CHAPTER 1

INTRODUCTION

Deepwater rice (DWR) is grown on flood-prone areas that are usually flooded at water depths of 50 to 100 cm or more for one month or longer during the growing season (Kwesi Ampong-Nyarko, 1991; Mazaredo *et al.*, 1996; Natsuki, 1993). The total DWR area covers about 9 million ha in Asia and West Africa (Catling, 1992). DWR is mainly grown in the river basins of the Ganges-Brahmaputra of India and Bangladesh, the Irrawaddy of Burma, the Mekong of Vietnam and Cambodia, and the Chao Phraya of Thailand (David, 1994; Harry, 1997). Some DWR is also grown in the upper and middle basins of the Niger River in West Africa (Mather and That, 1984; International Rice Research Center, 1988).

DWR is a common crop in lowland flooded area, where no other economic crop can be grown in such an environment (Mather and That, 1984). The DWR variety does not response to chemical fertilizer applications, and the yield is relative low (1.8 to 2.0 t ha^{-1}) (Harry, 1997; Maclean *et al.*, 2002; Mather and That, 1984). The major different characteristic among the deepwater rice and the rice in other ecosystems is the deepwater rice has the ability to elongate its internodes as the water rises (Catling, 1992). Planting date of deepwater rice production starts in April to May as direct seeding in the early rainy season. After seed germination, rice plant grows in the moist soil without flood water until late July to August. Flooding has begun in late July to August annually.

In flood condition, deepwater rice plant is able to elongate along the rising of flood water. Average increasing rate of flood water is normally less than 10 cm d^{-1} (Catling, 1992). It has a long growth duration period of 8-9 months in the field, from April to December or January depending on variety. Eleven DWR varieties have been released from 1959 to the present for growing in deepwater area of Thailand by Rice Department, Ministry of Agriculture and Cooperative (Department of Agriculture, 2004b). Most of which are photosensitive varieties except RD17. The average yield ranges from 2.2 to 3.7 t ha^{-1} for photosensitive rice varieties in deepwater conditions, and 4.0 t ha^{-1} for RD17 which is non photosensitive variety. There are two new plant type deepwater rice varieties, Prachin Buri 2 and Ayuttaya 1. Their growth are fluctuated from water depths less than 50 cm to as high as 50 to 100 cm. For cases where water depth does not exceed 25 cm: Prachin Buri 2 and Ayuttaya 1 are able to provide yields as high as 5.3 t ha^{-1} (Department of Agriculture, 2004b). From a practical standpoint, water level is dependent on the amount and distribution of rainfall, which varies from year to year (Maclean *et al.,* 2002). Unexpected onset and unpredictable depth of flooding result in high risks for production. These recommended DWR varieties are able to grow only one crop per year, during the rainy season.

From an economic aspect, DWR production has a low return rate as compared to a rate from flooded rice (FDR) production system. Recently, introduction of a national policy to install regional irrigation schemes (Khun Dan Prakan Chon Dam, Phra Prong Dam, and Kwae Rabom Siyat Dam) has enabled farmers to adopt a double-cropping system of flooded rice. The national policy is intended to provide security in terms of water supply for rice production in the area, and therefore enhance the stability of systems of staple food production. It is an opportunity for farmers to select the other technologies, farmers have used various sources of information to modify their cultural practices for rice production. The farmers in such area have no specific technologies for FDR production because they have been familiar the traditional DWR production for long time. Therefore, more researches and investigations are necessary to achieve sustainable FDR production systems for the farmers in the area.

The FDR is a high yielding rice variety with non sensitive to photoperiod. It has a shorter growing season compared to DWR and reaches harvest maturity at about 90 to 140 days after planting. It can be grown all year round on the area with sufficient water for irrigation throughout the growing season (Department of Agriculture, 2004b). The transition from DWR to FDR has mainly been done through trial and error by farmers. There is, therefore, a need to define alternative technologies for improved decision making.

Fertilizer application plays important role to increase flooded rice yield. Selection of the best combination of fertilizer application rates, times of application and application modes remains a complex process for fertilizer management in flooded rice production. The previous research indicated that up to 40-80% of fertilizer is lost onto the rice field after application due to excessive rates of application and inappropriate application times. More than 60% of fertilizer applied to rice fields is nitrogen (N) fertilizer (Department of Agriculture, 2004a). A FDR production system using a non-photosensitive rice variety is a high-input production system, especially of chemical fertilizer. Fertilizer application for FDR production, as recommended by the Rice Department, Ministry of Agriculture and Cooperatives, is divided into two broad groups: rainfed and irrigated rice production systems. Under clayey soil conditions, rainfed or photosensitive rice production is recommended to apply two times at 20 days after seed germinated and at panicle initiation (PI) stage for the rate of 54 kg N $ha^{-1}$and 31 kg P_2O_5 ha^{-1}, while non-photosensitive rice production has been recommended three times at 20 days after seed germination, tillering and PI with the rate of 88 and 38 kg ha^{-1} for N and P_2O_5, respectively (Department of Agriculture, 2004a). Since most farmers apply an overdose of fertilizer and at inappropriate times, the recommendation of alternative technologies for fertilizer application could simultaneously reduce fertilizer loss and also increase yield. A great deal of field research has been conducted to find technologies to improve N application efficiency. Urea deep placement (UDP) is a dominant technology to increase efficient use of chemical nitrogen fertilizer and increase yields in irrigated rice production system (International Fertilizer Development Center, 2007). However, it is still a lack of appropriate technology for FDR production in deepwater areas to support transformation of the complex rice production system (McConnell and Dillon, 1997).

DWR area where water supply is available in early rainy season and in dry season periods, FDR production would be a better alternative for farmers. The FDR production can produce two crops per year, instead of a single crop from the deepwater rice production system. Transformation from a DWR production system to a FDR production system necessitates a certain set of technologies to ensure profitability and reduce risk like weather and economic. Risk of weather refers to amount and distribution of rainfall which affect on onset, flooding duration and receding of flooding pattern. While economic risk refers to additional input management such as chemical fertilizer application and chemical for disease and insect pest control (Harry, 1997; Maclean *et al.*, 2002; Mahabub *et al.*, 1994).

The transition from DWR to FDR is a critical period. It is completely different in terms of characteristics of rice varieties, growth duration, and management practices (Mahabub *et al.*, 1994). A failed cropping season will likely make a farmer's life difficult for several years on debt and food security of their household (Kawasaki, 2010). Key factors to the success of FDR production include the proper selection of the rice variety, appropriate planting date and suitable fertilizer applications in terms of the time of application, the fertilizer rate, and the mode of application. It is simultaneously a challenge and an opportunity to increase the income of smallholder farmers in such area.

Field experiments and crop models are able to be integrated to evaluate crop yields under different soil properties, cultivars, management, and even different climate scenarios (Hoogenboom, 2000; Hoogenboom *et al.,* 1999). Fertilizer management is one of rice production input that can be simulated to compare the efficiency of N fertilizer application under different modes of application. Soil fertility differs from place to place depending on soil type and soil management (Harry, 1997; International Rice Research Institute, 1989). It is costly to conduct experiment for every soil type. A crop model is powerful tool, and has recently been accepted worldwide. Alternative methods for flooded rice production can be formulated from field experiments and crop simulation models (Jones *et al.,* 2003; Kerdsuk, 2002; Mankeb, 1993).

The overall goal of this study is to assess farmers' criteria for management practices of FDR production systems in a DWR area. Research is conducted to find out the proper alternative set of technologies for FDR production in DWR areas like fertilizer application, rice variety and appropriate planting date. Specific objectives of this research are:

1) To inquire the current situation of the DWR production system and to assess the farmers' criteria to convert from DWR to FDR production system.

2) To identify potential sources of information that aid farmers in their decision making process for crop production during the transition process from DWR to FDR.

3) To determine the effect of planting date, rice variety and fertilizer management practice on growth and yield of FDR production in the deepwater area.

4) To calibrate and evaluate the CSM-CERES-Rice model with data sets collected from the field experiments on the effects of planting date and variety of FDR production system in deepwater area. It is to confirm the applicable ability of the model before applying to formulate the suitable management options in this production system. In addition, the model would make the reader to gain better understanding on FDR production system in deepwater area in term of its components and their effects.

My thesis book is separated in to five chapters including introduction, literature reviews, materials and methods, results and discussions, and conclusions. The second chapter reports a review of literature on the current and challenges of transitional phase from DWR rice to FDR systems and what are constraints to be solved. The third chapter covers materials and methods used in the dissertation and appended by data analysis methods. The fourth chapter shows the results of the study and discussions. This chapter is divided into six parts including, Part 1) Transitional phase from deepwater rice to flooded rice systems in Thailand: Current situation and challenges, Part 2) Effect of planting date and variety on flooded rice production in the deepwater area of Thailand, Part 3) Effect of chemical nitrogen fertilizer management and variety on flooded rice production in the deepwater area of Thailand, Part 4) CSM-CERES-Rice model calibration using GENCALC and GLUE programs to estimate the flooded rice GC under the deepwater area of Thailand, and Part 5) The evaluation of CSM-CERES-Rice model application on effect of rice cultivar, planting date, and fertilizer management on flooded rice production system in the deepwater area of Thailand, and Part 6) The alternative management practices for FDR production and adoption possibility of farmer. The alternative managements are formulated in the part two to part five researches. Then those formulated alternative managements are provided to farmers in the area. Ex-ante analysis technique is used for evaluation the adoption of the formulated set of FDR production practices. Finally, chapter five provides conclusion and specific recommendation for the FDR production in the deepwater areas. Alternative sets of management practices could be a choice of farmers for transition from the DWR production system to the FDR system under the limit of environmental factors and inputs. Rice yield in the deepwater area could be increased by double crop of the FDR production in a year. Moreover, alternative sets of management practices from this research would be convinced the farmers to select the appropriate rice growing pattern for their beneficial from new frontier more than the previous deepwater rice pattern in the world.