in Bangladesh (Wahiduzzaman 1993). Among the insect pests recorded in Bangladesh, 20-30 species are economically important (Miah and Karim 1984).

Many scientists and workers have studied the biology, seasonal incidence, loss assessment and control of major insect pests of rice as well as parasitization rate, effectiveness and distribution of their natural enemies in the world and also in Bangladesh. But the research on the effect of agro ecosystem diversification i.e. polycultures on the abundance and diversity of insect pests and natural enemies in rice fields are fewer in the world and in Bangladesh. However, the literature available on insect pests and natural enemies in relation to the present research work are reviewed below.

2.1. Rice stem borer

Ragini *et. al.* (2005) conducted a survey to evaluate the seasonal occurrence and relative abundance of 3 rice stem borer species, i.e the yellow stem borer (YSB, *Scirpophaga incertulas*), the pink stem borer (PSB, *Sesamia inferens*) and the dark headed borer (DHB, *Chilo polychrysus*). YSB was the most predominant species in June- September (60.0%) and October -January (48.43%). PSB was as abundant as YSB in October - January (48.43%). DSB was least abundant during either season (4.29-7.18%). YSB infestation was predominant from early tillering to maximum tillering stage and decreased gradually with increasing PSB infestation from the flowering stage.

Srinavasa *et al*. (2000) monitored 3 insect pests of rice viz. *Nephotettix* spp., *Nilaparvata lugens* and *Scirpophaga incertulas*. They reported that *Nephotettix* spp. and *Nilaparvata lugens* were present throughout the year but showed peaks of abundance in November and May; *S. incertulas* was also present throughout the year with low incidence in March, and had peaks in November and June.

Rai *et al*. (1989) conducted a field survey to determine the relative abundance of stem borers infesting the deepwater rice and to study the population dynamics of these species. The stem borer species were Pyralids *Scirpophaga incertulas*, *Chilo polychrysus* and *C. suppressalis*, and the Noctuid *Sesamia inferens*. The relative composition of the different species as a percentage of the total stem borer population during the growing and no growing seasons were 3-89, 12-81, 2-28 and 8 for the 4 species respectively in Bihar. Populations of *C. suppressalis* were highest during the first 2 weeks of November and remained high until July. *S incertulas* and *S. inferens* were predominant during the wet season.

Alam (1988) studied the relative abundance and species composition of 3 Lepidopterous stem borers in upland and irrigated rice in Nigeria and they found that the pyralid *Maliarpha separatella* was the predominant species in upland and irrigated rice, followed in upland rice by the Noctuid *Sesamia calamistis* and another pyralid, *Chilo zacconius*, and in irrigated rice by *Zacconius* and *S. calamistis*. The proportion of *M. separatella* was higher in irrigated rice than in upland rice.

Saha and Saharia (1970) reported that stem borer moths preferred to oviposit on rice plants grown with high rates of nitrogenous fertilizers. The larvae also grown better on heavily fertilized plants.

Kamran and Raros (1967) worked on seasonal fluctuations in abundance of various rice borers in Philippines, both during the wet and dry seasons. They also found that borer infestations were high during the wet season.

The rice stem borers are generally considered as the most serious pest of rice. They occur regularly and attack plants from seedling to maturity stages. About 16 different stem borer species are found in rice fields and among them the yellow stem borer, dark headed striped borer and pink borer are of major borer and have great economic significance. (Kapur 1967; Rao and Israel 2004).

2.2. Rice hispa

Rao *et al.* (2004) studied on population build up of rice hispa, *Dicladispa armigera* Oliv. and reported that the maximum population of adults and grubs were found in the month of August when the crop was in the mid tillering stage. They also found that minimum temperature and relative humidity were significantly correlated with the adult and grub population.

Dutta and Hazarika (1994) showed that the variety Govind, Mala, Garem, Bijer 3 and Bengubisi were rated less susceptible (<20% leaf damage), while the variety, Saker 4 was found to be highly susceptible (100% leaf damage).

Dutta and Hazarika (1992) studied eleven summer varieties were moderately resistant (11-20% leaf damage) and thought suitable as donors of resistance. Mala and Govind were high yielding making them promising for hispa endemic areas.

Hazarika and Datta (1991) reported that the susceptible check Borsali had 100% infestation while the local varieties Malbhog, Silguti, Gajep Sali 1 and Sarusokua suffered 15-20% leaf damage. Glutinous varieties are less preferred by rice hispa and non-preference for feeding may be exploited as resistance mechanism.

Singh *et.al.* (1990) reported that the variety CR192-9-1, PR-107, and TKN6 had least damage caused by *D. armigera*.

Chand and Tomar (1984) noted that the variety OR165-94-1 (15.6% leaf damage) and KAU1945 (18.6% leaf damage) were found to be moderately resistant to rice hispa.

2.3. Rice leaf and plant hoppers

Different species of leaf and plant hoppers infest rice in the Indian subornment. Of these, the green leafhopper, zigzag leafhopper, the white backed plant hopper and the brown plant hopper are considered economically important (Misra and Israel 1970). The several areas, they frequently occur in large number enough to cause hopper burn.

Nath and Bhagabati (2005) reported that the leafhopper population was first appeared in the rice seedbed during June- July, reaching the peak in October - November in the main rice field and disappeared from field from December to May. They also reported that the population of *N. virescens,* the most efficient vector of rice tungro virus disease was low compared to *N. nigropictus,* but more than *Recilia dorsalis.*

Tsueda *et al.* (2002) studied on the occurrence of rice bugs, a total of 22 species, in rice fields. They also observed that *Stenotus rubrovittatus* was the important species and the peak occurrence of it coincided with the date of heading of early -ripening rice. They further reported the populations of bugs and rate of damaged rice was related to the area of heading rice.

Mallick and Chowdhury (2000) observed the population dynamics of zigzag leafhopper in rice ecosystems. They found that one peak appearance of this insect was from April to May and the second one from October to November. They also reported that *R. dorsalis* was the less efficient vectors of rice tungro virus than *N. virescens* and *N. nigropictus* to some extent; its presence in seed beds was expected to play a vital role on the carry over of the virus.

Reddy *et al.* (1995) stated that both nymphs and adults infest the rice crop at all stages of plant growth. They insert their stylets into plant tissue and suck sap from the phloem cells. Apart from the direct damage, brown plant hopper (BPH) acts as a vector of virus disease in several rice growing countries.

Chakraborty *et al.* (1990) studied that the abundance of rice pests at 2 sites in Bihar and Orissa, India. Patterns of relative pest abundance were similar in most years of the study. They also found that *Nilaparvata lugens* was the most abundant pest at the Orissa site. While *Nephotettix* sp. were the most abundant at the Bihar site. The most abundant natural enemies of rice pests at both sites were *Cyrtorhinus lividipennis* and spiders of the families Lycosidae and Tetragnathidae.

Cook and Perfect (1989) investigated the population dynamics of 3 vectors of rice tungro bacillifrom and spherical viruses, *N. virescens*, *N. nigropictus* and *Recilia dorsalis* in farmers' fields. They also reported that *R. dorsalis* was the most abundant vector species on the rice seed beds.

Gupta *et al.* (1989) reported that the pentatomids *Nezara viridula* and *Eusarcoirs ventralis* caused 6.9%- 14.8% grain damage during the dry season and 2.3%- 8.1% grain damage during the wet season.

Reduced settling on the resistant varieties was attributed to chemical cues, mainly the hydrocarbon and carbonyl containing fractions of the surface wax (Woodhead and Padgham, 1988).

Velusamy (1988) reported that significantly more individual of *N. lugens* were settled on susceptible TN1 rice plants than resistant ones.

Sharivastava *et al.* (2000) found that the major period of activity of both species was September to November with the highest in October. The frequency of peaks in the catches indicated the possibility of the completion of 4 to 5 generations during the kharif season (July to December).

Kim *et al.* (1986) observed the low population growth of s*N. malayanus* and *N. virescens* on resistant rice cultivar.

The green leafhoppers, *Nephotettix* spp. (Homoptera: Cicadellidae) are most devastating pests of rice throughout the rice growing areas of Asia (Razzaque *et al.* 1985). These have been reported from Bangladesh, Bhutan India, Indonesia, Kampuchea, Malaysia, Nepal, Phillippiness, Sri Lanka, Thailand, and Vietnam (Alam 1983; Alam and Catling 1976; Heinrichs *et al.* 1982; Reissing *et al.* 1985). They don't do only cause direct damage by sucking plant sap and by ovipositing on the leaf sheath but also act as efficient vector of rice tungro virus, one of the most menacing diseases of rice.

As a result of feeding both the nymphs and adults at the base of tillers, plants turn yellow and dry up rapidly. At early infestation, round yellow patches appear which soon turn brownish due to the drying up of the plants. This condition is called hopper burn. The patches of infestation then may spread out and cover the entire field (Heinrichs *et al.* 1985).

Misra *et al.* (1985) reported that the seasonal changes in population density of *Nephotettix virescens, N. nigropictus, Nilaparvata lugens, Sogatella furcifera, Recilia dorsalis, Tettigoniella spectra* and *Nisia atrovenosa*, which are important pests of rice in India during the kharif season.

Zhang *et al.* (1984) reported that population number of *N. lugens* on the new rice lines viz. Hong-Yuan and Tainuo-Xuan were less than the susceptible variety TN1.

Alam *et a.l* (1983) reported that the brown plant hopper has become a serious pest of high yielding variety of rice. The leafhoppers feed on the leaves and supper parts of the rice plant whereas the plant hopper confines themselves to the basal parts. In the warm and humid tropics, different species of leafhoppers and plant hoppers remain active year round and their population fluctuates according to the availability of food plants, natural enemies end environmental conditions.

Orientation and settling response of *N. lugens* on rice varieties is gustatory other than olfactory, as the insect discriminate resistant and susceptible varieties only after contact with the phloem sap (Sogawa 1982 and Nugaliyadde 1994).

Hibino (1979) and Chen & Chu (1981) reported that *N. lugens* is vector of the virus diseases-grassy stunt, ragged stunt, wilted stunt.

Soekhardjan *et al.* (1974) reported that in general there is an increase in the level of green leafhopper infestation with the increase of the age of the rice plants. Hinckley (1963), Kisimoto (1965) and Hiesh (1972) reported that the plant age of 50 to 70 days after transplanting in the fields was the most suitable for green leafhopper population increase.

Alam (1971) found that at IRRI, *N. virescens* were more abundant during the late dry and wet season. Hiesh (1972) also found that green leafhoppers were generally more abundant on the wet season crops than on the dry season crops. Too much rain could suppress the insect abundance.

2.4. Rice bug

Rice bug, *Leptocorisa acuta* (Thunburg) and *Leptocorisa oratoria* (Fabricius) are important pests infesting the rice crop at the flowering stage. These are also known as Gandhi bugs because of the peculiar odour they emit. The insects were earlier identified as *Leptocorisa acuta* from India, but now called as *Leptocorisa oratoria* (Fabricius). These two closely related species may occur together in rice fields. They are most abundant at 27^0C to 28^0C and about 80 % relative humidity. Population usually increases at the end of a rainy season but declines rapidly during dry month.

Ito (2003) reported that the bugs, *Nezara viridula*, *Trigonotylus coelestialium* and *Eysarcoris lewisi* were dominant among 40 species of Hemiptera that cause pecky rice in Japan. He also reported that these bugs fed on the ears of

various kinds of grasses, and rice was a preferred food plant. He suggested that weed control around rice fields could reduce bug populations.

Singh and Chandra (1967) observed that rice bug migrates from alternate hosts to rice fields during the flowering stage. The hibernating adults become active with the onset of summer rains. Intermittent rains and high temperature during summer are conducive to terminating its aestivation. They also found that the rice bug reacts favorably to the higher humidity and rainfall prevailing from April to June in Bihar, India, which are the active season of the bugs.

2.5. Rice leaf folder

Rice leaf folder complex consisted of three species *Cnaphalocrocis medinalis* (Guenee), *Marasmia patnalis* Bradley and *M. exigua* Butler (De Kraker *et al*. 1999). He characterized leaf folder population dynamics by an egg peak at maximum tillering stage and a broad larval peak around booting stage. Peak densities ranged from 0.2-2.0 larvae per hill. Most larvae originated from immigrant moths and there was no substantial second generation. Malik *et al.* (1985) observed the lowest incidence of leaf folder in Basmati-370 which was 5.2%.

Kraker *et al*. (2004) studied that the populations of rice leaf folder in irrigated rice and found that the rice leaf folder complex consisted of three species: *Cnaphalocrocis medinalis* (Guence), *Marasmia patnalis* Bradley and *M*. *exigua* Butler. They also reported that leaf folder population dynamics were characterized by an egg peak at maximum tillering and a broad larval peak around booting stage.

Cheng and Wu (1999) reported that the number of adult *Cnaphalocrocis medinalis* Guenee showed 8 population peaks annually. They found two main peaks, one during milky to maturity stage of rice and another during second rice cropping season. During each cropping season, the leaf folder could

complete 3 generations, earlier transplanting of rice usually resulted in lower population growth rates compared with those transplanted later. They also reported that larvae always injured the top 3 leaves of rice with most injured occurring approximately 14 days after the population peaks. The main infestation of rice plants was during the heading to milky stages.

Dhaliwal *et al.* (1988) studied the incidence of the pyralid *Cnaphalocrocis medinalis.* On late transplanted rice it was found to higher than on the early planted crop. The planting of rice upto third week of June suppressed the leaf folder population.

Patel *et al.* (1987) found that the long dry spell interspersed with cloudy weather may have adversely affected the natural enemies of the pest and thus promoted the population build up of leaf folder.

2.6. Grasshopper

Lanjar *et al.* (2002) studied the occurrence and abundance of grasshopper species on rice and found that four species infesting rice crop which were *Hieroglyphus banian* (rice grasshopper), *Oxya nitidula* (small green grasshopper), *Chrologonus trachypterus* (surface grasshopper), and *Aiolopus tamulus* [*A. thalassinus*] (small grasshopper). *C. trachypterus* was recorded in maximum number (12.8 nymphs and 39.20 adults/observation) during July-October under a mean temperature of 37.95^0C.

Reissing *et al.* (2000) reported that the rice grasshoppers, *Hieroglyphus banian* (Fabricius). *Hieroglyphus nigropictus* Bolivar, *Hieroglyphus oryzivorus* Carl and *Oxya* sp. (Orthoptera: Acrididae) are important pests of rice throughout the rice growing countries in Asia. In Bangladesh, they have already been recognized as important pests of rice at plant growth stages. They also observed that adults and nymphs feed on rice leaves from the margin of leaf blades, thereby decreasing leaf area and finally affecting the total yield.

Manley (1985) reported that *Conocephalus* is widespread and common in rice fields throughout South East Asia. After flowering the Tettigoniid feeds on flowers and later on young grains.

2.7. Leaf feeders

Among the leaf feeders, green horned caterpillar, green semilooper, grass hoppers, rice hispa, leaf folder, ear cutting caterpillar, rice hairy caterpillar etc, infest rice and cause considerable damage in Bangladesh. The green homes caterpillar, green semilooper and skipper caterpillar start feeding on rice leaves from margin to midrib and infest rice from seedling to maturity stage. Long horned grasshoppers also feed on rice leaves from margins and short horned grasshoppers and known to transmit yellow mottle disease and rice hispa attacks rice leaves and scrap on the green portion of leaves resulting the drying of leaves (BRRI, 1985). Rice hairy caterpillars are known to feed on rice leaves and cause a considerable damage to rice.

2.8. Varietals susceptibility and abundance of insect pests.

Different scientists conducted research on varietal performances of different rice varieties to different insect pest infestation. Koral *et al.* (1998) evaluated rice cultivars for resistance to insect pests. Mo-1, Co-29 and IET- 10750 were resistant to major insect pests (white backed plant hopper, leaf folder and stem borer) of rice. These cultivars yielded 17.54-17.94% higher grain yields over presently recommended high yielding varieties like Masuri and Narmada Breeders can utilize these promising cultures as donor for developing high yielding and pest resistant variety of rice.

Emmanuel *et al.* (2003) evaluated 65 rice genotypes for their resistance against the white backed plant hopper (*S. furcifera*). The overall assessment in the present study indicated that resistance in rice to WBPH was shown by the combined influence of non-preference, antibiosis and tolerance. The recently released rice hybrid CORH2, which was moderately resistant a couple of years

back, now shows the characters of highly susceptible genotypes with respect to all the components of resistance, clearly indicating the break down of its resistance.

Rao *et al.* (2002) reported that four lines, namely INRC 15703, 15708, 15725 and 15732 showed a consistent damage rating of 1 under natural infestation condition. Among the plant morphological characters studied, leaf width was significantly correlated with leaf folder infestation, while plant height had no effect on leaf folder infestation. Majority of the lines, which had damage rating of 1 and 3, had rough texture.

Venkateswarlu *et al.* (2002) reported that of the 100 rice cultivars screened to leaf folder infestation, only twenty- two showed a consistent damage rating of 1 during both years. Among the plant morphological characters studied (plant height, leaf width, and leaf length and leaf texture), only leaf width and leaf texture were significantly correlated with leaf folder infestation. The majority of the cultivars with damage ratings of 5 and 7 had smooth leaves. The incidence was least in MTU 20, Karidadi, Panama and Gandasale.

Soundarajan *et al*. (2002) conducted antibiosis mechanism of rice resistance to brown plant hopper, *N. lungens,* operating in 104 double haploid (DH) rice lines derived form cross IR 64 X Azucena (a traditional upland japonica variety), was studied. DH rice lines showed a greater variation in population buildup, wing form, sex ratio, and days taken for wilting, nymph population. DH rice lines ranged from 26.33 to 172.00 and the parents IR 64 (120.33) and Azucena (31.00) showed higher population.

There was no significant difference in Macroptarous form production by Brachypterous form production showed variation among the rice lines. More males emerged on 77 lines and the IR 64 parents favored more females and Azucena males. The lines harboring more nymphs wilted quickly and wilting ranged from 15.33- 42.33 days.

Alice and Sujeetha (2001) studied the effect of 7 rice cultivars on the population of rice brown plant hopper (BPH), *N. lugens*. The population was highest on TN 1 (53.00 BPH/ hill) and lowest on ADT 36 (15.00 BPH/hill) at 30 DAT. The number of BPH on TN 1 was on par with ADT 41 throughout the period. The rate of increase was more or less the same up to 45 DAT. The peak density occurred at 60 DAT with 18.00 (Lowest) BPH/hill on ADT 36 and 59.33 BPH/hill (highest) on TN 1. The population on CORH 1 and IR 20 was on par at all periods of observation. The highest grain yield of 5074.33kg/ha was recorded by ASD 18 and the lowest by TN 1 (3352.00 kg/ha), BPH multiplication was lowest on ADT 36 and MDU 5.

Misra *et al.* (2001) evaluated 27 cultivars for growth performance and pest and disease resistance. Brown plant hopper, *Nilaparvata lugnes* and green leafhopper, *Nephotettix virescens* were below moderate levels on all cultivars except Suryu- 52, IRRI- 137, MTU- 1001 and Nagarjuna. Yellow stem borer (*Scirpophaga incertulas*) incidence was low to moderate in Pusa-basmati, IRRI- 123, Basmati and Nagarjuna, but was trace to low in all other cultivars. The occurrence of biological control agents and natural enemies in these cultivars was also recorded.

White -backed plant hopper, *Sogatella furcifera* which was previously only a minor pest of rice in the Kuttanad region of Kerala, India reached the status of a major pest during the rabi season of 1997-98. The population packed during January 1998 (Ambikadevi *et a.l* 1998).

Quing *et al.* (2000) also reported that white- backed plant hopper (*Sogatella furcifera*) is becoming a major pest in the rice- cultivating area around Luzhou, Sichuan, China, with the extension of hybrid rice growing in recent years.

Khan and Kushwaha (1999) studied on the population dynamics of white-backed plant hopper, *Sogatella furcifera* on 6 rice varieties. The general trend of population build-up was the same on all varieties. A sudden and steep decline in population at each ends of September occurred on all varieties except Jaya and HKR 120, on which the decline was more gradual. The peak populations of 63.5, 33.33, 62.3, 15.3, 5.0 and 4.7 larvae/hill on Pusa 33, Pusa 212, T(N)1, Jaya, PR 106 and HKR 120, respectively occurred between the last week of August and the 3rd week of September, when the temperature, relative humidity and sunshine were 28.3-30.2^{0}C, 65.25 n 13.75% and 9.54 n 1.46 hours, respectively. This also coincided with the rice growth - stage between heading and dough. The apparent resistance of variety HKR 120 to the pest is emphasized.

Oudhia *et al.* (1999) recorded the response of 9 hybrids and one local variety of rice to brown plant hopper, *Nilaparvata lugens.* VRH-704 was the most susceptible variety, and Proagro 6201 and Mahamayaa were the least susceptible.

Suresh *et al.* (1999) evaluated the resistance of several rice hybrids to brown plant hopper, *N. lugens*. Seven high yielding susceptible rice cultivars viz. IR50, Kannagi, TKM9, Co33. ASd16, ADT36, and Co37, were crossed with the resistant cultivars TNAU-BPHR831283, TNAU831521, W1263,ARC6650 and ARC10550. Five hybrids viz., Co33 X ARC 10550, ADT36 X ARC 6650, ADT36 X ARC 10550, Co33 X W1263, and C633 X ARC 1055 were found to be resistant. Thirteen hybrids were moderately resistant, 11 were susceptible, and 6 were highly susceptible to brown plant hopper, *N. lugens*.

Nanda *et al.* (1999) showed that more *Macropterous adulu* (*Nilaparvata lugens*) settled on susceptible TN 1 (30.4%) compared with 6.2 to 9.0% adults settled on other resistant varieties after 48 h of exposures with regard to brachypterous adults susceptible TN 1 harbored a greater number (36.4%), whereas the resistant accessions could attract 2.5 to 12.4% of the population.

Malleshappa and Kumaraswarity (1998) conducted a research on twelve local and two control varieties (Mahaveera and Shakthi) grown during kharif 1993-94. Of the 12 cultivars, MTU 20 and Karidadi gave the best yields (3679 and 3214 kg/ha, respectively) over both years while leaf folder incidence was least in MTU 20, Karidadi, Panama and Gandasale.

Reddy and Misra (1996) studied on 30 rice varieties that were screened against *N. virescens* and *N. nigropictus*, two green leafhopper species. Those showing anti-xenotic resistance were: IR8, Jays and OR 34-16; the remaining varieties did not show a stable reaction.

Rana *et al.* (1994) reported that fifty-six of the varieties were resistant to BPH, 13 to GM and 12 to BLB. Only 9 varieties exhibited strong resistance to grain moth, with infestation restricted to only 0.8% of grains. R 650-1820 was the only variety resistant to BLB, BPH, GM and grain moth infestation.

Gu *et al.* (1993) described the production of japonica rice variety (Hujingkang) with moderate resistance to the Delphacid brown plant hopper, *Nilaparvata lugens* by repeated crossing with a resistant indica variety, including backcrossing nursery screening and selection etc. In field tests in 1985, 1987 and 1998 in the Shanghai area, China, good resistance was found in plots not treated with pesticides.

Misra *et al*. (1991) found that out of 53 varieties /cultures of rice, RR 19-2 and RR 50-3 were found to be most resistant to attack by rice bug, *Leptocorisa varicornis* (*L. acuta*).

Sudhakar and Singh (1991) reported that among 24 rice varieties tested for resistance to the pyralid *C. medinals*, IET 7564,ES 29-3-3-1, Pusa 2-21 and Type-3 were the least susceptible (with 3.90, 4.45, 4.97 and 6.02% infestation, respectively). Varieties Rashi 17-1B-13. Rajshree, Rastu 16-413 -11 and UPR 238T were highly susceptible (35.35, 30.08, 30.19 and 28.25%, respectively)

Infestation of extra early, early, mid-early, medium and late varieties averaged 4.49, 8.97, 24.73, 18.93 and 16.01%, respectively.

Shrivastava (1989) observed the effect of infestation of leaf folder, *C. medinalis* in different rice varieties. All the varieties tested were susceptible, in the order: Kram > Mahsuri > Madhuri > Asha > Gurmatia > Safri 17 > Makdo > CR1014. Correlation indicated that the greater the level of infestation, the shorter the panicle length and the lighter the panicle weight.

Khonglah and Saharia (1988) studied the infestation of leaf folder, *C. medinalis* on rice cvs. IR36, IR50 and Sket-4 in relation to various morphological plant characters. The number of tillers per plant did not appear to influence infestation levels. Cv.IR 50 was the most resistant variety, followed by Saket-4 and IR36.

Mishra and Misra (1988) identified seventeen lines as new donors for resistance to the pest white- backed plant hopper, *Sogatella furcifera.*

Patnaik *et al.* (1987) studied the reaction of 22 medium- duration (101-125 days) and 24 medium-late duration (126-140 days) rice cultivars to the leaf-folder (*Cnaphalocrocis medinalis*) and observed the incidence of *C. medinalis* at 50 days after transplanting. None of the cultivars was free from infestation; most were moderately resistant.

Patel *et al.* (1987) reported that average numbers of leaves damage caused by leaf folder were 2/hill in the short duration, Proorva and 5.8/hill in the medium duration IR36. It was thought that the long dry spell inter spread with closely weather may have adversely affected the natural enemies of the pest and thus promoted its population build-up.

Misra *et al.* (1985) conducted a research on the reaction of the rice variety Udaya (CR 190-103), culture from the cross CR129-118 XCR 57-49-2 to insect pests and diseases in farmers fields. The variety was found to be resistant to the brown plant hopper.

Kumar and Chelliah (1986) conducted an experiment using the seedling bulk test. He found that out of 27 rice accessions, 5 (IR24, IR29, IR54, ASD 4 and Ponmani CR1009) were resistant to green leafhopper, *N. virescens*.

Wu *et al.* (1980) reported that the modified seedling bulk-screening test was used to evaluate resistance to brown plant hopper, *Nilaparvata lugens* in cultivated and wild rice. The results indicated that this technique could be used efficiently to identify resistance, not only in resistant plants but also in moderately resistant ones. However, with an infestation of 14 nymphs/seeding of the same leaf stage, moderately resistant plants were rated of susceptible.

The nature of varietal resistance has been categorized into three broad categories non- preference, antibiosis and tolerance (Painter 1951). According to Patanakamjorn and Pathak (1967), there are significant relationship between the degree of infestation and characters like height and diameter number of elongated internodes, length and width of lamina etc. Manwan (1975) reported that the most important factor of resistance to *S. incertulus* was probably antibiosis which adversely affected the survival and the growth of the larvae. The non- preference for feeding or boring is probably due to biophysical and /or biochemical and the tolerance of the rice varieties. The wild relatives of cultivated rice may be useful source of genes for broadcasting the gene pool of cultivated rice, enhancing their resistance to insect and pathogen attack (Khan *et al*. 1989)

2.9. Pest abundance in relation to crop age

Subbash *et al*. (2001) suggested that economic injury level was 4% folded leaves during the first year and 8% folded leaves during the second year at panicle emergence of the crop. It was based on grain threshold of 0.39 tons/ha and regression coefficient of yield infestation model.

Prabal *et al.* (1999) reported that in plots with no protection at the reproductive stage there was higher leaf folder damage and lowest grain yield, with minimum avoidable yield losses of 4.2 and 5.5% for rice varieties IR-50 and Co- 45, respectively. Leaf folder damage was reduced and higher grain yields were observed in rice, when protection (monocrotophos at 1.1 L/ha) was achieved at all growth stages compared with untreated plants. The protection of crops at ETL (i.e. 10% leaf damage at vegetative growth of 5% at flowering stages) was most economical with higher cost benefit ratio.

Pandats *et al.* (1990) studied on the fluctuation of green leafhopper population in relation to age of rice crop. They found a highly significant negative correlation between the numbers of green leafhopper, *N. nigropictus* caught using light traps and the age of the rice crop. It easy concluded that control measures in rice crop would be more effective when used at a young stage, a time when the initial population of the Delphacid remains high.

Noda (1987) reported that sucking damage by the Delphacid was heavy in young plants. The population peaked in the 1st generation after immigration declined in the 2^{nd} generation as adults left the fields.

Crop age was a contributing factor in pest abundance. Hinckley (1963) and Hiesh (1972) reported that the plant age of 50 to 70 days after transplanting in the fields was the most suitable for the population increase of green leafhopper.

Soekhardjan *et al.* (1974) reported that in general there is an increase in the level of infestation with the increase of the age of the rice plan

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the experimental field of the Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during T-Amon season of June to October 2009 to explore the resistant and tolerant varieties among different hybrid rice varieties against major insect pests. The materials and methods adopted in this study are discussed in the following sub-headings:

3.1. Location and duration

The experimental site was located at the experimental field of Sher-e-Bangla Agriculture University, Dhaka-1207 located at $90^{o}335'$ E longitude and $23^{o}774'$ N latitude at a height 8 meter above the sea level during the period from June to October, 2009. The land was medium high and well drained. The soil of the experimental plots belonged to the agro ecological zone Madhupur Tract (AEZ-28).

3.2. Land preparation

Experimental land was timely ploughed followed by laddering and proper leveling. All kinds of weeds, stubble and crop residues were removed from the field.

3.3 Climate

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi Season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

Plate: 1 Rice growing field

3.4. Treatments

The seven varieties/genotypes, of which six hybrid rice and one high yielding variety (BR 11) as check were collected from the local market of Dhaka. Each variety of which was considered as an individual treatment. The rice varieties used as treatments of the present study are given as follows:

Variety	Sources of availability
Hira-2	Local market of Dhaka
Taj-1	
Aftaf-108	
Krisan-2	
Madhumati-2	
Aloron	
BR 11 (Check variety)	

3.5. Planting material

Seeds of hybrid varieties of rice, Hira-2, Taj-1, Aftaf-108, Krisan-2, Madhumati-2, Aloron and HYV of rice BR 11 were used as the planting materials of the present study.

3.6. Soil of the experimental plot

The soil of the experimental field area was under the Agro Ecological zone of Madhupur Tract (AEZ-28) with pH 5.8-6.5, CEC 25-28 (Haider *et al.* 1991).

3.7. Collection of seeds and seedling raising

Seeds of hybrid varieties of rice were used for seedling raising in the seedbed. Before sowing seeds in the seedbed, the germination test was done to ensure standard viability measuring approximately 90% germination. Pre-soaked, for 48 hrs to ensure germination, seeds were sown in the mud of nursery bed during June (Amon season) of 2009 as recommended by Mustafiz (2007). Irrigation and other intercultural operations were done as required.

3.8. Experimental design and layout

The study was conducted in randomized complete block design (RCBD) with three replications. A good tilth area was divided into 3 main plots/blocks. Each block was sub-divided into 12 sub plots each of which was of 4 m x 3 m with maintaining 0.75 m borders and the distance between hill to hill and row to row was kept 20 cm and 25 cm, respectively.

3.9. Seedling transplanting and fertilization

Only one 30 days old seedling was transplanted per hill of the land. The crop was raised following standard agronomic practices of irrigation, and Urea, TSP, MP, Gypsum and Zinc Sulphate as the source of Nitrogen (N_2), Phosphorus (P_2O_5), Sulphur (S) and Zinc (Zn) fertilizers were applied @ 150:60:80:30:5 kg-ha. All TSP, MP, Gypsum, Zinc Sulphate and 1/3 of total Urea was applied at the time of transplanting. Rest of Urea was applied as top dressing in three equal splits at maximum tillering, panicle initiation and flowering stage of the rice plants. Subsequent irrigation and other intercultural operations were performed uniformly and equally to all the plots.

3.10. Intercultural operations

3.10.1. Weeding

Different kinds of weeds infesting the crop were controlled uprooting with hand.

3.10.2. Irrigation and drainage

Irrigation and drainage were done as required at the experimental plot during vegetative and reproductive stage. Two excess irrigations were applied in the field.

3.10.3. Plant protection measures

No plant protection measures were taken because of different rice varieties against major insect pests would be done under natural condition.

3.11. Data collection and calculation

For data collection five plants were randomly selected and tagged. Data collection was started at 24 days after transplanting (DAT). All the data were collected once a week. The data were collected on different parameters such as number of rice hispa, brown plant hopper, rice bug, green leaf hopper, short horned grasshopper, long horned grasshopper, white-backed leafhopper, rice leaf roller per five selected plants both by visual estimation and by sweep net; number of infested tillers by these pests, number of infested leaves per tillers per five selected hills, number of dead heart infested tiller, number of white head infested tiller, leaf area damage, 1000 seed weight, weight of grain of five selected hills, weight of total grain per plot and yield (kg/ha), and percentage of yield loss by calculation.

3.11.1. Borer infestation

Five hills were selected at random per replication for each treatment. The dead hearts and white heads were counted. The observations were recorded at the first observation of dead heart symptom and were continued up to maturity of the grains at 7 days interval. At the time of harvest the tillers of all hills were counted to record the white ear heads. The data on the yield was also recorded.

3.11.2. Data calculation

The infestation was expressed as percent dead hearts and white ear heads calculated by using the formula as suggested by Shafiq *et al.* (2000).

Percent dead heart infestation: Number of dead heart infested tillers was counted from total tillers per five selected hills and percent dead heart was calculated by using the following formula:

$$\% \text{ dead heart tillers} = \frac{\text{No. of dead heart infested tiller}}{\text{Total no. of tillers per five hills}} \times 100$$

Percent white head infestation: Number of white head infested tillers was counted from total tillers per five hills and percent white head was calculated by using the following formula:

$$\% \text{ white head tillers} = \frac{\text{No. of white head infested tiller}}{\text{Total no. of tillers per five hills}} \times 100$$

Percent rice hispa infestation: Number rice hispa infested plants (hills) was counted from total plants (hills) per plot and percent of plant infestation was calculated by using the following formula:

$$\% \text{ rice hispa infested plant} = \frac{\text{No. of rice hispa infested plant}}{\text{Total no. of plant per plot}} \times 100$$

3.12. Number of different pests

The number of brown plant hopper, rice bug, green leaf hopper, short horned grasshopper, long horned grasshopper, rice leaf roller on 5 randomly selected plants and per three sweeps by sweep net from each plot was counted once a week at 24 DAT and continuing 63 DAT.

3.13. Yield and yield contributing characters

The crop was harvested at full maturity stage from 21st October to 14th November 2009. For the purpose of the study of yield contributing character viz. data on yield of 5 selected hills, 1000 seed weight, number of filled and unfilled grain within 1000 seeds were recorded.

3.14. Statistical analysis

The data were analyzed using the statistical package MSTAT-C program. The analysis of variance (ANOVA) of different parameters was done and the mean were separated by using the Duncan's Multiple Range Test (Duncan, 1955).

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to find out the resistance sources among different hybrid rice varieties/genotypes against major insect pests. The results under the experiment have been presented, discussed and possible interpretations have also been given under the following sub-headings:

4.1. Incidence of rice stem borer infestation

Significant variations among different hybrid rice varieties were observed in respect of the incidence of rice stem borer infestation in the field, which are interpreted and discussed on the following sub-headings:

4.1.1. Dead heart infestation

The dead heart infestation among different hybrid rice varieties was varied significantly at 52 days after transplanting (DAT) and 60 DAT. In case of 52 DAT, the highest dead heart infestation (25.0%) was recorded in Aloron hybrid rice variety, which was statistically different from all other varieties. This was followed Madhumati-2 (22.72%), which was statistically similar with Aftaf-108 (21.29%) followed by Taj-1 (19.43%) (Table 1). On the other hand, the lowest dead heart infestation (14.42%) was recorded in BR 11 followed by Krisan-2 (17.73%) and Hira-2 (17.76%). In case of 60 DAT, more or less similar trends of results were also observed, where the highest dead heart infestation (25.34%) was recorded in Aloron, which was statistically different from all other varieties followed Taj-1 (23.95%), Madhumati-2 (22.84%). On the other hand, the lowest dead heart infestation (12.65%) was recorded in Aftaf-108 followed by Hira-2 (14.28%), BR 11 (15.46%) and Krisan-2 (16.10%).

Considering the mean dead heart infestation, the highest dead heart infestation (25.17%) was recorded in Aloron hybrid rice variety, which was statistically similar with Madhumati-2 (22.78%) and Taj-1 (21.69%). On the other hand, the lowest dead heart infestation (14.94%) was recorded in BR 11 followed by Hira-2 (16.02%), Krisan-2 (16.92%) and Aftaf-108 (16.97%). As a result, the trend of the resistance among hybrid rice varieties along with a check variety (BR 11) in respect of dead heart infestation caused by rice stem borer is BR 11 > Hira-2 > Krisan-2 > Aftaf-108 > Taj-1 > Madhumati-2 > Aloron.

Table 1: Incidence of dead heart infestation among different hybrid rice varieties caused by rice stem borer at different days after transplanting (DAT)

Variety	Dead heart infestation						
	52 DAT			60 DAT			Mean (%)
	Total tiller (no.)	Infested tiller (no.)	Infestation (%)	Total Tiller (no.)	Infested Tiller (no.)	Infestation (%)	
Hira-2	30.00 a	5.00 b	17.76 d	35.00 a	5.00 bd	14.28 e	16.02 bc
Taj-1	20.58 de	5.33 ab	19.43 c	23.67 c	5.67 ab	23.95 b	21.69 abc
Aftaf-108	28.17 b	3.67 d	21.29 b	29.00 b	3.67 e	12.65 f	16.97 bc
Krisan-2	26.33 c	4.67 bc	17.73 d	29.00 b	4.67 cd	16.10 d	16.92 bc
Madhumati-2	22.00 d	5.00 b	22.72 b	23.33 c	5.33 ac	22.84 c	22.78 ab
Aloron	20.00 e	6.00 a	25.00 a	23.67 c	6.00 a	25.34 a	25.17 a
BR11	25.37 c	4.00 cd	14.42 e	28.00 b	4.33 de	15.46 d	14.94 c
$LSD_{(0.05)}$	1.483	0.776	1.483	2.622	0.866	0.867	7.152
CV%	3.01	8.07	3.02	4.79	8.76	8.69	15.21

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 5 randomly selected hills/plot as per variety.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.2. Infestation of white head

The white head infestation among different hybrid rice varieties was varied significantly at 75 and 80 DAT. In case of 75 DAT, the highest white head infestation (66.42%) was recorded in Aloron, which was statistically different from all other varieties. This was followed Madhumati-2 (61.65%) and Taj-1 (46.95%) (Table 2). On the other hand, the lowest white head infestation

(28.90%) was recorded in BR 11 followed by Hira-2 (32.92%), Krisan-2 (34.32%) and Aftaf-108 (38.11%). In case of 80 DAT, more or less similar trends of results were also observed, where the highest white head infestation (57.75%) was recorded in Aloron, which was followed Madhumati-2 (53.52%), Taj-1 (38.57%) (Table 2). On the other hand, the lowest white head infestation (24.77%) was recorded in BR 11 followed by Hira-2 (29.89%), Krisan-2 (33.34%) and Aftaf-108 (35.71%).

Considering the mean white head infestation, the highest white head infestation (62.08%) was recorded in Aloron, which was statistically similar with Madhumati-2 (57.58%) followed by Taj-1 (42.76%). On the other hand, the lowest white head infestation (26.83%) was recorded in BR 11 followed by Hira-2 (31.40%), Krisan-2 (33.83%) and Aftaf-108 (36.91%). As a result, the trend of the resistance among hybrid rice varieties along with a check variety (BR 11) in respect of white head infestation caused by rice stem borer is BR 11 > Hira-2 > Krisan-2 > Aftaf-108 > Taj-1 > Madhumati-2 > Aloron.

Table 2: Incidence of white head infestation at different DAT among different hybrid rice varieties

Variety	White head infestation						
	75 DAT			80 DAT			Mean (%)
	Total tiller (no.)	Infested tiller (no.)	Infestation (%)	Total Tiller (no.)	Infested Tiller (no.)	Infestation (%)	
Hira-2	26.33 c	8.67 d	32.92 e	29.00 b	8.67 b	29.89 f	31.40 d
Taj-1	22.00 d	10.33 c	46.95 c	23.33 c	9.00 b	38.57 c	42.76 b
Aftaf-108	25.37 c	9.67 c	38.11 d	28.00 b	10.00 b	35.71 d	36.91 c
Krisan-2	28.17 b	9.67 c	34.32 e	29.00 b	9.67 b	33.34 e	33.83 cd
Madhumati-2	20.00 e	12.33 b	61.65 b	23.67 c	12.67 a	53.52 a	57.58 a
Aloron	20.58 de	13.67 a	66.42 a	23.67 c	13.67 a	57.75 b	62.08 a
BR11	30.00 a	8.67 d	28.90 f	35.00 a	8.67 b	24.77 g	26.83 e
$LSD_{(0.05)}$	1.483	0.814	1.483	2.622	1.276	1.482	4.548
CV%	3.01	3.90	3.01	4.79	6.18	2.99	5.47

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 5 randomly selected hills/plot as per variety.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Plate:2. White head symptom showing white panicles caused by stem borer

Plate: 3. Dead heart symptom caused by rice stem borer

4.1.3. Incidence of adult stem borer moth

The incidence of the adult moths of rice stem borer collected from different hybrid rice varieties by sweep net was varied significantly and more or less similar trends of results in respect of the incidence of adult stem borer moths were also observed through out the growing period (49, 56, 63, 70 and 80 DAT). The incidence of adult moths was ranged from 0.33 to 1.00 adult/plot at 49 DAT, 2.00 to 3.67 adults/plot at 56 DAT, 2.67 to 5.00 adults/plot at 63 DAT, 3.00 to 4.67 adults/plot at 70 DAT and 3.33 to 5.33 adults/plot at 80 DAT (Table 3). All these cases, the highest incidence of adult moths was observed in the hybrid variety Aloron and the lowest incidence was recorded in the check variety BR 11 followed by the hybrid variety Hira-2.

Considering the mean incidence of adult stem borer moths, the highest incidence (3.93 adults/plot) was recorded in Aloron, which was statistically similar with Madhumati-2 (3.40 adults/plot) followed by Taj-1 (3.26 adults/plot), Aftaf-108 (3.13 adults/plot) and Krisan-2 (3.06 adults/plot). On the other hand, the lowest incidence (2.26 adults/plot) was recorded in BR 11 followed by Hira-2 (2.73 adults/plot). As a result, the trend of the host preference among hybrid rice varieties in respect of incidence of adult stem borer moths is BR 11 > Hira-2 > Krisan-2 > Aftaf-108 > Taj-1 > Madhumati-2 > Aloron.

Table 3: Incidence of adult stem borer moth among different hybrid rice varieties throughout the growing season June to November, 2009

Variety	Adult moth (No./Plot)					
	45 DAT	52 DAT	60 DAT	70 DAT	80 DAT	Mean (No./Plot)
Hira-2	0.33 c	2.67 b	2.67 c	3.67 b	3.33 c	2.73 cd
Taj-1	0.67 b	3.00 b	4.33 ab	4.67 a	3.67 bc	3.26 bc
Aftaf-108	0.67 b	3.00 b	4.00 b	4.33 a	3.67 bc	3.13 bc
Krisan-2	0.67 b	3.00 b	4.33 b	3.67 b	3.67 bc	3.06 bc
Madhumati-2	0.67 b	2.67 b	4.67 ab	4.67 a	4.33 b	3.40 ab
Aloron	1.00 a	3.67 a	5.00 a	4.67 a	5.33 a	3.93 a
BR11	0.33 c	2.00 c	2.67 c	3.00 c	3.33 c	2.26 d
$LSD_{(0.05)}$	0.211	0.491	0.641	0.596	0.706	0.5445
CV%	17.27	8.55	8.11	7.30	9.05	13.38

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 sweep by sweep net.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

From the above findings it was revealed that among six hybrid (Hira-2, Taj-1, Aftaf-108, Krisan-2, Madhumati-2 and Aloron) and one check variety (BR 11) of rice, Aloron performed as the most susceptible variety to stem borer in respect of dead heart (25.17%), white head (62.08%) infestation and incidence of adult moth (3.93 adult/plot) followed by Madhumati-2 (22.78%, 57.58% and 3.40 adult/plot, respectively). Conversely, the BR 11 performed as resistant (14.94%, 26.83% and 2.26 adult/plot respectively) followed by Hira-2 (16.02%, 31.40% and 2.73 adult/plot, respectively). About similar findings were also observed by several researchers. Misra *et al.* (2001) evaluated 27 cultivars for growth performance and pest and disease resistance. They reported that yellow stem borer (*Scirpophaga incertulas*) incidence was low to moderate in Pusa-basmati, IRRI- 123, Basmati and Nagarjuna, but was trace to low in all other cultivars. Manwan (1975) reported that the most important factor of resistance to *S. incertulas* was probably antibiosis which adversely affected the survival and the growth of the larvae. The non- preference for feeding or boring is probably due to biophysical and /or biochemical and the tolerance of the rice varieties. Khan *et al*. (1989) reported that the wild relatives of cultivated rice may be useful source of genes for broadcasting the gene pool of cultivated rice, enhancing their resistance to insect and pathogen attack.

4.2. Incidence and infestation of rice hispa

Significant variations of rice hispa were observed in the field of different rice varieties, which are interpreted and discussed on the following sub-headings:

4.2.1. Incidence of adult rice hispa

The incidence of adult hispa were significantly influenced by different hybrid varieties/ genotypes of rice. In case of visual observation, among different rice varieties, the highest incidence of adult hispa (3.67, 5.33, 3.33 and 1.67 adults/5 plants at 25 DAT, 32 DAT, 39 DAT, 46 DAT, respectively) was recorded in the hybrid variety Taj-1, which was followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2 (Table 4). Whereas the lowest incidence (2.63, 1.67, 1.03 and 0.67 adults/5 plants at 25, 32, 39 and 46 DAT, respectively) was recorded in BR 11. More or less similar trends of results were also observed in case of the incidence of adult rice hispa recorded through sweep net.

Considering the mean incidence of adult rice hispa, among different rice varieties, the highest incidence (3.50 adults/5 plants) was recorded in Taj-1, which was followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2. On the other hand, the lowest incidence (1.50 adults/5 plants) was recorded in BR11 when the adult hispa were counted through visual observation. More or less similar trends of results were also observed in case of the incidence of adult rice hispa when counted through sweep net.

Dutta and Hazarika (1992) and Hazarika and Datta (1991) showed the results which was supported by the present study.

Table 4: Incidence of adult rice hispa among different hybrid rice varieties throughout the tillering stage of rice

Variety	Incidence of adult rice hispa									
	25 DAT		32 DAT		39 DAT		46 DAT		Mean	
	Visual observation (No./5 plant)	Sweep net (No./3 sweep)	Visual observation (No./5 plant)	Sweep net (No./3 sweep)	Visual observation (No./5 plant)	Sweep net (No./3 sweep)	Visual observation (No./5 plant)	Sweep net (No./3 sweep)	Visual observation (No./5 plant)	Sweep net (No./3 sweep)
Hira-2	3.33 ab	5.67 ab	3.33 b	3.00 b	2.70 b	2.00 ab	1.33 a	1.00 c	2.67 b	2.91 b
Taj-1	3.67 a	7.00 a	5.33 a	4.67 a	3.33 a	2.30 a	1.67 a	1.67 a	3.50 a	3.91 a
Aftaf-108	2.67 b	6.67 ab	3.33 b	3.33 b	2.33 bc	2.00 ab	1.33 a	1.33 b	2.41 b	3.33 ab
Krisan-2	4.00 a	6.33 ab	3.00 b	3.00 b	2.00 c	2.00 ab	1.33 a	0.67 d	2.58 b	3.00 b
Madhumati-2	3.33 ab	7.00 a	3.00 b	3.00 b	2.33 bc	2.33 a	1.33 a	0.33 e	2.49 b	3.16 ab
Aloron	3.67 a	6.67 ab	2.67 b	2.67 b	2.00 c	2.33 a	1.67 a	1.00 c	2.50 b	3.16 ab
BR11	2.63 b	5.33 b	1.67 c	1.00 c	1.03 d	1.67 b	0.67 b	0.33 e	1.50 c	2.08 c
$LSD_{(0.05)}$	0.681	1.259	0.909	1.061	0.606	0.384	0.456	0.310	0.7323	0.7186
CV%	10.24	9.87	14.26	17.98	13.46	9.22	17.09	17.05	19.54	15.70

In a column, numeric data represents the mean value of 3 replications; each replication derived from 5 randomly selected hills/plot by visual observation and 3 sweep by sweep net per plot.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.2.2. Incidence of larvae of rice hispa

Presence of larvae on plant leaves is very much harmful because of higher incidence cause higher damage of crops. Different hybrid varieties/ genotypes of rice were greatly influenced by number of larvae present on rice leaves under the present study (Table 5).

The results exposed that the highest number of larvae/fully opened 3 leaves per five selected plant (4.00, 4.00, 2.67 and 2.00 respectively) were observed in variety, Hira-2 at different growth stages (25, 30, 35 and 40 DAT respectively) which was not significantly different from Krisan-2 and Madhumati-2 at 25 DAT and Taj-1 to Madhumati-2 and Aloron at 35 DAT. The results obtained from Taj-1 at 25 DAT, Aloron at 30 DAT and Taj-1, Krisan-2, Madhumati-2, Aloron at 40 DAT showed significantly similar with Hira-2. On the other hand variety BR11 showed the lowest (2.67, 2.33, 1.67 and 0.63 respectively at 25, 30, 35 and 40 DAT respectively) result at all growth stages which was not significantly different from Aftaf-108 at 25 DAT. Table 5 indicates that the highest number of and lowest number of larvae/fully opened 3 leaves per five selected plant were obtained with the variety Hira-2 and BR11 respectively.

Generally presence of larvae on plants depends on its susceptibility and plant characters. De Kraker *et al*., (1999), Malik *et al.* (1985) and Cheng and Wu (1999) gave statement which was supported with the present study.

Table 5: Incidence of rice hispa larvae among different hybrid rice varieties throughout the tillering stages of rice

Variety	Incidence of rice hipa larvae (No./5 hill)				
	25 DAT	32 DAT	39 DAT	46 DAT	Mean
Hira-2	4.00 a	4.00 a	2.67 a	2.00 a	3.16 a
Taj-1	3.73 ab	3.33 bc	2.67 a	1.67 ab	2.85 ab
Aftaf-108	2.67 c	3.00 cd	2.33 a	1.33 b	2.33 c
Krisan-2	4.00 a	3.33 bc	2.67 a	1.67 ab	2.91 ab
Madhumati-2	3.83 a	2.67 de	2.67 a	1.67 ab	2.71 bc
Aloron	3.33 b	3.66 ab	2.67 a	1.67 ab	2.83 ab
BR11	2.67 c	2.33 e	1.67 b	0.63 c	1.82 d
LSD	0.414	0.603	0.596	0.374	0.3902
CV%	5.97	9.43	12.08	12.38	9.86

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 fully opened leaves per five randomly selected hills per plot.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.3. Incidence and infestation of rice bug

The incidence of rice bug was significantly influenced by different hybrid varieties/ genotypes of rice. In case of sweep by sweep net, among different rice varieties, the highest incidence of rice bug/3 sweep by sweep net /plot (1.67, 1.67, 3.00, 5.67 and 6.67 respectively) were observed in variety Madhumati-2 at different growth stages (35, 42, 49, 56 and 63 DAT respectively) which was followed by Hira-2 and Aftaf-108 at 42 DAT, Taj-1 and Aloron at 49 DAT and Hira-2 at 63 DAT. On the other hand, the lowest incidence (1.00, 1.00, 2.33, 3.33 and 4.33 respectively at 35, 42, 49, 56 and 63 DAT respectively) result at all growth stages which was not significantly different from Taj-1 at 35 and 42 DAT and Hira-2 at 49 DAT. Table 6 indicates that the highest and lowest incidence of rice bug/3 sweep by sweep net /plot were obtained with the variety Madhumati-2 and BR 11 respectively.

Considering the mean incidence of rice bug the highest incidence (3.73 adults/5 plants) was recorded in madhumati-2, which was followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2. On the other hand, the lowest incidence (2.39 adults/5 plants) was recorded in BR11 when the rice bug was counted through sweep net.

Rice bug, *Leptocorisa acuta* (Thunburg) and *Leptocorisa oratoria* (Fabricius) are important pests infesting the rice crop at the flowering stage. This was similarly stated by and Ito (2003) under the present study.

Table 6: Incidence of rice bug among different rice varieties at different DAT through sweep net

Variety	Incidence of rice bug (No./plot)					
	25 DAT	32 DAT	39 DAT	46 DAT	53 DAT	Mean
Hira-2	1.00 c	1.63 a	2.33 b	4.00 bc	6.00 a	2.99 bc
Taj-1	0.67 d	1.00 c	2.98 a	5.33 ab	5.67 ab	3.13 ab
Aftaf-108	1.33 b	1.65 a	2.67 ab	5.00 ab	4.67 bc	3.06 b
Krisan-2	1.00 c	1.33 b	2.67 ab	4.00 bc	4.67 bc	2.73 bc
Madhumati-2	1.67 a	1.67 a	3.00 a	5.67 a	6.67 a	3.73 a
Aloron	0.67 d	1.42 ab	2.96 a	4.67 ac	5.67 ab	3.07 b
BR11	1.00 c	1.00 c	2.33 b	3.33 c	4.33 c	2.39 c
$LSD_{(0.05)}$	0.211	0.268	0.485	1.416	1.116	0.612
CV%	9.78	9.69	8.95	15.50	10.38	15.54

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 sweep by sweep net.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.4. Incidence and infestation of rice leaf roller

Presence or incidence of rice leaf roller in plant population is very much harmful for successful crop production. Under the present study, different hybrid varieties/ genotypes of rice was greatly influenced by number of rice leaf roller, which are interpreted and discussed on the following sub-headings:

4.4.1. Incidence of rice leaf roller

From the above findings it was revealed that among six hybrid (Hira-2, Taj-1, Aftaf-108, Krisan-2, Madhumati-2 and Aloron) and one check variety (BR 11) of rice, the highest incidence (3.92 rice leaf roller /plot) of rice leaf roller /3 sweep by sweep net/plot was observed in variety Madhumati-2 at different growth stages (25, 32, 39, 46 and 53 DAT respectively) which was not significantly different from Hira-2, Aftaf-108 and Krisan-2 at 70 DAT (Table 7). On the other hand, variety BR11 performed as resistant (0.33, 2.00, 2.67, 3.00 and 3.33 respectively at 25, 32, 39, 46 and 53 DAT respectively) result at

all growth stages which was not significantly different from Taj-1 at 25, 32 and 39 DAT.

Considering the mean incidence of rice leaf roller the highest incidence (3.92 adults/5 plants) was recorded in Aloron, which was followed by Hira-2, Krisan-2, Aftaf-108, and Madhumati-2. On the other hand, the lowest incidence (2.25 adults/5 plants) was recorded in BR11 .

Table 7: Incidence of rice leaf roller moth among different hybrid rice varieties at different DAT

Variety	Number of Adult moth /plot					
	25 DAT	32 DAT	39 DAT	46 DAT	53 DAT	Mean
Hira-2	0.68 b	2.67 b	4.67 ab	4.67 a	4.33 b	3.40 ab
Taj-1	0.33 c	2.67 b	2.67 c	3.67 b	3.33 c	2.71 cd
Aftaf-108	0.68 b	3.00 b	4.33 ab	4.67 a	3.67 bc	3.26 bc
Krisan-2	0.67 b	3.00 b	4.00 b	4.33 a	3.67 bc	3.13 bc
Madhumati-2	0.67 b	3.00 b	4.33 b	3.65 b	3.67 bc	3.06 bc
Aloron	1.01 a	3.67 a	5.00 a	4.67 a	5.33 a	3.92 a
BR11	0.33 c	2.00 c	2.67 c	3.00 c	3.31 c	2.25 d
$LSD_{(0.05)}$	0.211	0.491	0.641	0.596	0.706	0.5445
CV%	17.27	8.55	8.11	7.30	9.05	13.38

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 sweep by sweep net.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.4.2. Infestation of tiller caused by rice leaf roller

Incase of infestation among the different rice varieties, Madhumati-2 showed the highest infestation of tillers/5selected plant; 6.53, 8.67, 11.03 and 13.20 respectively at 25, 30, 35 and 40 DAT respectively. The lowest infestation of tillers/5selected plant; 4.73, 5.43, 6.60 and 6.27 respectively were observed in BR 11 at 25, 30, 35 and 40 DAT respectively which were not significantly different from Hira-2, Aloron at 25 DAT, Hira-2, Aftaf-108, Aloron at 35 DAT. Considering the infestation of leaf roller, among different rice varieties, the highest infestation (9.85%) was recorded in Madhumati-2, which was followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Taj-i. On the other hand, the lowest infestation (5.75%) was recorded in BR11.

The highest incidence (9.85%) caused by rice leaf roller was recorded in Madhumati-2, which was followed by Hira-2, Krisan-2, Aftaf-108. On the other hand, the lowest incidence (5.75%) was recorded in BR11.

As a result, the trend of the resistance among hybrid rice varieties along with a check variety (BR 11) in respect of rice leaf roller infestation was BR 11 >Aloron > Aftaf-108 >Hira-2 > Taj-1 > Krisan-2 > Madhumati-2.

Table 8: Infestation of tiller caused by rice leaf roller among different rice varieties at different DAT

Variety	**Rice leaf roller infested tiller (%)**				
	25 DAT	32 DAT	39 DAT	42 DAT	Mean
Hira-2	4.80 c	6.93 b	7.00 d	8.33 bc	6.76 bc
Taj-1	5.53 b	6.93 b	7.80 c	8.07 bc	7.08 bc
Aftaf-108	5.67 b	6.43 bc	6.87 d	7.07 de	6.51 bc
Krisan-2	5.87 b	7.10 b	9.80 b	8.73 b	7.87 b
Madhumati-2	6.53 a	8.67 a	11.03 a	13.20 a	9.85 a
Aloron	4.93 c	6.07 cd	6.80 d	7.53 cd	6.33 bc
BR11	4.73 c	5.43 d	6.60 d	6.27 e	5.75 c
$LSD_{(0.05)}$	0.493	0.758	0.761	0.918	1.465
CV%	4.56	5.59	4.77	5.43	11.91

In a column, numeric data represents the mean value of 3 replications; each replication was derived from five selected hills/plot as per variety.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.4.3. Infestation of leaves caused by rice leaf roller

Infestation of leaves was greatly influenced by different hybrid varieties of rice against rice leaf roller. Incase of infested leaves among the different rice varieties, Krisan-2 showed the highest percent infestation of leaves; 10.93%, 13.47%, 14.77% and 14.77% respectively at 25, 30, 35 and 40 DAT respectively. The lowest percent infestation of leaves; 5.10%, 7.30%, 8.63% and 9.40% respectively were observed in BR11 at 25, 30, 35 and 40 DAT, respectively (Table 9). The highest percent infestation of leaves per five selected plants was obtained with the variety Taj-1. On the contrary, the lowest percent infestation of leaves was BR11.

As a result, the trend of the resistance among hybrid rice varieties along with a check variety (BR 11) in respect of rice leaf roller infestation was BR 11 >Aloron > Aftaf-108 >Hira-2 > Taj-1 > Krisan-2 > Madhumati-2.

Table 9. Infestation of leaves caused by rice leaf roller larvae among different rice varieties at different DAT

Variety	Rice leaf roller infested leaf (%)				
	25 DAT	32 DAT	39 DAT	42 DAT	Mean
Hira-2	9.000 b	10.70 c	13.07 b	12.90 c	11.42 bc
Taj-1	11.73 a	11.10 c	14.80 a	14.40 ab	12.82 ab
Aftaf-108	7.633 c	11.03 c	11.27 c	12.17 c	10.52 c
Krisan-2	10.93 a	13.47 a	14.77 a	14.77 a	13.49 a
Madhumati-2	8.40 bc	12.17 b	12.80 bc	13.13 c	11.67 bc
Aloron	9.00 b	13.97 a	14.87 a	13.27 bc	12.78 ab
BR11	5.10 d	7.30 d	8.633 d	9.40 d	7.61 d
$LSD_{(0.05)}$	1.27	0.72	1.57	1.16	1.40
CV%	7.20	3.18	6.10	4.52	7.12

In a column, numeric data represents the mean value of 3 replications; each replication was derived from five selected hills/plot as per variety.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.5. Incidence of rice green leaf hopper

The incidence of rice green leaf hopper was significantly influenced by different hybrid varieties/ genotypes of rice. Among the different rice varieties the highest incidence of rice green leaf hopper (2.33, 4.67, 4.00, 5.00 and 5.33 adults/5 plants, respectively) was observed in variety Krisan-2 at different growth stages which was not significantly different from Hira-2, Madhumati-2 and Aloron (Table 10). On the other hand showed the lowest (0.67, 1.67, 2.67, 3.00 and 1.67 adults/5 plants, respectively at 35, 42, 49, 56 and 63 DAT respectively) was recorded in BR11.

Considering the mean incidence of rice green leaf hopper, among different rice varieties, the highest incidence (4.26 adults/5 plants) was recorded in Krisan-2, which was followed by Hira-2, Madhumati-2 and Aloron. On the other hand, the lowest incidence (1.93 adults/5 plants) was recorded in BR11 when the rice green leaf hopper was counted through sweep net.

Soekhardjan *et al.* (1974) reported that in general there is an increase in the level of infestation with the increase of the age of the rice plants. Misra *et al.* (2001), Kumar and Chelliah (1986), Reddy and Misra (1996) and Soekhardjan *et al.* (1974) also gave supporting results under the present study incase of green leaf hopper.

Table 10: Incidence of green leaf hopper among different hybrid rice varieties at different DAT through sweep net

Variety	Number of Green leaf hopper/plot					
	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	Mean
Hira-2	2.33 a	3.67 b	3.00 bc	3.33 cd	4.33 b	3.33 b
Taj-1	1.33 b	2.33 cd	3.00 bc	3.67 bc	4.33 b	2.93 b
Aftaf-108	1.33 b	2.67 c	3.33 a-c	4.00 b	4.67 ab	3.20 b
Krisan-2	2.33 a	4.67 a	4.00 a	5.00 a	5.33 a	4.26 a
Madhumati-2	2.33 a	2.67 c	3.67 ab	3.67 bc	4.67 ab	3.40 b
Aloron	2.33 a	3.67 b	4.00 a	5.00 a	5.33 a	4.06 a
BR11	0.67 c	1.67 d	2.67 c	3.00 d	1.67 c	1.93 c
$LSD_{(0.05)}$	0.352	0.723	0.782	0.505	0.742	0.6448
CV%	9.70	11.92	11.59	6.40	8.57	14.96

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 sweep by sweep net per plot.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.6. Incidence and infestation of grasshopper

Presence or incidence of grasshopper in plant population is very much harmful for successful crop production. Under the present study, different hybrid varieties/ genotypes of rice was greatly influenced by number of rice leaf roller, which are interpreted and discussed on the following sub-headings:

4.6.1. Incidence and infestation of short horned grasshopper

The results exposed that the highest incidence of short horned grasshopper /3 sweep by sweep net/plot (6.67, 10.00, 6.00, 6.67 and 6.67adults/5 plants respectively) were observed in variety Krisan-2 at different growth stages (35, 42, 49, 56 and 63 DAT respectively) which was not significantly different from Taj-1, Hira-2, Aftaf-108 and Madhumati-2 (Table 11). Whereas the lowest incidence (2.67, 3.33, 3.33, 4.00 and 4.00 adults/5 plants at 35, 42, 49, 56 and 63 DAT respectively) was recorded in BR11 at all growth stages.

Considering the mean incidence of short horned grasshopper, among different rice varieties, the highest incidence (7.20 adults/5 plants) was recorded in Krisan-2, which was followed by Taj-1, Hira-2, Aftaf-108 and Madhumati-2.

On the other hand, the lowest incidence (3.46 adults/5 plants) was recorded in BR11 when the short horned grasshopper was counted through sweep net.

Similar findings also reported by (BRRI, 1985). Long horned grasshoppers and short horned grasshoppers feed on rice leaves from margins to midrib and known to transmit yellow mottle disease (BRRI, 1985).

Table 11: Incidence of short horned grasshopper among different rice varieties at different DAT through sweep net

Variety	Number of short horned grasshopper/plot					
	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	Mean
Hira-2	4.00 c	6.00 c	4.33 bc	6.33 ab	6.00 a	5.33 bc
Taj-1	5.30 b	8.33 b	6.00 a	5.33 bc	6.00 a	6.19 ab
Aftaf-108	3.70 c	6.33 c	4.67 b	5.67 a-c	6.33 a	5.34 bc
Krisan-2	6.67 a	10.0 a	6.00 a	6.67 a	6.67 a	7.20 a
Madhumati-2	3.67 c	5.00 d	3.67 bc	4.67 cd	5.67 a	4.53 c
Aloron	3.67 c	4.33 d	4.33 bc	5.33 bc	5.67 ab	4.66 c
BR11	2.67 d	3.33 e	3.33 c	4.00 d	4.00 b	3.46 d
LSD $_{(0.05)}$	0.894	0.986	1.005	1.252	1.592	1.03
CV%	10.56	7.98	10.88	11.55	13.83	15.04

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 sweep by sweep net per plot.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Plate: 4. Grasshopper infested rice plant showing damaged leaves

4.6.2. Incidence and infestation of long horned grasshopper

The results showing that the highest incidence of long horned grasshopper/3 sweep by sweep net/plot (1.67, 3.67, 3.00, 4.67 and 6.00 adults/5 plants respectively) were observed in variety Taj-1 at different growth stages (35, 42, 49, 56 and 63 DAT respectively) which was not significantly different from Krisan-2, Hira-2, Aftaf-108, Krisan-2 (Table 12).

Whereas the lowest incidence (0.67, 1.33, 1.33, 2.00 and 4.00 adults/5 plants at 35, 42, 49, 56 and 63 DAT respectively) was recorded in BR11 at all growth stages. Considering the mean incidence of long horned grasshopper, among different rice varieties, the highest incidence (3.13 adults/5 plants) was recorded in Krisan-2, which was followed by Taj-1, Hira-2, Aftaf-108 and Madhumati-2. On the other hand, the lowest incidence (1.86 adults/5 plants) was recorded in BR11 when the long horned grasshoppers were counted through sweep net.

Considering the mean incidence of long horned grasshopper, among different rice varieties, the highest incidence (3.80 adults/5 plants) was recorded in Taj-1, which was followed by Hira-2, Aftaf-108 and Madhumati-2. On the other hand, the lowest incidence (1.86 adults/5 plants) was recorded in BR11 when the long horned grasshopper was counted through sweep net.

Table 12: Incidence of long horned grasshopper among different rice varieties at different DAT through sweep net

Variety	Number of long horned grasshopper/plot					
	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	Mean
Hira-2	1.33 ab	1.67 d	2.33 b	3.67 b	6.00 a	3.00 b
Taj-1	1.67 a	3.67 a	3.00 a	4.67 a	6.00 a	3.80 a
Aftaf-108	1.00 bc	3.00 b	1.67 b	2.67 bc	6.33 a	2.93b
Krisan-2	1.67 a	1.67 d	2.33 ab	3.00 bc	7.00 a	3.13ab
Madhumati-2	1.00 bc	1.67 d	1.67 b	3.00 bc	5.67 b	2.60b
Aloron	1.33 ab	2.33 c	1.83 b	3.67 ab	6.00 a	3.03b
BR11	0.67 c	1.33 e	1.33 c	2.00 c	4.00 c	1.86c
$LSD_{(0.05)}$	0.478	0.599	0.641	0.981	1.465	0.672
CV%	19.29	13.43	14.80	15.16	12.53	17.67

In a column, numeric data represents the mean value of 3 replications; each replication was derived from 3 sweep by sweep net per plot.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.7. Leaf area damage caused by grasshopper

Table 13 showing data under the heading of Leaf area damage of 3 top leaves/5 selected plants at different days after transplanting (DAT) was explained as percentage value. It was observed that 25% leaf area damage was occurred more frequently than 50%, 75% and 100% within all the varieties of rice under the present study. Highest leaf area damage was occurred within 25% at all growth stage and that was the highest owner with variety BR11. But incase of 50% and 75% leaf area damage the highest results obtained with Hira-2 and Taj-1 respectively. 100% leaf area damage among the different varieties was not significant at different days after transplanting.

Table 13: Leaf area damage caused by grasshopper among different rice varieties at different DAT

Variety	Leaf area damage (No/5 hills)															
	25 DAT				32 DAT				39 DAT				46 DAT			
	25% damage	50% damage	75% damage	100% damage	25% damage	50% damage	75% damage	100% damage	25% damage	50% damage	75% damage	100% damage	25% damage	50% damage	75% damage	100% damage
Hira-2	10.90 d	2.90 a	1.00 b	0.00	10.17 d	4.00 a	1.00 b	0.00	10.08 d	4.00 a	1.00 c	0.00	9.97 b	3.00 a	2.00 b	0.00
Taj-1	10.16 e	3.00 a	2.00 a	0.00	9.997 d	3.00 b	2.00 a	0.00	9.867 d	2.00 c	3.00 a	0.00	10.16 ab	2.00 b	3.00 a	0.00
Aftaf-108	12.06 c	2.00 b	1.00 b	0.00	11.47 c	3.00 b	1.00 b	0.00	11.30 c	2.00 c	3.00 a	0.00	10.53 ab	3.00 a	2.00 b	0.00
Krisan-2	10.93 d	3.00 a	1.00 b	0.00	9.983 d	3.00 b	1.00 b	1.00	10.26 d	3.00 b	1.00 c	1.00	10.58 ab	2.00 b	2.00 b	1.00
Madhumati-2	13.03ab	1.00 c	1.00 b	0.00	12.25 b	1.00 d	1.00 b	1.00	12.27 b	1.00 d	1.00 c	1.00	11.00 a	2.00 b	1.00 c	1.00
Aloron	12.37bc	1.67 b	1.00 b	0.00	10.90 c	2.00 c	1.00 b	1.00	11.23 c	1.00 d	2.00 b	1.00	10.00 b	2.00 b	2.00 b	1.00
BR11	13.68 a	2.00 b	0.00 c	0.00	13.63 a	2.33 c	0.00 c	0.00	13.32 a	1.00 d	1.00 c	0.00	11.00 a	2.00 b	2.00 b	0.00
$LSD_{(0.05)}$	0.723	0.429	0.167	NS	0.723	0.565	0.219	NS	0.833	0.275	0.245	NS	0.905	0.289	0.268	NS
CV%	3.04	9.68	8.57	--	3.23	10.82	11.06	--	3.73	6.95	7.18	--	4.33	6.31	6.65	--

In a column, numeric data represents the mean value of 3 replications; leaf area damage was measured by eye estimation.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.8. Yield attributes and yields of rice

Significant effects of different yield contributing characters viz. number of filled and unfilled grains, weight of 1000 grains and yield of seven rice varieties were observed (Table 14).

4.8.1 Percent of unfilled grain

Number of filled and unfilled grain for the crop production is a considerable event and these are important factors for higher and quality grain yield (Andrews, 1972). Number of filled and unfilled grain was significantly influenced by resistance sources among different hybrid varieties of rice (Table 14). It was evident that the lowest percent of unfilled grain (6.56%) was obtained with BR11 where the highest percent of unfilled grain (26.30%) was with Madhumati-2. The results obtained from other treatments showed intermediate results.

4.8.2 Weight of 1000 grains

1000 seed weight is an important yield contributing characters for gaining uniform yield of crop (Sing 1978) and it contributes higher performance of successful crop production (Agrikar, 1979). The weight of 1000 seeds was significantly influenced by different varieties of rice (Table 14). It was observed that highest 1000 seed weight (27.39 g) with BR11 which was statistically alike with Taj-1, Aftaf-108, Krisan-2, Madhumati-2 and Aloron. On the other hand, the lowest 1000 seed weight (26.17 g) was with Hira-2.

4.8.3. Yield of rice

The weights of grains were significantly influenced by different varieties of rice (Table 14). It was marked that the highest grain weight (2.6266 kg/plot) was obtained with BR11, where the lowest (1.1683 kg/plot) was with Aftaf-108. The results obtained from other treatments showed significantly different results compared to highest and lowest results.

Table 14: Yield and yield attributes of different hybrid rice varieties

Variety	Yield attributes and yield			
	1000 grain wt	Unfilled grain (%)	Yield (kg/plot)	Yield (ton/ha)
Hira-2	26.17 b	15.23 c	1.2333 d	2.055 d
Taj-1	27.16 ab	7.47 g	1.4111 c	2.351 c
Aftaf-108	27.10 ab	11.67 d	1.1682 e	1.946 e
Krisan-2	26.33 ab	9.83 e	1.5233 b	2.538 b
Madhumati-2	26.20 ab	21.07 b	1.4152 c	2.358 c
Aloron	26.41 ab	26.30 a	1.5372 b	2.561 b
BR11	27.39 a	6.56 f	2.6262 a	4.376 a
$LSD_{(0.05)}$	1.139	0.536	0.2311	0.243
CV%	2.14	4.67	7.89	2.154

In a column, numeric data represents the mean value of 3 replications.
In a column mean having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University (SAU) during T-Amon season from June to November 2009 to study resistance source(s) among different hybrid varieties/genotypes of rice against major insect pests. The study was conducted in randomized complete block design (RCBD) with three replications. Seven rice varieities were evaluated in the present study, among them six hybrid varieties viz. Hira-2, Taj-1, Aftaf-108, Krisan-2, Madhumati-2, Aloron and one check variety BR 11 developed by Bangladesh Rice Research Instutute as HYV.

Considering the response of rice stem borer among seven rice varieties the highest dead heart infestation (25.17%) caused by stem borer was recorded in Aloron hybrid rice variety, which followed by Madhumati-2 (22.78%) and Taj-1 (21.69%). On the other hand, the lowest dead heart infestation (14.94%) was recorded in BR 11 followed by Hira-2 (16.02%), Krisan-2 (16.92%) and Aftaf-108 (16.97%). The highest white head infestation (62.08%) caused by stem borer was recorded in Aloron, which was statistically similar with Madhumati-2 (57.58%) followed by Taj-1 (42.76%). On the other hand, the lowest white head infestation (26.83%) was recorded in BR 11 followed by Hira-2 (31.40%), Krisan-2 (33.83%) and Aftaf-108 (36.91%). As a result, the trend of the resistance among hybrid rice varieties along with a check variety (BR 11) in respect of white head infestation caused by rice stem borer is BR 11 > Hira-2 > Krisan-2 > Aftaf-108 > Taj-1 > Madhumati-2 > Aloron.

In case of the response of rice hispa seven rice varieties, the highest incidence (3.50 adults/5 plants) caused by adult rice hispa was recorded in Taj-1, which was followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2. On the other hand, the lowest incidence (1.50 adults/5 plants) was recorded in BR11 when the adult hispa were counted through visual observation. More or less

similar trends of results were also observed in case of the incidence of adult rice hispa when counted through sweep net.

Among different rice varieties, the highest incidence (3.73 adults/5 plants) of rice bug was recorded in madhumati-2, followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2. On the other hand, the lowest incidence (2.39 adults/5 plants) was recorded in BR11 when the rice bug was counted through sweep net.

The highest incidence (3.92 adults/5 plants) of rice leaf roller moth was recorded in Aloron, which was followed by Hira-2, Krisan-2, Aftaf-108, and Madhumati-2. On the other hand, the lowest incidence (2.25 adults/5 plants) was recorded in BR11.

Among different rice varieties, the highest incidence (4.26 adults/5 plants) of rice green leaf hopper was recorded in Krisan-2, followed by Hira-2, Madhumati-2 and Aloron. On the other hand, the lowest incidence (1.93 adults/5 plants) was recorded in BR11 when the rice green leaf hopper was counted through sweep net.

The highest incidence (7.20 adults/5 plants) of short horned grasshopper was recorded in Krisan-2, which was followed by Taj-1, Hira-2, Aftaf-108 and Madhumati-2. On the other hand, the lowest incidence (3.46 adults/5 plants) was recorded in BR11 when the short horned grasshopper was counted through sweep net.

Considering the mean incidence of long horned grasshopper, the highest incidence (3.80 adults/5 plants) was recorded in Taj-1, followed by Hira-2, Aftaf-108 and Madhumati-2. On the other hand, the lowest incidence (1.86 adults/5 plants) was recorded in BR11 when the long horned grasshopper was counted through sweep net.

Considering the grain yield, the highest grain weight (2.6266 kg/plot) was obtained from BR11, where the lowest (1.1683 kg/plot) was with Aftaf-108.

Thus the results exhibited under the present study followed by resistance sources among different hybrid varieties of rice against major insect pests have been concluded below-

- The rice stem borer, rice hispa, rice bug, rice leaf roller, rice green leaf hopper, short horned grasshopper, long horned grasshopper were found as the major insect pests of rice and caused significant damages on all rice varieties.

- The check variety BR 11 performed best against all major insect pests among the varieties. The hybrid rice varity Hira-2 and Krisan-2 performed better against stem borer whereas susceptible found against Rice hispa. Aloron found susceptible against stem borer followed by all other insect pests except short horned grass hopper.

- Considering yield and yield contributing characters, BR11 was also superior to the others. The highest yield/plot with BR11 was (4.376 ton/ha) where the lowest (1.946 ton/ha) was with Aftaf-108. Among hybrid varieties, the maximum yield (2.561 ton/ha) was produced by Aloron that was second highest of all varieties.

CHAPTER VI

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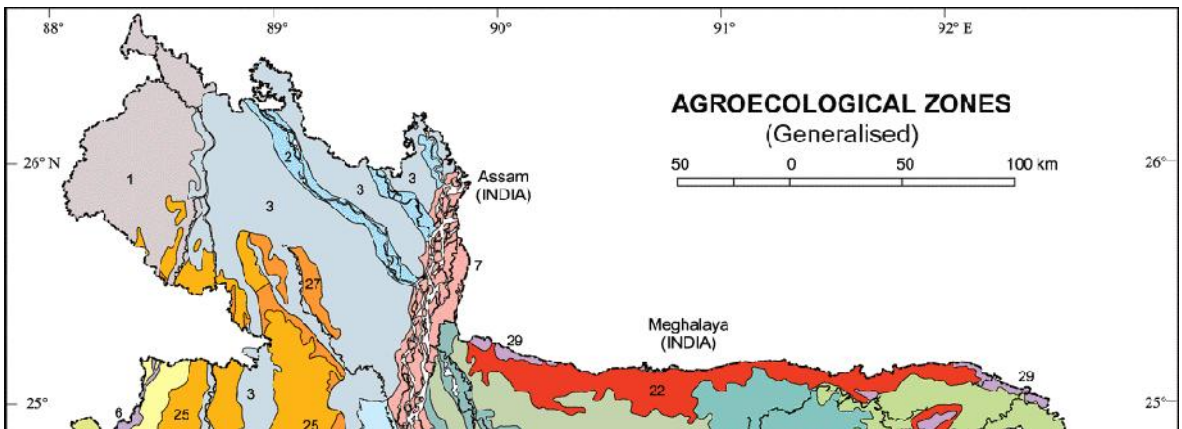
CHAPTER VII

APPENDICES

Appendix I: Location of experimental site compared with other Agro-ecological Zones of Bangladesh



Appendix II. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from July 2009 to November 2009

Month (2007)	*Air temperature (^{0}c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
June	27.1	16.7	67	30	8.6
July	31.4	19.6	54	11	7.9
August	33.6	23.6	69	163	8.1
September	22.4	13.5	74	00	7.6

October	29.18	18.26	81	39	7.4
November	25.82	16.04	78	00	8.1

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Physical characteristics and chemical composition of soil of the experimental plot

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University (SAU) during T-Amon season from June to November 2009 to study resistance source(s) among different hybrid varieties/genotypes of rice against major insect pests. The study was conducted in randomized complete block design (RCBD) with three replications. Seven rice varieities were evaluated in the present study, among them six hybrid varieties viz. Hira-2, Taj-1, Aftaf-108, Krisan-2, Madhumati-2, Aloron and one check variety BR 11 developed by Bangladesh Rice Research Instutute as HYV.

Considering the response of rice stem borer among seven rice varieties the highest dead heart infestation (25.17%) caused by stem borer was recorded in Aloron hybrid rice variety, which followed by Madhumati-2 (22.78%) and Taj-1 (21.69%). On the other hand, the lowest dead heart infestation (14.94%) was recorded in BR 11 followed by Hira-2 (16.02%), Krisan-2 (16.92%) and Aftaf-108 (16.97%). The highest white head infestation (62.08%) caused by stem borer was recorded in Aloron, which was statistically similar with Madhumati-2 (57.58%) followed by Taj-1 (42.76%). On the other hand, the lowest white head infestation (26.83%) was recorded in BR 11 followed by Hira-2 (31.40%), Krisan-2 (33.83%) and Aftaf-108 (36.91%). As a result, the trend of the resistance among hybrid rice varieties along with a check variety (BR 11) in respect of white head infestation caused by rice stem borer is BR 11 > Hira-2 > Krisan-2 > Aftaf-108 > Taj-1 > Madhumati-2 > Aloron.

In case of the response of rice hispa seven rice varieties, the highest incidence (3.50 adults/5 plants) caused by adult rice hispa was recorded in Taj-1, which was followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2. On the other hand, the lowest incidence (1.50 adults/5 plants) was recorded in BR11 when the adult hispa were counted through visual observation. More or less

similar trends of results were also observed in case of the incidence of adult rice hispa when counted through sweep net.

Among different rice varieties, the highest incidence (3.73 adults/5 plants) of rice bug was recorded in madhumati-2, followed by Hira-2, Krisan-2, Aftaf-108, Aloron and Madhumati-2. On the other hand, the lowest incidence (2.39 adults/5 plants) was recorded in BR11 when the rice bug was counted through sweep net.

The highest incidence (3.92 adults/5 plants) of rice leaf roller moth was recorded in Aloron, which was followed by Hira-2, Krisan-2, Aftaf-108, and Madhumati-2. On the other hand, the lowest incidence (2.25 adults/5 plants) was recorded in BR11.

Among different rice varieties, the highest incidence (4.26 adults/5 plants) of rice green leaf hopper was recorded in Krisan-2, followed by Hira-2, Madhumati-2 and Aloron. On the other hand, the lowest incidence (1.93 adults/5 plants) was recorded in BR11 when the rice green leaf hopper was counted through sweep net.

The highest incidence (7.20 adults/5 plants) of short horned grasshopper was recorded in Krisan-2, which was followed by Taj-1, Hira-2, Aftaf-108 and Madhumati-2. On the other hand, the lowest incidence (3.46 adults/5 plants) was recorded in BR11 when the short horned grasshopper was counted through sweep net.

Considering the mean incidence of long horned grasshopper, the highest incidence (3.80 adults/5 plants) was recorded in Taj-1, followed by Hira-2, Aftaf-108 and Madhumati-2. On the other hand, the lowest incidence (1.86 adults/5 plants) was recorded in BR11 when the long horned grasshopper was counted through sweep net.

Considering the grain yield, the highest grain weight (2.6266 kg/plot) was obtained from BR11, where the lowest (1.1683 kg/plot) was with Aftaf-108.

Thus the results exhibited under the present study followed by resistance sources among different hybrid varieties of rice against major insect pests have been concluded below-

- The rice stem borer, rice hispa, rice bug, rice leaf roller, rice green leaf hopper, short horned grasshopper, long horned grasshopper were found as the major insect pests of rice and caused significant damages on all rice varieties.

- Among seven rice varieties, BR 11 and Hira-2 were degignated as moderately resistant to rice stem borer, rich hispa and all other major insect pests, whereas Krisan-2, Aftaf-108 as susceptible and Aloron, Madhumati-2 and Taj-1 were designated as most susceptible.

- Considering yield and yield contributing characters, BR11 was also superior to the others. The highest yield/plot with BR11 was (4.376 ton/ha) where the lowest (1.946 ton/ha) was with Aftaf-108. Among hybrid varieties, the maximum yield (2.561 ton/ha) was produced by Aloron that was second highest of all varieties.