SCREENING OF RICE VARIETIES (AUS) AGAINST *Rhizoctonia solani CAUSING* SHEATH BLIGHT OF RICE

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SCREENING OF RICE VARIETIES (AUS) AGAINST *Rhizoctonia solani* CAUSING SHEATH BLIGHT OF RICE

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CERTIFICATE

This is to certify that the thesis entitled, "**SCREENING OF RICE VARIETIES (AUS) AGAINST *Rhizoctonia solani* CAUSING SHEATH BLIGHT OF RICE**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in PLANT PATHOLOGY**, embodies the result of a piece of *bona fide* research work carried out by **ROKEYA AKTER, Registration No. 01063** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information, as has been availed of received during the course of this investigation have been duly acknowledged.

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MY BELOVED

PARENTS

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SCREENING OF RICE VARIETIES (AUS) AGAINST *Rhizoctonia solani* CAUSING SHEATH BLIGHT OF RICE

ABSTRACT

An experiment was conducted in the field of SAU (Sher-e-Bangla Agricultural University) farm, Dhaka to screen out the resistant varieties of rice against sheath blight (*Rhizoctonia solani* kuhn) during Aus season in 2007. Seven rice (Aus) varieties viz. BR3, BR14, BR16, BR21, BR26 and BRRI dhan 27 were used as treatments. The screening of the varieties were done based on different parameters like disease incidence, disease severity, yield and yield contributing characters. The highest lesion size was recorded in the variety BR16 (4.02 cm) and lowest lesion size (3.50 cm) was in BRRI dhan 27 at maturity stage. The value of the relative lesion height (%RLH) was large in the susceptible variety and small in the moderately susceptible variety. Among the varieties, BR3, BR14, BR21, BR24, BR16 and BR26 were graded as susceptible and BRRI dhan 27 was graded as moderately susceptible to sheath blight. The disease was more severe in advanced growth stages of the plants. The highest grain yield per hectare (3.00 t/ha) was recorded in the variety BRRI dhan 27 and the lowest grain yield (1.14 t/ha) was recorded in the variety BR24. The highest weight of thousand grains (32.73 gm) was recorded in the variety BRRI dhan 27 and the lowest weight of thousand grains (29.43 gm) was recorded in the variety BR3. BRRI dhan 27 performed better in respect of all the parameters considered against sheath blight of rice.

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa*) is the most important cereal crop as well as staple food for about 135 million people of Bangladesh and grown in this country from time immemorial. Rice also comprised the staple food of 60% of the world population. It provides about 71% of the total calories and 51% of the total protein in a typical diet in Bangladesh (Anon, 1998). It occupies about 75% of the total cropped area covering 26.6 million acres and is the only source of income for many farmers in our country. In Bangladesh, 26.6 million acres of total cultivable land produce more than 25.2 million metric ton of rice annually (BBS, 2004). The average world production of the rice is 3.75 metric ton per hectare. But the average yield of Bangladesh is poor, only 1.98 metric ton per hectare (FAO, 2002). Per hectare yield of rice in Bangladesh is quite low compared to other rice growing countries of the world. The national average yield of rice in Bangladesh is only 2.42 ton/ha (Statistical Bulletin Bangladesh, December 2004) in contrast to about 7-8 ton/ha in China.

The population of Bangladesh is increasing in an alarming rate of 1.48% (Bangladesh Arthanitik Samikkha, 2005) but the rice growing area is decreasing day by day for different development activities. Therefore, there is no other alternative to increase rice yield per unit area to feed the extra millions in the coming years.

There are so many reasons accountable for the low yield of rice in our country. Among them vulnerability of the crop to pests and diseases is important one (Fakir, 1982). Rice diseases caused by different microorganisms are grouped into viruses, bacteria, fungi, nematodes etc.

Thirty six fungal, twenty one viral, six bacterial and six nematode diseases are recorded in rice (Ou, 1985). So far in Bangladesh around 31 rice diseases have been identified of which ten are considered as major (Miah and Shahjahan, 1987). Among them five diseases, viz. tungro, bacterial blight, sheath blight, blast and ufra have been considered as most important because of their widespread occurrence and significant damage potential.

Rice sheath blight is a major rice disease throughout the world. This disease is caused by *Rhizoctoria solani* Kuhn (teleoporph: *Thanatephorus cucumeris* (Frank) Donk) which was first reported in 1910 and now occurs throughout temperate and tropical areas being the most prominent where rice is grown under intense, high fertility production systems (Eizenga *et al.,* 2002).

Rice sheath blight prevalent in almost all rice growing areas and in all season of Bangladesh and is one of the major constraints to rice production in the country (Miah *et al.,* 1985). The disease was first reported in Bangladesh in 1973 (Miah *et al.,* 1994). Both local and high yielding varieties are susceptible to this disease (Miah *et al.*, 1985; Shahjahan *et al.,* 1987). The intensity of the disease is severe in Aus and T. Aman seasons in Bangladesh (Miah *et al.,* 1985). Northern and central part of the country experiences frequents epidemic outbreak of the disease. This might be due to the change of varieties and cultivation practices. High temperature and relative humidity favour sheath blight disease (Hashiba, 1982). Short stature, high tillering and high nitrogen responsive varieties are comparatively more susceptible as the microclimates inside the rice canopy is more favourable when such type of varieties are grown as compared to the traditional ones of tall plant type with low tillering ability (Sharma *et al.,* 1985).

Initial symptoms consist of lesions on the sheaths of lower leaves at late tillering or early internode elongation growth stages. Under favourable conditions of low sunlight, high humidity ($\geq$ 95%), and warm temperature (28 to 32^{0}c), the infection spreads rapidly by means of runner hyphae to upper plants parts, including leaf blades and adjacent plants. lesions may coalesce to encompass the entire leaf sheath and stem (Eizenga *et al.,* 2002).

The sheath blight of rice may cause substantial yield losses in the severely infected fields. The extent of yield loss depends mainly on the severity of the disease in the fields (Kozaka, 1970; Hori and Anraku, 1971). The yield loss of 25% was recorded when severe infection occured in the leaf sheath and leaf blade (Kozaka, 1970). Inoculation at tillering and boot stages of plant growth resulted 43.0% and 22.3% yield reduction, respectively (Tsai, 1974). Under the field condition, the disease cause yield losses of as high as 32% especially in the modern cultivars (Ou and Bandong, 1976; Shahjahan *et al.,* 1986). In the USA, 50% yield losses occurred in susceptible cultivars when all the leaf sheaths and leaf blades are infected (Lee and Rush, 1983). Yield loss studies in Bangladesh indicated that the disease caused 14.0 to 17.3% yield reduction in different varieties during Aus and T. Aman season (Shahjahan *et al.,* 1986).

Despite the widespread occurrence and the significant yield reduction throughout the rice growing countries of the world its control has not been very successful. Traditionally chemical control of plant disease is a widely practiced by the farmer. But in discriminate and irrational use of chemical pesticide causing the enormous environmental hazards and distorting the balance of Agro-ecosystem. Thus substitutions of hazardous chemical with ecofriendly approaches are of a global concerned. Use of resistant germplasm against a disease is a nice option. However, sources of resistance or resistant cultivars need to explore.

Reddy (1985) tested several varieties of rice against sheath blight in India and found JC5, JC18 and JC41 are resistant to this disease. According to Eizenga *et al.,* (2002) *Oryza* spp, *O. minuta, O. officinalis* are resistant to this disease and transferred into cultivated rice through backcrossing. These studies indicate that *O. minuta, O. officinalis* are important sources of sheath blight resistant genes. Transferring these genes into rice cultivars adapted to the production area in the southern United States is an important disease management strategy. A large number of wild rices, rice varieties and breeding lines have been screened for resistance to *Rhizoctonia solani* in United States.

Long-grain cultivars similar to *Indicia* rices possessed little sheath blight resistance, particularly those with a short maturing time (Lee and Rush, 1983). In Taiwan some relatively resistant cultivars were found with tall plants (Teng and Hsu, 1979).

Screening of germplasm of rice (Aus) to evaluate their resistance against *Rhizoctonia solani* have immense value for the management of the disease in this country. A few workers attempted to search for sheath blight resistant varieties of rice with little success. However, for finding out the resistant cultivars the present research programme has been carried out with the following objectives:

1. To screen out the resistant germplasm/cultivars against sheath blight of rice (Aus).
2. To characterize the resistant germplasm(s) of rice against sheath blight.

Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Rice (*Oryza sativa* L.) is the principal food crop in Bangladesh. Rice suffers from more than 60 different diseases. Among the diseases, sheath blight of rice caused by *Rhizoctonia solani* kuhn is documented to be major and destructive disease. Evidence of research work regarding screening of rice is very limited. However some available and important findings on various aspects of sheath blight of rice has been compiled and presented below.

2.1. History and distribution

Miyake (1910), who named the casual organism as *Sclerotium irregularle*, first described sheath blight disease on rice from Japan. Subsequently, the occurrence of disease was reported from Formosa, Philippines, Srilanka, China, Taiwan and Bangladesh. The causal pathogens were identified as *Rhizoctonia solani* (Sawada, 1912; Reinking, 1918; Park and Bertus, 1932; Wei, 1934; Chen *et al.,* 1961; Talukder, 1968). The fungus has also been recorded interalia on rice in Louiriana, U.S.A. (Stroube, 1954). Since the disease was first identified and reported from oriental countries, it was commonly called oriental sheath blight of rice (Hashioka and Makino, 1969). The disease was also reported from Brazil, Surinam, Venezuela and Madgascar (Amaral and Jesus, 1973; Ou, 1985; Barat, 1959; Malaguti, 1950). It has become one the most important disease in Mekang Delta of Vietnam (kim *et al*., 1981). Its occurrence was also reported from Burma, Indonesia, Iran, Korea, Liberia, Thailand, Malaysia and rainfed rice in Africa (The Rice Pathology Newsletter, 1975; Chin, 1976; Manser, 1984).
The occurrence of sheath blight in India was first reported by Paracer and Chahal (1963) from Gurdaspur in the Punjab. In Kerala, it is one of the

major constraints in rice production in the kuttand tract and the severity of the disease has increased after the introduction of high yielding varieties in 1969 (Rajan, 1981; Menon, 1982).

Sheath blight is considered the second most important rice disease in Japan next to blast. The average area affected during the five-year period from 1978 to 1982 was estimated at 1.08 million hectares which was equal to about 44% of the total cultivated rice area of 2.36 million hectares (Hori, 1984). Sheath blight of rice is now considered one of the major diseases of rice in the tropical, subtropical and temperate regions of Asia, Africa and the America (Ou, 1985).

Bordered sheath spot and aggregate sheath spot caused, respectively by *R. orzyae* Ryker and Gooch and *R. orzya-sativa* (sawada). Mordue were only minor diseases in Japan, USA, Taiwan, Vietnam and Thailand (Hashioka and Makino, 1969; Ou, 1985). The shift in the cultivation practices and varieties appeared to have increased the occurrence of these two diseases. This is evident from reports of their occurrence in the Philippines, USA, Japan, India and Bangladesh (Mukherjee *et al.*, 1980; Gunnel and Webster, 1984; Shahjahan and Mew, 1986; Shahjahan *et al.*, 1988).

2.2. Symptoms and Epidemiology

The disease causes spots on the leaf sheath. Initial symptoms are expressed as circular to oblong grey-green, water-soaked spots on leaf sheaths at the base of culms near water level in lowland and ground level in upland fields. Outer leaf sheaths are first attacked, the causal fungus later extending to the inner sheaths. On susceptible cultivars, these greenish grey and ellipsoidal or oval lesions enlarge to about one-half inch in width and 1-1$^{1}/_{2}$ inches in length. The centre of the lesion becomes white, lighten or grey. The lesions will have an irregular blackish brown or purple brown border. Under favorable microclimatic conditions, infection spreads rapidly to upper sheaths and leaf blades on the same or adjacent tillers. Lesions on the upper parts of plants extend rapidly coalescing with each other to cover entire tillers from the water line to the flag leaf. On leaf blades the lesions are larger and some what irregular in shape, which are first greenish grey and gradually enlarge and become greyish white with brown margin. Under moist conditions, cob-web-like mycelia spread externally and sclerotia, initially white but turning brown on maturity, are produced superficially on diseased plant parts. These are loosely attached and easily dislodged from the plant at maturity.

Disease development is most rapid in the early heading and grain filling stages; particularly in humid conditions, the sheath surrounding the ear may be infected, in which case the ear is prevented from emerging and expanding normally. The presence of several large lesions on a leaf sheath usually causes death of the whole leaf, and in severe cases all the leaves of a plant may be blighted. The tillers or entire plants are killed leaving irregular round patches of dead plants in the field. Severely diseased plants often snap at the upper diseased parts on lodge entirely on the ground before maturity. Plants heavily infected in the early heading and grain filling stages produce poorly filled grain, especially in the lower part of the panicle (Hashioka, 1970; Kozaka, 1970; Ou, 1985; Lee and Rush, 1983; Rush and Lindberg, 1984).

2.3. Pathogenic description of *Rhizoctonia solani*

The causal agent has been reported in the literature to be *Corticium sasakii* (Shirai) Matsumoto (Matsumoto, 1934), *C. vagum* Berk. and Curt. (Gadd and Bertus, 1928), *Sclerotium irregulare* I. Miyake (Miyake, 1910), *Hypochnus sasakii* Shirai (Shirai, 1906), *Pelicularia sasakii* (Shirai) S. Ito (Rogers, 1943) and *Rhizoctonia solani* Kuhn (Reinking, 1918). Researchers now generally accept *R. solani,* perfect stage *Thanatephorus cacumeris* (Frank) Donk in the AG-1 anastomosis group's series as the causal pathogen (Chin, 1976; Kozaka, 1975; Nell *et al*., 1977). Miyake (1910) first describe this in Japan and named the causal organism as *Sclerotium irregulare.* Sawada (1912) later found the fungus to be identical with *Hypochnus sasakii*, a fungus first reported by Sasakii on leaves of camphor trees and described by Shirai (1906). A very disease was reported in Philippines by Reinking (1918) and Palo (1926) and in Srilanka by Park and Bertus (1932) and was referred to be identical with *Rhizoctonia solani*.

Rhizoctonia oryzae- sativae was first described by Sawada (1922) in Taiwan. He named the fungus *Sclerotium oryzae-sativae* Sawada and Mordue (1974) transferred it to *Rhizoctonia* as *R. oryzae-sativae* (Sawada) Mordue.

Rogers (1943) established the genus *Pellicularia* and the species *P. filamentosa* (Pat) Rogers to include *Corticium solani* (Prill. & Delacr.) The rice fungus has also been called *P. filamentosa* (Pat) Rogers *F. sasakii* and *P. sasakii* (Shirai) S. Ito. Talbot (1970) considered *Thanatephours cucumeris* (Frank) Donk to be the correct name and treated it as an aggregate of species including the rice fungus. Sclerotia are superficial, more or less globose but flattened below, white when first formed and then turning brown or dark brown. The sclerotia reach their maximum size after 30 hours and starts to pigment. Individual sclerotia measure up to 5 mm but may unit to from a large mass in culture (Ou, 1985). Initially, sclerotia are dense and sink in water, but at maturity the cells in the outer layer become vacuolated, and the sclerotia become buoyant in water (Hashiba and Mogi, 1975).

The sclerotial masses of *R. oryzae* are of idefinite shape and size and are frequently formed above the main hyphal branches. The colour of the sclerotial masses varies somewhat with the substrate but is generally a shade of salmon (Ou, 1985). The sclerotia of *R. solani* are large and round and more regular in shape, and generally brown. The mycelium is superficial or submerged in culture, 6-10 µm in width, branching at a right angle with a slight constriction and with a septum a short distance from the point of constriction.

The mycelium of *R. solani* is colourless in young culture and yellow brown in older cultures. The hyphae have a prominent dolipore septum, multinucleate and are generally 8-12 (Ou, 1985). Three types of specialized mycelium produced by the pathogen and these are straight runner hyphae, lobate hyphae and monilioid cells. The straight running mycelium grows on the surface of the plant tissue. The lobate type infects the plant tissue and produce lesions. Monilioid cells are short, broad cells produced in short chains that continue to produce sclerotia.

Taheri *et al.* (2004) reported that the genetic diversity of 150 *Rhizoctonia solani* isolates collected from rice showing sheath blight symptoms in India using amplified fragment length polymorphism analysis. A total of 225 polymorphic bands were scored. At 80% similarity, the isolates clustered into 33 groups. Groups with more than 2 isolates and high genetic similarity were considered clones. Anastomosis group studies showed that 5 isolates belonged to AG1-IA and clustered with the tester isolate of *R. solani*, with more than 93% DNA similarity.

2.4. Screening of rice varieties against sheath blight

Jia *et al.* (2007) developed a standardized laboratory micro-chamber screening method to quantify resistance to *R. solani* in rice. Five rice cultivars, representing a wide range of disease reactions under field conditions of which two cultivars, Jasmine 85 and Lemont consistently have shown the highest and lowest levels of resistance, respectively, in previous field and greenhouse studies, were used as standards. Concurrent field experiments in Arkansas and Texas also were performed to compare the greenhouse disease ratings with those observed under field conditions. Overall, the relative disease ratings of the seven test cultivars were consistent between test locations and with field evaluations. Thus, the micro-chamber screening method can be used as an effective approach to accurately quantify resistance to the sheath blight pathogen under controlled greenhouse conditions and should help expedite the selection process to improve resistance to this important pathogen.

Li *et al.* (2004) evaluated resistance to sheath blight in transgenic rice lines. A total of 42 homozygous rice lines transformed with the chitinase gene RC24 and the beta -1, 3-glucanase gene beta-1,3-Glu was evaluated for resistance to sheath blight caused by *Rhizoctonia solani*. The lines were categorized as resistant, moderately resistant, moderately susceptible and susceptible. The majority (92.1%) belonged to the moderately resistant or moderately susceptible groups. Disease resistance was remarkably correlated with chitinase activity in transgenic lines except in the resistant ones, wherein the enzyme activity coded by the gene was lower than the moderately resistant type. A uniform chitinase activity was observed in transgenic lines tested at different times after inoculation and in different plant organs, suggesting that gene expression was constitutive.

McClung *et al.* (2004) studied rice (*Oryza sativa*) cultivar Saber (CV-117, PI 633624), an early-maturing semidwarf cultivar was officially released in 2001. Developed from the cross Gulfmont/RU8703196//Te Qing (cross number B8910A11), this cultivar is resistant to rice sheath blight (*Rhizoctonia solani*).

Sato *et al.* (2004) conducted experiment with the rice line WSS2 which was derived from the Vietnamese indica variety Tetep, displays a high partial resistance to sheath blight caused by *Rhizoctonia solani.* Quantitative trait locus (QTL) analysis of the resistance using simple sequence repeat and sequence-tagged site markers was conducted in a BC1F1 population derived from the cross Hinohikari/WSS2//Hinohikari. Sheath blight resistance in this population and its cross-parents was studied using syringe inoculation. Two QTLs for sheath blight resistance (qSB-3 and qSB-12) were identified on chromosomes 3 and 12. Their resistance alleles were derived from the resistant parent WSS2. These QTLs totally explained 29.6% of the phenotypic variation. Sheath blight resistance was significantly correlated with culm length and heading date. Among the QTLs for culm length and heading date, qCL-3 for culm length was located in the same region as qSB-3, and the remaining QTLs were not linked to qSB-12. Thus, it was reasonable to assume that qSB-12 would enable to breed rice variety resistant to sheath blight.

Sha *et al.* (2004) developed *Oryza sativa cv. Pirogue* (CV-118, PI 634544), the first high-yielding, early maturing, short stature, short-grain rice cultivar for production in the southern USA. Pirogue was officially released by the LSU AgCenter in 2003. Pirogue was derived from the cross 'Rico 1'/'S-101' made at the Rice Research Station in 1990 (90CR159). In statewide and regional trials during 1999-2002, it showed excellent grain yield and good milling yield. It is moderately resistant to sheath blight (*Rhizoctonia solani*).

Sahai *et al.* (2004) studied Rajendra Mahsuri 1 (designated RAU83-500), developed from the cross BR51-46/Mahsuri, is a new rice cultivar released in 2003 for commercial cultivation. It is moderately-resistant to sheath blight (*Rhizoctonia solani*). In yield trials and on-farm trials, Rajendra Mahsuri 1 showed yield consistency and wide adaptability. Under medium land conditions, it gave higher yield (5.0 t/ha) than Sita (4.2 t/ha) and Kanak (4.4 t/ha). Under shallow lowland conditions, it also had higher yield (4.9 t/ha) than Radha (4.0 t/ha) and Satyam (4.1 t/ha).

Yuan *et al.* (2004a) studied the effects of inoculation method, *Thanatephorus cucumeris* strains, and cultivar on the resistance of rice to sheath blight during 2 growing seasons. All the factors tested had significant effects on the resistance of the crop, with the growing season having the highest effects on the resistance of the crop. The 9 rice cultivars tested exhibited significant variation in terms of resistance to sheath blight. Cultivar Baiyeqiu exhibited stable resistance to the 3 strains of the pathogen during the 2 growing seasons, regardless of the inoculation method used.

Yuan *et al.* (2004 b) studied the characters of resistance to rice sheath blight of Zhongda 2, a transgenic rice line modified by chitinase gene (RC24). Zhongda 2, a transgenic line derived from the indica cultivar Zhuxian B though the modification of its rice chitinase gene (RC24), had high resistance to sheath blight (*Rhizoctonia solani*) in both laboratory and field conditions in Guangdong, China. However, the pathogen could infect the sheath of Zhongda 2 and induce typical disease symptoms. There was no difference in the time of penetration or incubation period between Zhongda 2 and Zhuxian B, but melting hyphae were observed earlier in the Zhongda 2 than Zhuxian B. Zhongda 2 inhibited mycelial growth in host tissues. Preliminary study on the resistance of hybrid rice combinations of Zhongda 2 crossed with 5 non-transgenic rice materials showed that the resistance of the F_1 populations was higher than those of the non-transgenic maternal parents.

Biswas (2003) evaluated forty hybrid rice cultivars (under very early, early, mid-early and medium duration of irrigation) in 1999-2002 in West Bengal India for response to *Rhizoctonia solani* infection. Inoculation of the pathogen was done on the maximum tillering stage. Disease reaction was recorded 10 and 40 days after inoculation. All hybrids were susceptible to the disease.

Hu *et al.* (2003) reported that identification of resistance to rice sheath blight of deep-water rice varieties. In a pot experiment, 12 deep-water rice varieties were artificially inoculated with rice sheath blight (*Rhizoctonia solani*), 35 days after transplanting. The agronomic characteristics of these varieties were investigated at the same time. A highly significant difference was observed in resistance level among the 12 varieties. The levels of most of the resistance varieties were between resistance and medium resistance. Some varieties showed a great degree of resistance.

Jodari *et al.* (2003) reported that *Oryza sativa* cv. Dellmati, released in the USA in 1999, is an aromatic, elongating, very early maturing and slender long-grain rice cultivar derived from the cross Domsiah /Lemont /Newbonnet /3/Lemont /Della. It is special purpose rice with good cooked kernel elongation (comparable with imported basmati rice) and strong aroma. It has moderate grain and milling yields and high ratoon yield. In regional trials from 1995 to 1998, Dellmati grain yield averaged 5330 kg/ha, compared with 5556 and 8281 kg/ha for Della and Cypress, respectively. It is moderately susceptible to sheath blight (*Rhizoctonia solani*).

Li *et al.* (2003 a) conducted on 41 homozygous rice lines, transformed with chitinase and beta -1,3-glucanase genes, to study the resistance to sheath blight (*Rhizoctonia solani*). The transgenic lines were divided into resistant, moderately resistant, moderately susceptible, and susceptible, where 92.1% were either moderately resistant or moderately susceptible. Sheath blight resistance in resistant or susceptible transgenic lines was significantly correlated with chitinase activity.

Li *et al.* (2003 b) evaluated chitinase activity and sheath blight (*Rhizoctonia solani*) reactions in the resistant control, susceptible parent and homozygous transgenic lines with the chitinase gene. The transgenic lines exerted a higher inhibitory effect on the growth of the fungus, and the resistance level was significantly correlated with the expression of the exogenous chitinase gene. When the chitinase activity in the wild type was low, the exogenous gene can cover up or inhibit endogenous gene expression. The chitinase activities in the resistant control and susceptible parent reached peak values at 72 h after pathogen inoculation. However, the intensity of chitinase activity was much higher in resistant cultivars than in susceptible ones.The chitinase activity in leaves of different rice materials were not significantly different after pathogen inoculation.

Mallik *et al.* (2003) reported that Bhudep (Pankaj/IR38699-49-3-1-2/IR41389-20-1-5), a new rice cultivar in eastern India, is non-lodging, semi-tall with 150-day growth duration. It is moderately resistant to sheath blight (*Rhizoctonia solani*).

Eizenga *et al.* (2002) studied rice wild relatives, *Oryza* species, are one possible source of sheath blight [*Rhizoctonia solani* (*Thanatephorus cucumeris*)] resistance genes. Thus, a growth chamber-greenhouse method of screening *Oryza* spp. and their early generation progeny is needed. Primary-secondary and ratoon tillers of rice cultivars-germplasm which ranged from moderately resistant to very susceptible were evaluated first for sheath blight susceptibility. Plants were inoculated by placing *R. solani* colonized toothpicks at the leaf collar, then incubating plants in a growth chamber. After 7 days, plants were visually rated for sheath blight severity, and the lesion length of each leaf was measured. Ranking of cultivar-germplasm susceptibility by visual rating of primary-secondary tillers corresponded to the ranking from field ratings. Visual ratings correlated best with combined lesion length of the second and third leaves. For ratoon tillers, visual ratings correlated best with second-leaf lesion length. Next, this method was used with ratoon tillers to evaluate sheath blight susceptibility of 21 *Oryza* spp. accessions and F_1 progeny from crosses between 17 accessions and cultivated rice.

Biswas (2001a) conducted an experiment during the *kharif* (wet) season of 2000 on 149 rice varieties to screen for resistance to sheath blight disease caused by *Rhizoctonia solani*. None of the varieties were resistant; 17 were moderately resistant; and 132 were susceptible to the disease. The location severity index was high (74). Disease incidence was high in very early, early and mid-early varieties. A few moderately resistant varieties were found among medium and late maturity groups particularly in irrigated and rainfed lowland ecosystems. One variety (IET 16307) showed consistency regarding resistance for the second consecutive year.

Biswas (2001b) evaluated rice germplasm for sheath blight disease resistance in West Bengal, India. One-hundred and eleven high yielding and traditional rice cultivars were inoculated with a highly virulent strain of *Rhizoctonia solani* during the active tillering stage. The field experiment was conducted during the *kharif* (wet) season (June-October) of 1999 in Chinsurah, West Bengal, India, to test their reaction to sheath blight under artificial inoculation conditions. Disease reaction was recorded 10 and 40 days after inoculation and cultivars were scored according to the standard rice evaluation system of IRRI. All cultivars were infected. Eight cultivars (IR 54, Palman 579, Dinesh, Seetabhog, Dee-Geo-Woo-Gen, Matangini, Matla and Sabita) scored 3 (resistant); 25 scored 5 (moderately resistant) and the rest scored 7 or 9 (susceptible). The disease incidence was heavy in most of the very early, early and mid-early duration cultivars where all plants inoculated with the pathogen died. A number of resistant and moderately resistant cultivars were observed in the medium and late maturity groups. The disease was usually more severe in high-yielding than in traditional cultivars.

Pan *et al.* (2001) conducted preliminary evaluation for breeding advancement of resistance to rice sheath blight. The resistance of 64 *Oryza sativa* subsp. *indica* cultivars/lines from Guangdong and Jiangsu province, China; Lemont and SY63/LH (susceptible controls), Jasmine 85 and Teqing (moderately-resistant controls); to rice sheath blight (caused by *Rhizoctonia solani*) was studied. Fourteen of the cultivars from Guangdong were resistant to highly resistant. The fourth-type cultivars, which were bred for accumulation of resistance from the cross Teqing/91-3, were distributed in moderately resistant and resistant groups (60% of these were in the resistant group).

Biswas (2000) evaluated 161 entries of NSN-I for their reaction to sheath blight disease (*Rhizoctonia solani*) under artificial inoculated condition. None of the test entries recorded a resistant reaction; six showed moderate reaction and the other 155 a susceptible reaction.

Dash *et al.* (2000) conducted cross inoculation of 8 anastomosis groups (AG) of *Rhizoctonia solani* against 8 rice cultivars were made to study the suitability of these cultivars as differentials for screening a large number of rice varieties against sheath blight of rice (*Rhizoctonia solani*). From three years of pot and field studies, it was observed that these rice cultivars can be satisfactorily used as differentials against predominant AG groups, irrespective of sclerotia, formation, size and survivability.

Kalita *et al.* (2000) reported that reaction of some rice cultivars against leaf and sheath blight of rice (*Rhizoctonia solani* Kuhn) in southern Assam. A field experiment was conducted during the 1998 and 1999 *kharif* seasons to evaluate the reaction of 11 rice cultivars against leaf and sheath blight of rice, caused by *Rhizoctonia solani*. Two of the cultivars, Andrewsali and Monoharsali, showed resistant reactions against this disease. The newly introduced Basmati cultivar gave a highly susceptible reaction.

Li *et al.* (2000) evaluated the resistance of keng (*japonica*) rice varieties to sheath blight [*Pellicularia sasakii* (*Thanatephorus sasakii*)], 190 accessions were planted under natural infection at Jiamusi in fields heavily infected in the previous year. Observations on response to the disease showed that 6 accessions were resistant, while 150 accessions were susceptible, moderately susceptible or highly susceptible. No immune materials were recorded. Infection by sheath blight was related to maturity, being higher in early maturing than in late maturing varieties.

Meena *et al.* (2000) screened 120 rice varieties/cultures for their relative resistance to sheath blight disease under artificial conditions of infection, none was found to be resistant. Relative lesion height (RLH) was calculated using the formula lesion height/plant height x 100. Seven cultures, AVT-M(H) 1808, AVT-M(H) 1810, AVT-M(H) 1814, IVT-J 2503, IVT-J 2507, IR 51673-50-2 and ACM-56 were moderately resistant (20-30 RLH%). Among the remaining cultures 13, 98 and 2 were moderately susceptible (31-45 RLH%), susceptible (46-65 RLH%) and highly susceptible (more than 65 RLH%) to the disease, respectively.

Singha and Borah (2000) conducted screening of local upland rice cultivars of Assam against sheath blight. Sixty local upland rice cultivars of Assam were screened against sheath blight, caused by *Rhizoctonia solani,* in trials conducted at Titabar, India during the ahu seasons of 1996 and 1997. Only one cultivar, i.e. Chingdar, was found to be resistant. Seven cultivars (As 93-1, Mairan, N-22, Panjasali, Up-52, Upland-2 and 1/69-70) rated as moderately resistant and rest as susceptible.

Singha *et al.* (2000) screened fifty-three hybrid rice varieties during the sali seasons (June/July-Nov/Dec) of 1996 and 1997 for resistance to sheath blight (*Rhizoctonia solani*). No hybrid rice was found to be highly resistant to the disease. Only 19 hybrid varieties were found to be moderately resistant.

Biswas (1999) evaluated resistance of rice germplasm to sheath blight disease in West Bengal, India. In the *kharif* (wet) season of 1998, 160 entries from the National Screening Nursery (NSN) I were evaluated for their reaction to sheath blight disease, caused by *Rhizoctonia solani*, under artificially inoculated conditions at Chinsurah. Disease reaction was recorded 10 and 40 days after inoculation. None of the test entries gave a resistant reaction; 10 were moderately resistant while the other 150 gave a susceptible reaction.

Lee *et al.* (1999) reported that sheath blight and rice blast resistance in recently introduced rice germplasm. Susceptibility to rice sheath blight, caused by *Rhizoctonia solani* and rice blast, caused by *Pyricularia grisea* (*Magnaporthe grisea*), in inoculated field and greenhouse tests was estimated for 282 rice accessions introduced into the USA. Approximately 62 of the entries tested had excellent resistance to selected *P. grisea* races commonly found in Arkansas. Approximately 25 entries had excellent sheath blight tolerance, rating 4.5 or less using the standard 0 = no disease to 9 = maximum disease rating scale. Many entries had acceptable sheath blight tolerance, rating 6.0 or less on the disease scale. Eight entries had excellent sheath blight tolerance in combination with desired blast resistance.

Raina *et al.* (1999) evaluated multiple disease resistance in rice. Advanced stage rice breeding lines were evaluated against sheath blight [*Corticium sasakii* (*Thanatephorus sasakii*) diseases under artificial inoculations at Kapurthala, during *kharif* 1997. Out of 980 entries, three were moderately resistant to sheath blight.

Marchetti *et al.* (1998) conducted experiment with Jasmine 85 rice (*Oryza sativa*), a mid-season aromatic long-grain cultivar with medium cooking quality. It was released in the USA in 1989 and was derived from the cross IR262 x Khao Dawk Mali 105. Jasmine 85 possesses the semidwarf gene found in IR262, but is intermediate in height (110 cm) between typical USA semidwarfs. It has moderate susceptibility to lodging similar to Cypress and averages 11 days later to 50% flowering date (102 days) than Katy. In regional tests during 1988-94, average grain yield was 6450 kg/ha for Jasmine 85, compared with 4488, 6643, 6700 and 5972 kg/ha for Della, Gulfmont, Cypress and Katy, respectively, although milling yield was lower than for these cultivars. Jasmine 85 is moderately resistant to sheath blight (*Rhizoctonia solani*)

Reddy *et al.* (1997) evaluated 457 breeding lines of rice during 1993-95 wet seasons for resistance to sheath blight (*Rhizoctonia solani*). Lines RNR 15336 and RNR82096 appeared to be resistant.

Marchetti *et al.* (1996) studied the *Oryza sativa* germplasm line B62-761 (PI592507) for its resistance to sheath blight (*Rhizoctonia solani*). Lebonnet, a long-grain cultivar, carries the dominant gene Pi-kh and the recessive gene pi-d, while Vista, a medium-grain cultivar, carries the dominant gene Pi-z. B82-761 was selected in the F_7 generation of this cross for its favourable combination agronomic characters and conventional long-grain cooking quality. B82-761 is also resistant to sheath blight. Plant height of B82-761 averages 132 cm and it matures in 119 days. In trials in Texas, rough rice yield (kg/ha) of B82-761 was less than that of currently grown cultivars, averaging 6040, compared with 6650 for Katy, 7530 for Gulfmont and 6994 for Cypress. B82-761 is adapted to the southern USA.

McClung *et al.* (1997) worked on 'Jefferson' rice. This very early maturing rice cultivar (PI593892) was released in 1996 for its improved resistance to sheath blight (*Rhizoctonia solani*). It was developed from the cross B82-761/Rosemont, where B82-761 is a sheath blight-resistant germplasm which also carries 3 major genes for blast resistance (Pi-d, Pi-z and Pi-kh). Jefferson is a semi dwarf cultivar with superior lodging resistance. Jefferson has good milling quality and is characterized as a conventional cooking and processing US long-grain rice.

Rosamma *et al.* (1994) reported that Kairali (Ptb49), a high-yielding rice variety with multiple resistance from Kerala, India.This elite line, released during 1993 and derived from the cross IR36 x Jyothi, has high yield potential and moderate to high levels of resistance to sheath blight (*Rhizoctonia solani*) Yields in station trials during 1987-91 averaged 4.1 t/ha and during the 1991-92 dry season, over 33 locations, it yielded 5.2 t/ha, 500 kg/ha more than the control Ratna. Kairali matures in 110-115 days and is recommended for all 3 growing seasons in Kerala.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted in the Field of SAU (Sher-e-Bangla Agricultural University) farm land allotted for the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207.

3.2 Experimental period

The experiment was carried out during the period from March 2007 to August 2007.

3.3 Soil type

The soil of the experimental plot was loam to clay loam in texture belonging to the Madhupur Tract (AEZ-28). The description of the Agro Ecological Zone (UNDP and FAO, 1988) of the experiment site is stated below:

Agro Ecological Region	: Madhupur Tract (AEZ-28)
Land type	: Medium high land
General soil type	: Non-Calcareous
Soil series	: Tejgaon
Topography	: Up land
Elevation	: 8.45 m
Location	: SAU Farm, Dhaka.
Field level	: Above flood level.
Drainage	: Fairly good
Firmness (Consistency)	: Compact to friable when dry

The physical and chemical characteristics of the soil have collected from Soil Resource Development Institute (SRDI), Farmgate, Dhaka and is presented below (For 0-14 cm depth):

Particle size distribution:

Sand : 34%

Silt : 46%

Clay : 20%

Soil texture : Loam to clay loam.

3.4 Climate

The climate of the experimental area was of sub-tropical in nature characterized by high temperature associated with heavy rainfall during *Kharif* season (April to September) and scanty rainfall with moderately low temperature during *Rabi* season (October to March).

3.5 Weather

The monthly mean of daily maximum, minimum and average temperature, relative humidity, monthly total rainfall and sunshine hours received at the experimental site during the period of the study have been collected from the surface synoptic data card, Bangladesh Metrological Department, Sher-e-Bangla Nagar, Dhaka and Shown in Appendix I.

3.6 Rice varieties used for screening

The test varieties were BR3, BR14, BR16, BR21, BR24, BR26, and BRRI Dhan 27. These varieties were developed by Bangladesh Rice Research Institute (BRRI) and released by National Seed Board (NSB). These varieties were used as Aus variety.

3.7 Treatments

Seven high yielding rice varieties collected from the store of Bangladesh Rice Research Institute (BRRI), Gazipur viz. BR3, BR14, BR16, BR21, BR24, BR26, and BRRI Dhan 27 were used as treatment in the experiment. Thus the experiment consisted 7 (seven) treatments as follows:

I. BR3 (Biplob), (T_1)
II. BR14 (Gazi) , (T_2)
III. BR16 (Shahibalam), (T_3)
IV. BR21 (Niamot), (T_4)
V. BR24 (Rahmot), (T_5)
VI. BR26 (Srabony), (T_6)
VII. BRRI Dhan 27 ,(T_7)

3.8 Collection of Seed

Half kg seeds of each variety were collected from the Bangladesh Rice Research Institute (BRRI) office at Gazipur for conducting the experiment.

3.9 Sprouting of seed

Seeds were soaked in water in a basket for 24 hours. The seeds were then taken out of water and kept in gunny bags at room temperature for 72 hours for sprouting before sowing in seedbed.

3.10 Preparation of Seedbed and Sowing of seed

Seedbed was prepared by puddling the soil with the help of power tiller and harrow in the farm land allotted for the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka. No manuring was done in the field as the land was rich in organic matters. But 10 kg phosphate and 5 kg potash was applied to the seedbed. Sprouted seeds were sown in the wet seedbed on 21 March 2007. Seedlings were properly taken care of. Weeds were removed and irrigation was given in the seedbed as and when necessary.

3.11 Preparation of Experimental Land

The land for the experiment was prepared with the help of power tiller and harrow. The land was first opened on 11 April 2007 and ploughed. After that, cowdung was incorporated to the puddle soil in the plot. After 9 days, the final ploughing was done with the help of power tiller followed by laddering to level the soil surface. Weeds and stubbles were removed from the land. Thus the land became ready for transplanting of rice seedlings. The layout of the experiment in the field was done according to the design adopted.

3.12 Design of the Experiment

The experiment was carried out in a Randomized Complete Block Design (RCBD) with 3 replications. Each block comprised 7 unit plots and total number of unit plots were 21 (7x3). The unit plot size was 4 m^2. The distance maintained between plots was 50 cm and between blocks was 1.5 m.

3.13 Fertilizer Application

Fertilizers were applied as per recommendation of BRRI (Adhunik Dhaner Chash, 2007).

The following amount of fertilizers was applied to the plots:

Fertilizers	Amount/ 4 m^2
Urea (N_2)	56 gm
TSP (P_2O_5)	36 gm
MP (K_20)	16 gm
Gypsum (S)	24 gm
Zinc Sulphate (Zn)	4 gm

All fertilizers except 2/3 Urea were incorporated with soil during final land preparation. Rest of the Urea was applied in equal two installments at 30 and 45 days after transplanting.

3.14 Transplanting of Seedling

Thirty days old seedlings were uprooted from the seedbed very carefully and then transplanted on 22 April 2007 in the main field. In the field experiment, row to row spacing was maintained as 25 cm and hill to hill 20 cm. About 2-3 seedlings were transplanted together in individual hill.

3.15 Intercultural Operations

Intercultural operation specially weeding, irrigation and top dressing with urea preformed properly. All together two times weeding and 3 (three) irrigation was done during the experimental period.

3.16 Assessment of the Disease Severity in the Field

Ten plants selected randomly from each unit plot considered for grading the severity of diseases on standing crop. Ten selected plants were tagged. Sheath blight severity was recorded in three growth stages viz. flowering stage, dough stage and maturity stage. The severity of sheath blight disease was recorded following the Standard Evaluation System of Rice (IRRI, 2001).The scale was formulated based on percent Relative Lesion Height (% RLH) which is given below:

0 = No incidence (Highly resistant)

1 = Less than 1% area affected (Resistant)

3 = 1-5% areas affected (Moderately resistant)

5 = 6-25% areas affected (Moderately susceptible)

7 = 26-50% areas affected (Susceptible)

9 = 51-100% areas affected (Highly susceptible)

The RLH is the average vertical height of upper most lesions on sheath expressed as a percentage of the average plant height. The mean value of rating (% RLH) was determined to get rating score of the material under each treatment. The percent relative lesion height was calculated as per the formula given below (Ansari, 1995)

$$\text{Relative Lesion Height (\%)} = \frac{\text{Lesion height}}{\text{Plant height}} \text{ X } 100$$

3.17 Harvesting and collection of data on yield and yield contributing parameters

The rice varieties were harvested on 09 August, 2007 at full ripening stage from field in plot wise. Moreover 10 tagged plants of each unit plot were harvested separately. The data on the following yield contributing parameters were recorded:

I. Number of tillers/hill
II. Number of infected tillers/hill
III. Lesion size(cm)
IV. % RLH (% Relative Lesion Height)
V. % Flag leaf sheath area infected (% FLSAI)

VI. Length of panicle (cm)
VII. Number of filled grains/panicle
VIII. Number of unfilled grains/panicle
IX. Weight of thousand grains (gm)
X. Grain yield (t/ha)
XI. Straw yield (t/ha)

3.18 Analysis of data

The data on different characters were subjected to statistical analysis using analysis of variance to find out the variation resulting from experimental treatments. Treatment means were compared by DMRT (Duncan's Multiple Range Test).

3.19. Isolation and purification of *Rhizoctonia solani*

Sheath blight infected sheaths of rice plants were collected by using polythene bag and were taken to the laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207. Thus the diseased sheaths were cut into pieces (0.5 cm) and these were washed in sterilized water thrice and were placed on to Potato Dextrose Agar (PDA) medium in petridish. The petridish containing sheath pieces (3 pieces/plate) were incubated at 25±1°C for 7 days. Then the organism that grew freshly onto culture medium were isolated by means of hyphal tip culture methods aseptically and were cultured again on PDA medium to have pure cuture and incubated at 25±1°C for a week and identified.

Chapter 4
Results

CHAPTER 4

RESULTS

The present experiment was conducted to screen out the resistant cultivars of rice (Aus) against sheath blight disease under natural epiphytotic conditions. The results obtained from the present study on the comparative performance of seven different rice varieties viz. BR3, BR14, BR16, BR21, BR24, BR26 and BRRI dhan 27 against sheath blight of rice were complied and presented in this chapter. The screening of the varieties was assessed based on different parameters like disease incidence, disease severity, yield and yield contributing characters.

4.1 Isolation and identification of causal agent

The causal fungus was isolated from infected sheath of plant and studied in the laboratory. The fungus was purified and identified as *Rhizoctonia solani* (Plate 1 and 2). The mycelium of *R. solani* is colourless in young culture and yellow brown in older cultures. The hyphae have a prominent dolipore septum, multinucleate and dolipore septum are generally 8-12 μm (Ou, 1985).

4.2 Varietal reactions on number of tillers and infected tillers against sheath blight of rice

The different treatments showed significant differences in respect of number of tillers per hill and number of infected tillers per hill that were presented in Table 1.

The number of tillers per hill ranged from 25.17 to 31.9. The highest number of tillers per hill (31.9) was observed in T_7 (BRRI dhan 27) followed by BR26 (30.3) and BR24 (28.67). The lowest number of tillers per hill was

Plate 1. Typical symptoms of sheath blight of rice caused by *Rhizoctonia solani*

Plate 2. Pure culture of *Rhizoctonia solani* on PDA medium and showing huge number of sclerotia

recorded in case of BR3 (25.17) which was statistically similar to those of BR14 (26.4), BR16 (26.07) and BR21 (26.37).

The different treatments showed significant differences in respect of number of infected tillers per hill at three stages viz. flowering stage, dough stage, and maturity stage. The means of number of infected tillers per hill for the treatments were increased with the increase of the age of the plants (Table 1). At flowering stage, the number of infected tillers per hill for all the treatments ranged from 1.13 to 5.67 where the highest number of infected tillers per hill (5.67) was observed in case of T_4 (BR24). The lowest number of infected tillers per hill (1.13) was recorded in T_7 (BRRI dhan 27) preceded by BR14 (1.27), BR24 (2.13), BR26 (2.33), BR16 (3.33) and BR3 (3.77).

In dough stage, the highest number of infected tillers per hill (6.75) was observed under T_4 (BR21). The lowest (1.33) number of infected tillers per hill was recorded in case of T_7 (BRRI dhan 27) preceded by BR26 (5.25), BR3 (5.16), BR16 (4.75), BR24 (4.25) and BR14 (2.15).

In maturity stage, the highest mean number of infected tillers per hill (8.5) was observed in case of BR3 and BR24 (8.5). The lowest number of infected tillers per hill was recorded in case of BRRI dhan 27 (5.7) preceded by BR21 (7.4), BR16 (7.71), BR14 (6.37) and BR26 (5.97) (Table 1).

4.3 Varietal reactions on percent infected tillers per hill against sheath blight of rice

The different varieties showed significant differences in respect of percent infected tillers per hill at three growth stages viz. flowering stage, dough stage, and maturity stage were presented in Table 2.

The cumulative percent of infected tillers per hill for the treatments were increased with the increase of the age of the plants (Table 2). At flowering stage, the percent infected tillers per hill for the treatments ranged from 4.00 to 21.46 where the highest percent infected tillers (21.46) was observed in case of T_4 (BR21) followed by BR3 (14.91) and BR16 (10.46). The lowest percent infected tillers per hill (4.00) was recorded in T_7 (BRRI dhan 27) preceded by BR14 (5.38), BR26 (9.21) and BR24 (9.55).

In dough stage, the highest percentage of infected tillers per hill (25.65) was observed under T_4 (BR24) followed BR26 (20.70) and BR3 (19.73). The lowest percent infected tillers per hill (4.72) was recorded in case of T_7 (BRRI dhan 27) preceded by BR14 (8.16), BR16 (15.73) and BR24 (19.03).

In maturity stage, the highest percent infected tillers per hill (42.01) was observed in case of BR26 followed by BR21 (37.54), BR24 (36.74) and BR3 (29.91). The lowest percent infected tillers per hill was recorded in case of BRRI dhan 27 (11.56) preceded by BR14 (22.64) and BR16 (26.62).

4.4 Varietal reactions on lesion size against sheath blight of rice

The reactions of different treatments on lesion size were determined and presented in Table 3. It was observed that the treatments showed significant differences at three stages of rice viz. flowering stage, dough stage and maturity stage. At flowering stage, the lesion sizes of different varieties ranged from 0.74 cm to 2.47 cm. The highest lesion size (2.47 cm) was observed in T_1 (BR3) followed by BR14 (2.13 cm) and BR16 (1.97 cm). The lowest lesion size (0.74 cm) was recorded incase of T_7 (BRRI dhan 27). The second lowest lesion size was recorded in BR26 (1.13 cm) which was statistically identical with BR21 (1.18 cm).

In dough stage, the lesion size of different varieties ranged from 1.63 cm to 3.15 cm. The highest lesion size (3.5 cm) was observed in T_1 (BR3) followed by BR21 (2.60 cm), BR16 (2.63 cm) and BR14 (2.22 cm). The lowest lesion size (1.63 cm) was recorded in case of T_7 (BRRI dhan 27) that was statistically identical with BR24 (1.78 cm) and BR26 (1.80 cm).

In maturity stage, the lesion size of different varieties ranged from 3.50 cm to 4.02 cm. The highest lesion size (4.02 cm) was observed in T_3 (BR16) which was statistically similar with BR3 (3.61 cm), BR14 (3.66 cm), BR26 (3.75 cm) and BR24 (3.87 cm). The lowest lesion size (3.50 cm) was recorded in case of T_7 (BRRI dhan 27).

4.5 Percentage of relative lesion height (% RLH) of different rice varieties against sheath blight disease

The different rice varieties showed significant differences in respect of percent relative lesion height. The highest % RLH (4.4%) among the treatments was observed under T_1 (BR3) which was statistically similar with BR14 (4.21%). The lowest % RLH (3.02%) was found under T_7 (BRRI dhan 27) preceded by BR24 (3.46%), BR26 (3.47%), BR21 (3.82%) and BR16 (3.86%).

4.6 Reaction of seven rice varieties to sheath blight disease

On the basis of sheath blight severity, different varieties of rice (Aus) were categorized into different groups mentioning their susceptibity reactions to sheath blight (Table 5). The test varieties showed different reactions against sheath blight. The variety BRRI dhan 27 showed 21.33% flag leaf sheath area infected and this was categorized as moderately susceptible. The rest of the varieties viz. BR3, BR14, BR21, BR24, BR16 and BR26 were categorized as susceptible those showed 35.5%, 29.75%, 27.2% 26.17%, 24.91% and 24.91% flag leaf sheath area infected, respectively.

4.7 Effect of sheath blight on yield and yield contributing characters of seven rice varieties

The varieties were found to differ significantly in respect of panicle length, filled grains per panicle, and unfilled grains per panicle, grain yield, straw yield and weight of thousand (1000) grains and presented in Table 6 (Plate 3, 4, 5 and 6).

The panicle length of seven different rice varieties ranged from 24.06 cm to 29.0 cm. The highest panicle length (29.0 cm) was recorded in BRRI dhan 27 which was statistically similar to that of BR26 (28.03 cm). The lowest panicle length was recorded in BR3 (24.06 cm) that also was statistically similar to BR14 (25.42 cm). The filled grains per panicle ranged from 41.4 to 53.2. The highest filled grains per panicle (53.2) were recorded in BRRI dhan 27. The lowest filled grains per panicle (41.4) was recorded in BR21 preceded by BR24 (45.17), BR16 (45.23), BR26 (48.1), BR14 (49.27) and BR3 (51.47).

In case of unfilled grains per panicle, the means of unfilled grains varied significantly among the varieties and ranged from 38.6 to 53.87. The highest number of unfilled grains per panicle (53.87) was recorded in BR21. The lowest number of unfilled grains per panicle (38.6) was recorded in BRRI dhan 27 preceded by BR26 (41.37), BR16 (43.64), BR24 (48.60) and BR3 (49.84).

In terms of grain yield (t/ha), mean grain yield of the varieties differed significantly and ranged from 1.14 t/ha to 3.00 t/ha. The highest grain yield (3.00 t/ha) was recorded in BRRI dhan 27 that was statistically identical with BR3 (2.96 t/ha). The lowest grain yield was recorded in BR24 (1.14 t/ha) which was also statistically identical with BR21(1.17 t/ha), BR26(1.20 t/ha) and BR16 (1.21 t/ha).

Considering the straw yield (t/ha) of rice varieties, the mean straw yield varied significantly among the varieties and ranged from 2.78 t/ha to 4.00 t/ha. The highest straw yield (4.00 t/ha) was recorded in BRRI dhan 27 that was statistically identical with BR3 (3.86 t/ha). The lowest straw yield (2.78 t/ha) was recorded in BR26 which was statistically similar with BR24 (2.96 t/ha) and BR21 (3.08 t/ha).

Means of 1000 grains weight varied significantly among the varieties and ranged from 29.87 gm to 32.73 gm. The highest weight of thousand grains (32.73 gm) was recorded in BRRI dhan 27 that was similar with BR26 (32.03 gm). The lowest weight of thousand grains (29.43 gm) was recorded in BR3 which was also statistically similar with BR21 (29.87 gm), BR 14 (30.23 gm) and BR24 (30.70 gm).

Table 1. Varietal reactions on number of tillers and infected tillers against sheath blight of rice

Treatments	No. of tillers per hill	No. of infected tillers per hill		
		Flowering stage	Dough stage	Maturity stage
T_1 = (BR-3)	25.17 d	3.77 b	5.16 b	8.5 a
T_2 = (BR-14)	26.4 d	1.27 d	2.15 d	6.37 c
T_3 = (BR-16)	26.07 d	3.33 b	4.75 bc	7.71 b
T_4 = (BR-21)	26.37 d	5.67 a	6.75 a	7.4 b
T_5 = (BR-24)	28.67 c	2.13 c	4.25 c	8.5 a
T_6 = (BR-26)	30.3 b	2.33 c	5.25 b	5.97 cd
T_7 = (BRRI dhan 27)	31.9 a	1.13 d	1.33 e	5.7 d
LSD at 1%	1.10	0.511	0.517	0.5632
CV%	5.59	7.33	4.92	3.14

In a column means having similar letter (s) are identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability.

Table 2. Varietal reactions on the incidence of infected tillers per hill against sheath blight of rice

Treatments	% infected tillers per hill		
.	Flowering stage	Dough stage	Maturity stage
T_1 = (BR-3)	14.91 b	19.73 c	29.91 d
T_2 = (BR-14)	5.38 e	8.16 f	22.64 f
T_3 = (BR-16)	10.46 c	15.73 e	26.62 e
T_4 = (BR-21)	21.46 a	25.65 a	37.54 b
T_5 = (BR-24)	9.55 cd	19.03 d	36.74 c
T_6 = (BR-26)	9.21 d	20.70 b	42.01 a
T_7 = (BRRI dhan 27)	4.00 f	4.72 g	11.56 g
LSD at 1%	0.985	0.486	0.459
CV%	3.68	1.20	4.62

In a column means having similar letter (s) are identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability.

Table 3. Reactions of seven rice varieties on lesion size of sheath blight of rice

Treatments	Lesion size (cm)		
	Flowering stage	Dough stage	Maturity stage
T_1 = (BR-3)	2.47 a	3.15 a	3.61 ab
T_2 = (BR-14)	2.13 b	2.22 c	3.66 abc
T_3 = (BR-16)	1.97 c	2.63 b	4.02 a
T_4 = (BR-21)	1.18 e	2.80 b	3.55 cd
T_5 = (BR-24)	1.83 d	1.78 d	3.87 abc
T_6 = (BR-26)	1.13 e	1.80 d	3.75 acd
T_7 = (BRRI dhan 27)	0.74 f	1.63d	3.50 c
LSD at 1%	0.136	0.22	0.54
CV%	3.07	3.82	5.75

In a column means having similar letter (s) are identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability.

Table 6. Effect of sheath blight disease on yield and yield contributing characters of seven rice varieties

Treatments	Length of panicle (cm)	No. of filled Grains/ panicle	No. of unfilled Grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Wt. of 1000 grains (gm)
T_1 = (BR-3)	24.06 d	51.47 b	49.84 b	2.96 a	3.86 b	29.43 d
T_2 = (BR-14)	25.42 cd	49.27 c	47.64 c	2.04 b	3.42 bc	30.23 d
T_3 = (BR-16)	27.08 bc	45.23 e	43.64 d	1.21 c	3.33 bcd	31.57 bc
T_4 = (BR-21)	26.17 cd	41.4 e	53.87 a	1.17 c	3.08 cd	29.87 d
T_5 = (BR-24)	27.07 b	45.17 e	48.60 bc	1.14 c	2.96 cd	30.7 cd
T_6 = (BR-26)	28.03 ab	48.1 d	41.37 e	1.20 c	2.78 d	32.03 ab
T_7 = (BRRI dhan 27)	29.0 a	53.2 a	38.6 f	3.00 a	4.00 a	32.73 a
LSD at 1%	1.654	1.087	1.63	0.473	0.523	1.07
CV%	2.47	3.95	7.54	10.46	6.26	3.39

In a column means having similar letter (s) are identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability.

Plate 3. A view of the experimental field.

Plate 4. Showing variety BRRI dhan 27 which was less affected by sheath blight disease

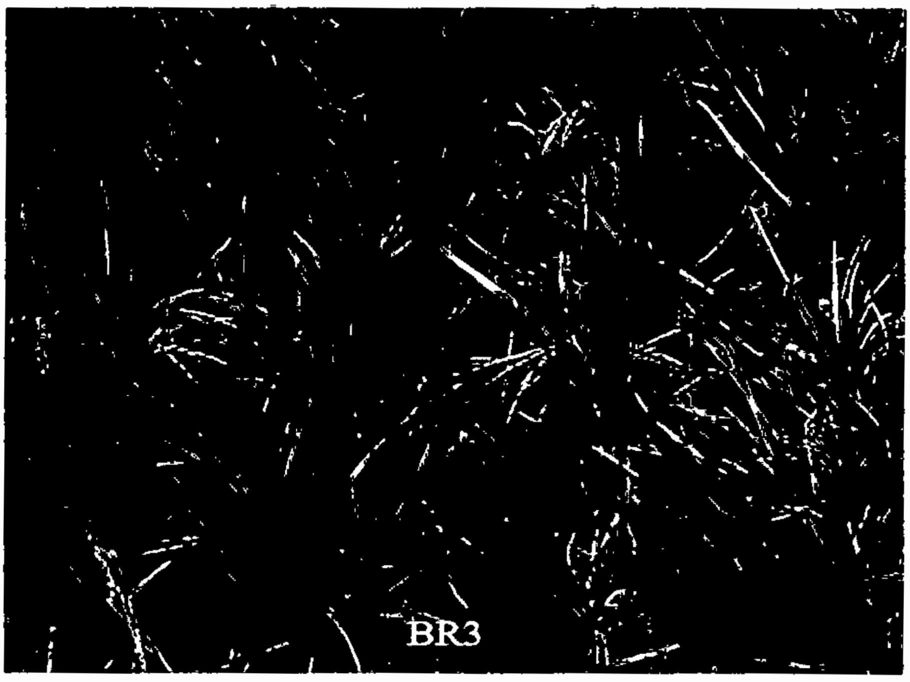

Plate 5. Showing variety BR3 which was severely affected by sheath blight disease

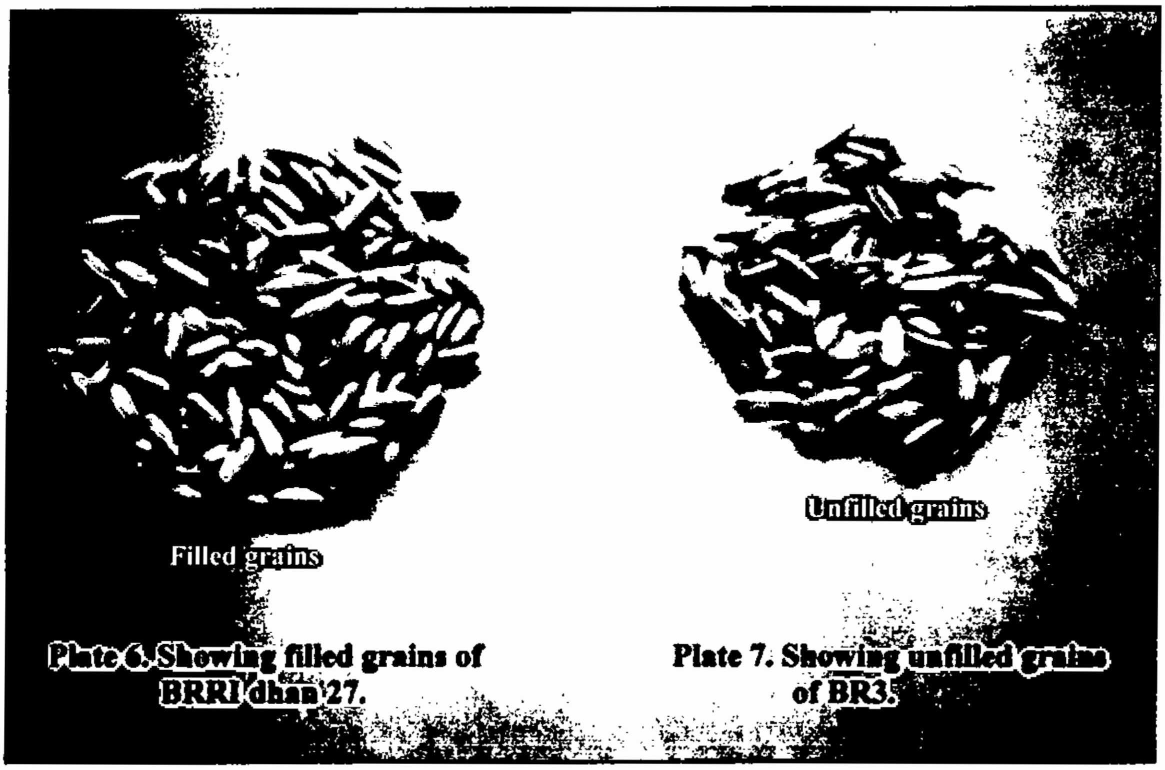

Plate 6. Showing filled grains of BRRI dhan 27.

Plate 7. Showing unfilled grains of BR3.

Chapter 5
Discussion

CHAPTER 5

DISCUSSION

The sheath blight disease of rice caused by *Rhizoclonia solani* is responsible for significant yield losses in Asia (Ou, 1985). Rice sheath blight is one of the major constraints to rice production in Bangladesh (Miah *et al.*, 1985). As the situation of the disease is destructive in certain area of Bangladesh causing 28 to 30% yield reduction under farmers field condition in susceptible rice cultivars in Bangladesh (Shahjahan *et al.*, 1986), the present study was carried out to screen out resistant cultivar(s) of Aus rice in controlling sheath blight disease caused by *Rhizoctonia solani* in field condition. Screening of the rice (Aus) varieties were determined on the basis of percent infected tillers per hill, disease incidence, disease severity and yield contributing characters.

From the experimental findings recorded for the 7 different varieties in respect of number of tillers per hill it is revealed highest number of tillers per hill (31.9) found in case of BRRI dhan 27 and the lowest number of tillers per hill (25.17) was found in BR3 which was statistically similar with BR16 (26.07), BR14 (26.04) and BR21 (26.37). Reactions of the varieties against sheath blight of rice on number of infected tillers under field condition at different stages viz. flowering stage, dough stage and maturity stage it was showed that the maximum infected tillers found at later growth stage and it was maximum in case of BR26 (42.01%) and the minimum in BRRI dhan 27 (11.56 %).

The reactions of the varieties in respect of lesion size at different growth stage revealed that the maximum lesion size were 2.47 cm and 3.15 cm found in BR3 and minimum lesion size were 0.74 cm and 1.63 cm found in

BRRI dhan 27 respectively at flowering stage and dough stage. In maturity stage, the highest lesion size was found in case of BR16 (4.02 cm) and the lowest lesion size was found in BRRI dhan 27 (3.50 cm).

Reaction of seven rice varieties against sheath blight on the basis of sheath blight severity (% Flag leaf sheath area infected) different varieties of rice (Aus) were categorized into different groups mentioning susceptibity reactions. Among the varieties essayed in this screening program, BRRI dhan 27 (21.33%) was found moderately susceptible to sheath blight of rice. On the other hand BR3 (35.5%), BR14 (29.75%), BR21 (27.2%), BR24 (26.17%), BR16 (24.91%) and BR26 (24.91) were susceptible to sheath blight of rice. These results of the present investigation are in agreement with the results reported by Li *et al.*, (2004), Biswas (2003), Biswas (2001a), Biswas (2001b), Biswas (2000), Dash *et al.,* (2000), Kalita *et al.*, (2000), Li *et al.,* (2000), Meena *et al.,*(2000), Singha and Borah (2000), Singha *et al.*, (2000), Biswas (1999) and Raina *et al.,* (1999). They screened rice germplasms against sheath blight (*Rhizoctonia solani*) of rice. But none of them found high yielding varieties resistant against sheath blight of rice. A few moderately resistant varieties were reported against sheath blight while most of the varieties categorized as susceptible.

On the basis of yield and yield contributing characters like panicle length, filled and unfilled grains per panicle, straw wt. and weight of 1000 grains against sheath blight of rice, the better performance was shown by BRRI dhan 27 that was graded as moderately susceptible against sheath blight disease of rice. No literature on yield and yield contributing characters of BRRI dhan 27 against sheath blight of rice is available.

Chapter 6
Summary and Conclusion

CHAPTER 6

SUMMARY AND CONCLUSION

Rice (*Oryza sativa* L.) is the most important cereal crop in Bangladesh. Rice plant suffers from many diseases of which sheath blight is common and devastating for its grain yield and quality of seeds.

The present piece of research work was conducted in the field of SAU (Sher-e-Bangla Agricultural University) farm allotted for the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka to screen out the resistant varieties of rice (Aus) against sheath blight disease (*Rhizoctonia solani* kuhn) during the period from March 2007 to August 2007 in Aus season. Seven rice (Aus) varieties BR3, BR14, BR16, BR21, BR24, BR26 and BRRI dhan 27 were evaluated against *Rhizoctonia solani* causing sheath blight disease of rice. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Screening of the rice varieties against *Rhizoctonia solani* causing sheath blight disease was done under natural conditions.Data were recorded at different stage viz., flowering stage, dough stage and maturity stage in terms of percent infected tillers per hill, disease severity, yield and yield contributing characters.

The rice varieties differed significantly among themselves in respect of tillers per hill. The highest tillers per hill (31.9) was observed in the variety BRRI dhan 27 and the lowest tillers per hill (25.17) was recorded in the variety BR3 which was statistically similar with BR16 (26.07), BR14 (26.4) and BR21 (26.37).

In flowering and dough stage the highest percent infected tillers per hill (21.46) and (25.65), respectively were recorded in the variety BR21 and lowest percent infected tillers per hill (4.00 and 4.72) were recorded in the variety BRRI dhan 27. In maturity stage, the highest percent infected tillers per hill (42.01) were observed in the variety BR26 and the lowest percent infected tillers per hill (11.56) were recorded in the variety BRRI dhan 27.

The highest lesion size at flowering and dough stage (2.47 cm and 3.15 cm) were recorded in the variety BR3 and lowest lesion size (0.74 cm and 1.63 cm) were recorded in the variety BRRI dhan 27. At maturity stage, the highest lesion size (4.02 cm) was recorded in BR16 which was statistically identical with the varieties BR3 (3.61 cm), BR14 (3.66 cm), BR26 (3.75 cm) and BR24 (3.87 cm). The lowest lesion size (3.50 cm) was observed in the variety BRRI dhan 27 which was also statistically identical with BR21 (3.55 cm). Disease development was found to be increased with the increasing age of the rice variety. The highest percent relative lesion height (% RLH) (4.4%) was observed in the variety BR3 and the lowest % RLH (3.02%) was recorded in the variety BRRI dhan 27.

The development of sheath blight of rice measured as percent flag leaf sheath area infected (% FLSAI) on some selected rice varieties belonging to four severity levels. Among the varieties, BR3, BR14, BR21, BR24, BR16 and BR26, respectively were susceptible and BRRI dhan 27 was moderately susceptible against sheath blight.

The highest length of panicle (29 cm) was observed in the variety BRRI dhan 27 and lowest length of panicle (24.06 cm) was recorded in the variety BR3.

Mean filled grains varied significantly among the selected rice varieties. The highest number of filled grains per panicle was recorded in the variety BRRI dhan 27 (53.2) and the lowest filled grains per panicle was observed in the variety BR21 (41.4). The highest unfilled grains per panicle (53.87) were observed in the variety BR21 and the lowest unfilled grains per panicle (38.6) were recorded in the variety BRRI dhan 27.

The average grain yield (t/ha) varied significantly among the varieties and ranged from 1.14 t/ha to 3.00 t/ha. The highest grain yield (3.00 t/ha) was recorded in the variety BRRI dhan 27 which was statistically similar to BR3. The lowest grain yield (1.14 t/ha) was recorded in the variety BR24. The highest straw yield (4.00 t/ha) was recorded in the variety BRRI dhan 27 and the lowest straw yield (2.78 t/ha) was observed in the variety BR26.

Mean 1000 grains weight varied significantly among the selected rice varieties and ranged from 29.43 gm to 32.73 gm. The maximum 1000 grains weight (32.73 gm) was recorded in case of variety BRRI dhan 27 which was statistically identical with BR26 (32.03 gm). The lowest 1000 grains weight (29.43 gm) was recorded in case of variety BR3 which was also statistically identical with the varieties BR21 (29.87gm) and BR16 (30.23gm).

Considering all the parameters it may be concluded that BRRI dhan 27 was graded as moderately susceptible against sheath blight disease among the varieties used in the experiment. However, screening program need to carryout for consecutive years in different agro ecological zones of the country to certify the results of the present findings.

Chapter 7
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CHAPTER 7

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APPENDICES

Appendix 1. Monthly mean of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours during March to August, 2007

Month	Temperature (°C)			**Relative Humidity (%)	*Rainfall (mm)	*Sun Shine (hrs)
	Max.	Min.	Ave.			
March	31.50	16.90	25.55	47.00	160	255.01
April	33.74	23.87	28.81	69.41	185	234.60
May	34.70	25.90	30.30	70.00	185	241.80
June	32.40	25.50	28.95	81.00	628	96.00
July	31.40	25.70	28.55	84.00	753	127.10
August	32.40	26.40	29.40	80.00	505	108.50

Source: Station name: PBO, Dhaka, Station No: 41923, Surface synoptic data card, Bangladesh Metrological Department, Sher-e-Bangla Nagar, Dhaka-1207.

* Monthly total

** Monthly average

Appendix 2. Analysis of variance of the data on number of tillers per hill

Source of variation	Degrees of freedom	Mean square
Replication	2	0.196
Treatment	6	17.250**
Error	12	0.196

** Significant at 0.01 level of probability

Appendix 3. Analysis of variance of the data on number of infected tillers per hill at different growth stage

Source of variation	Degrees of freedom	Mean square		
		No. of infected tillers/ hill		
		Flowering stage	Dough stage	Maturity stage
Replication	2	0.042	0.043	0.051
Treatment	6	7.632	10.638**	4.063**
Error	12	0.042	0.043	0.051

** Significant at 0.01 level of probability

Appendix 4. Analysis of variance of the data on percent infected tillers per hill at different growth stage

Source of variation	Degrees of freedom	Mean square		
		% infected tillers/ hill		
		Flowering stage	Dough stage	Maturity stage
Replication	2	0.156	0.038	0.034
Treatment	6	105.161**	163.31**	325.44**
Error	12	0.156	0.038	0.034

** Significant at 0.01 level of probability

Appendix 5. Analysis of variance of the data on lesion size at different growth stage

Source of variation	Degrees of freedom	Mean square		
		Lesion size (cm)		
		Flowering stage	Dough stage	Maturity stage
Replication	2	0.003	0.008	0.047
Treatment	6	1.172**	1.026**	0.117**
Error	12	0.003	0.008	0.047

** Significant at 0.01 level of probability

Appendix 6. Analysis of variance of the data on Percent relative lesion height (% RLH)

Source of variation	Degrees of freedom	Mean square
		% Relative lesion height (% RLH)
Replication	2	0.095
Treatment	6	0.938**
Error	12	0.048

** Significant at 0.01 level of probability

Appendix 7. Analysis of variance of the data on percentage flag leaf sheath area infected (% FLSAI)

Source of variation	Degrees of freedom	Mean square
		% Flag leaf sheath area infected (% FLSAI)
Replication	2	0.190
Treatment	6	78.770**
Error	12	0.190

** Significant at 0.01 level of probability

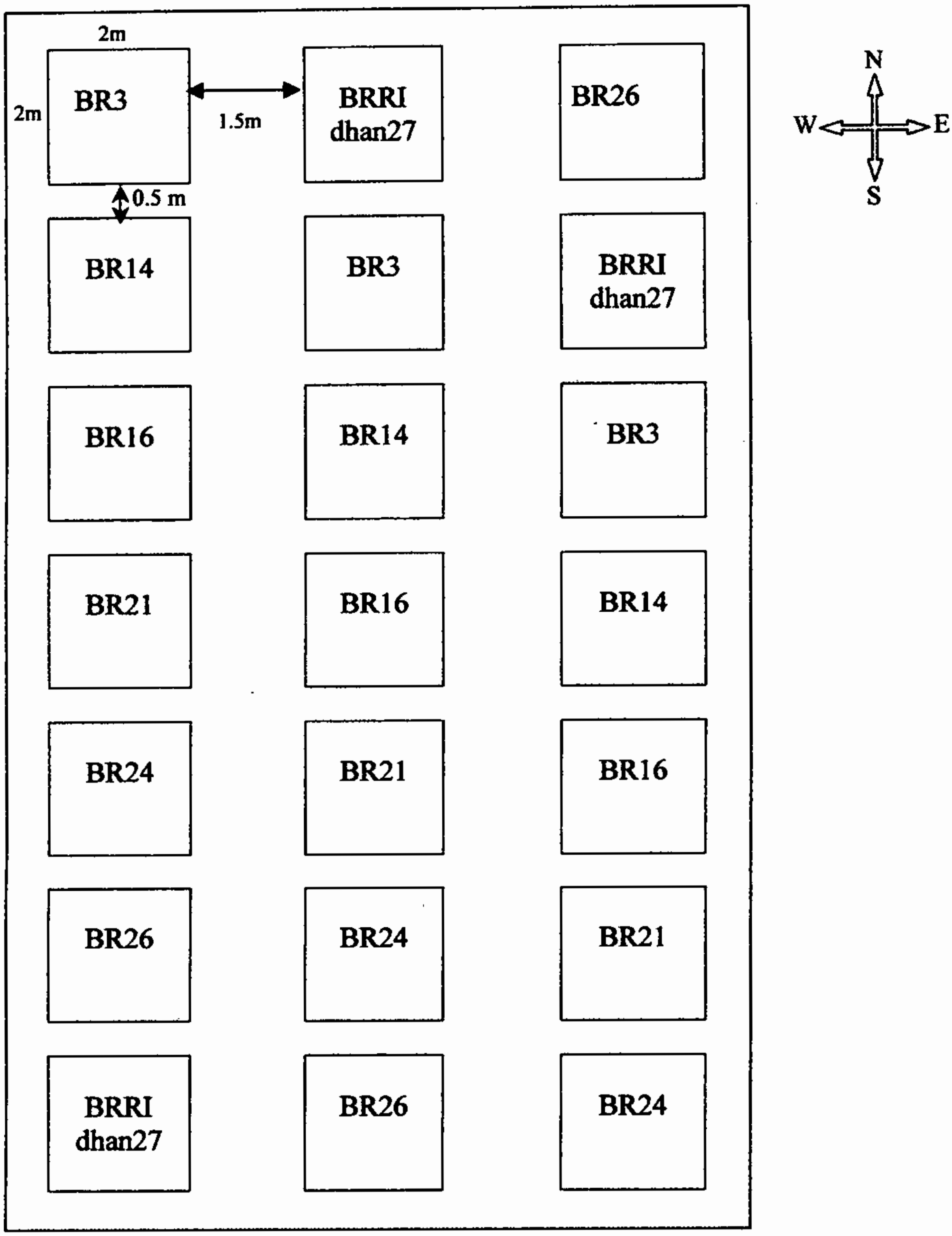
Appendix 8. Analysis of variance of the data on yield and yield contributing characters

Source of variation	Degrees of freedom	Mean square					
		Length of panicle (cm)	No. of filled Grains/ panicle	No. of unfilled Grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Wt. of 1000 grains (gm)
Replication	2	0.440	0.190	0.195	0.036	0.044	0.185
Treatment	6	5.889**	53.502**	53.709**	2.199**	0.619**	3.583**
Error	12	0.440	0.190	0.195	0.036	0.044	0.185

** Significant at 0.01 level of probability

Appendix 9. Layout of the experimental filed (RCBD)

Plot size : 2 m × 2 m



Layout of the experimental field

Appendix 10. Composition of Potato Dextrose Agar (PDA)

Components	Composition
Potato	200 gm
Dextrose	20 gm
Agar	20 gm
Water	1000 ml