The importance and production of rice

Though rice (Oryza sativa L.) is a staple food for half of the world’s population, farmers need to produce more food in less area because agricultural land use is reducing day by day (Reyes & Chin, 2009; Mohanty, 2009; Zeigler, 2006). The world population is expected to be exceeded 9 billion by 2040 with an increase of about 50% in less than 40 years (U. S. census Bureau, Population Division, 2009). This crop is different from other important crops such as soybean, maize and wheat because of its high concentration in consumption and production (Mohanty, 2009). Rice is not just like another commodity, it has social, cultural and even religious role which make it more psychological weight (Ritter, 2008).

Around 90 percent of total rice is produced in Asia which makes it an Asian crop (Mohanty, 2009). Rice is also becoming an important cereal food and supporting lives of many people in Central America, Europe and Africa. About 50 million tons of rough rice is to be increased per year by 2015 to face world’s demand where the projected demand for Asia is an additional 38 million tons (Pandey, 2008; Mohanty, 2009). Out of 1. 1 billion poor people of the world, about 700 million populations having an income of less than $1 per day live in Asian rice growing countries (Pandey, 2008). Rice is the most important staple cereal crop for more than two billion people in Asia (Mew et al., 2004) and accounts for more than 40 percent of the calorie consumption of most Asians (Pandey, 2008).

The economy of Bangladesh mainly depends on agriculture. Rice is the main cereal food in Bangladesh. One-half of the agricultural GDP and one-sixth of the national income of Bangladesh come from rice sector. Total rice production in Bangladesh, after the year of independence, 1971, was 10. 59

million tons to feed 70. 88 million people (BRKB, 2009) whereas the country now is the fourth rice producer in the world followed by China, India and Indonesia and produces 43. 7 million tons (6. 9% of global rice harvest) rice to feed about 150 million people (Workman, 2008) within 147, 570 square kilometer area which indicates that the growth of rice production is much faster than the growth of population. Therefore, rice plays an important role in the livelihood of the people of Bangladesh.

Production of enough food to feed the growing world population is a continuous challenge for farmers. They face environmental constraints such as co-evolution of pests, pathogens and hosts which has an impact on agricultural production (Tilman et al., 2001). Among the yield limiting factors of rice, diseases caused by different pathogens play an important role of which plant parasitic nematodes are one of the major economic pests that affect the quality and quantity of major agricultural crops. The worldwide yield loss due to plant parasitic nematodes has been estimated to about 12. 3 percent annually (Sasser, 1987). They are responsible for global agricultural losses which are equivalent to $157 billion annually (Abad et al., 2008). Yield losses in rice caused by Meloidogyne graminicola is ranged from 20-80% and 11-73% in upland and in intermittently flooded conditions, respectively (De Waele & Elsen, 2007). Hirschmanniella spp. is also a problem for rice production (Fortuner, 1977). Approximately 10-30% (Ahmed 1994) crop losses have been observed annually in Bangladesh due to diseases. There is a big yield gap of rice of about 1. 5-2. 0 t/ha in Bangladesh due to many factors including diseases (Razzak, 2006). In deep water rice, 9. 1-22% yield loss is observed in rice in Bangladesh due to M. graminicola whereas this loss is 1ton/ha in control field compared to chemical treatment in rainfed low land rice ecosystem (Rahman et al., 1990; Padgham et al., 2004). More recently, rice root-knot caused by M. graminicola and rice root rot caused by H. oryzae have become a major threat for rice cultivation and the intensification of agricultural production systems favors their population build up (Mew et al., 2004, Hossain et al., 2007).

The climatic changes, especially water scarcity helps researchers think to develop production technologies for cultivation of rice under less water condition which may increase activity of M. graminicola (De Waele & Elsen, 2007). Developing technologies to save water such as cultivation of direct seeded rice by drum seeder, maintain of alternate wetting and drying condition in rice field and use of aerobic rice (BRKB, 2009) could increase M. graminicola infection. Because of little knowledge, the nematode problems are not recognized properly. More knowledge on the interaction between rice plant and nematodes is necessary to get the nematode problem under control.

Agricultural commodities of the world have been pressurized by the growing population. Since the possibility of increasing production of rice by increasing land is practically little, especially in Asia, the ways to increase yield per unit area must be explored in different angles. Chemicals are the main option to manage disease in many parts of the world. Biodegradation can occur due to the repeated use of nematicides as well as the active ingredient is metabolized rapidly by micro-flora in the soil. On the other hand, chemicals are being withdrawn from use due to their harmful effects to the environment (Fuller et al., 2008). The challenge of feeding an alarming everincreasing people by increasing crop yield can only be realized if basic researches lead to new applicable resources in the future.

Plants produce different types of hormones, such as GA, auxin, ABA, CK, SA, ET, JA and strigolactones which may play role in plant-pathogen interaction (Umehara et al., 2008). Though most of the components of most of the hormonal pathways of the dicot model plant arabidopsis (Arabidopsis thaliana) are well known, interest in the involvement of hormones of rice, a monocot plant, to the infections of microorganisms has recently been come up. A few informations on the role of hormones in the response of rice plant to the infection of fungal pathogen, such as, Magnaportha oryzae and bacterial pathogen, such as, Xanthomonas oryzae pv. oryzae are available. In order to facilitate the infection in root, how the nematodes interact with the rice hormonal pathway is not well known. Recently, significant positive effect of exogenous abscisic acid (ABA), salicylic acid (SA), jasmonate (JA), methyl jasmonate and ethylene (ET) on rice resistance against M. graminicola and H. oryzae have been observed (De Bruyne et al., 2009; Njira et al., 2009). However, there is no report available on the role of Gibberellins in the response of rice to M. graminicola and H. oryzae.

Positional cloning in rice has been much more efficient due to major advances in rice genomics during the last few years (Jeon & Ronald, 2007). The consortium of international rice genome sequencing Project (IRGSP) used japonica rice cultivar Nipponbare for rice genome sequencing and they decoded a highly accurate map-based genomic sequence of this cultivar in 2005 (IRGSP, 2005). Other wild type rice, Taichung 65 and its GA-deficient, GA-insensitive and DELLA mutants are available for study of the GA signalling pathway upon nematode infections.

Hypothesis:

1. Defense signalling of rice is important to limit M. graminicola and H. oryzae infections;

2. Gibberellin pathway involved in defense signalling is turned on during the interaction of rice with

Objectives:

1. To observe the Gibberellin pathway in defense response of rice during the infection with M. graminicola and H. oryzae.

2. To quantify the expression of Gibberellin pathway during infection of those nematodes in rice by molecular analysis.

2. LITERATURE REVIEW

Literatures on plant parasitic nematodes including classification and agricultural importance are studied giving emphasis on importance and infection process of M. graminicola and H. oryzae causing root knot and root rot disease, respectively of rice. Available informations on rice, its classification, scientific and agricultural importance and its defense mechanisms have been reviewed. Finally, a comprehensive review on the signalling pathways of Gibberellins and in brief, other hormones, such as Abscisic acid (ABA), ethylene (ET), jasmonic acid (JA) and salicylic acid (SA) that are known to be involved in defense responses is given.

2. 1. THE HOST PLANT: RICE

2. 1. 1. DESCRIPTION

The genus Oryza of rice consists of 22 species of which only 2 species are cultivated and rest of them are wild types. One of the 2 cultivated species is Oryza sativa which is most commonly cultivated worldwide and the other one is O. glaberrima which is mainly grown in West and Central Africa. Out of two subspecies of Oryza sativa, one is japonica mainly grown in subtropical and tropical regions and another one is indica rather cultivated in tropical to temperate areas (OECD, 1999).

Nipponbare: The main rice cultivar japonica cv. Nipponbare is used in the research for this thesis because of its scientific importance, such as, genome data of this rice cultivar are publicly available; most of the researches is done on this cultivar and different transgenic lines and mutants of this rice are available (Kikuchi et al., 2003).

Taichung 65: It is wild type rice. Four mutants of this rice namely slr1; gid1-3, waito C and d35 are used in our study.

Rice mutant, slr1 (slender rice1): Ueguchi-Tanaka et al. (2008); Itoh et al. (2002); Ikeda et al. (2001) reported that rice mutant slr1 showed a constitutive GA response phenotype. Gubler et al. (2002); Peng et al. (1997) mentioned that SLR1 gene encoded a putative transcriptional regulator orthologous to barley SLN, maize D8, wheat Rht and arabidopsis GAI and RGA. They referred these proteins to the GRAS regulatory protein family which consisted of the DELLA subfamily. Itoh et al. (2003) described that DELLA acted as suppressors of GA.

Rice gid1-3 mutant: Ueguchi-Tanaka et al. (2005); Sasaki et al. (2003); Itoh et al. (2001) reported that rice gid1 mutant had a GA-insensitive and dwarf phenotype. They reported that rice mutant gid1-1 had a severe dwarf phenotype with dark-green and wide leaf blades which was typical of rice GA-related mutants. Ueguchi-Tanaka et al. (2005) mentioned that as this mutant was inherited in a recessive manner and did not develop fertile flowers, it had to maintain as a heterozygote. They isolated four different alleles of which gid1-1, gid1-3 and gid1-4 showed similarly severe dwarfism whereas the gid1-2 showed slightly milder phenotype. They examined that gid1-1 mutant plants did not show any of the GA-responsive phenotypes. They also found that gid1-2 and gid1-1 mutants accumulated at about 95 and 120 times more GA1 than wild-type plants, respectively which demonstrated that gid1 was a GA-insensitive mutant.

Ueguchi-Tanaka et al. (2005) recorded that GID1 and SLR1 acted in the same GA signalling pathway because a double mutant gid1-1/slr1-1 exhibited the slr1-1 phenotype. They reported that SLR1 was epistatic to GID1 and did not degrade in the mutant gid1plants. Sasaki et al. (2003) reported that GA action was regulated by GA-dependent degradation of SLR1 and inhibition of this degradation showed the GA-insensitive phenotype in plants. GA treatment reduced the amount of SLR1 in the wild type plants but not in gid1-1 mutants.

Rice mutant waito C and d35: They are GA deficient plants and show dwarf phenotype.

2. 1. 2. IMPORTANCE OF RICE:

Rice is an important agricultural food crop. Besides feeding people, it carries a lot of scientific informations. Rice could be model for monocotyledonous plants because of its scientific and social/agricultural advantages (Izawa & Shimamoto, 1996).

Scientific advantages: Though arabidopsis has been serving as a model for dicotyledonous plants for many years, it is different from monocotyledonous plants. Most of the economically important crops, such as, rice, wheat, millet and maize are monocots.

The rice genome is sequenced completely in 2005. The complete rice genetic information will serve as a gold mine for future researches on rice and other cereal species. Phillips et al. (2007) reported that rice (Oryza sativa L.) had the lowest DNA content (389-Mb genome) and its gene content and gene order were found in other grass species used for food which make it