# CHAPTER 1

# INTRODUCTION

Rainfed lowland rice (*Oryza sativa* L.) covers about 46 million hectares in Asia and occupies 30% of the total world rice area (Maclean *et al.,* 2002). Water supply for rainfed lowland rice comes from rainfall, which can not be controlled in either amount or timing throughout the growing season. When it has not rained for a long time, soil loses water until rice roots experience aerobic conditions. If rainfall is high and constant, the soil becomes submerged and rice roots encounter anaerobic condition. This means that rainfed lowland rice must undergo physiological acclimation with each change in soil-water regime during crop growth.

In Southeast Asia, the soils of rainfed lowlands usually have low levels of nutrients, especially of nitrogen and phosphorus (White *et al.,* 1997b; Wade *et al.,* 1998). Nitrogen and phosphorus are the most limiting nutrients for plants in rainfed lowland systems. Adequate nitrogen and phosphorus supply is required throughout the active growing period (Bell *et al.,* 2001). In rainfed conditions, rice growth is limited not only by intermittent aerobic and anaerobic soils but also by nitrogen and phosphorus deficiency, which are also related to the soil water status.

In aerobic soil, the main problems for rice plants are the lack of water supply and nutrient availability. The lack of nutrient availability is exacerbated by the effect of a changing soil-water regime on nutrient forms and their availability in the soil (Bell *et al.,* 2001). Marschner (1986) reported that low soil water content reduces nutrient delivery to the roots surface by reduction of both mass-flow and diffusion processes. Moreover, solubilization of nutrients particularly phosphorus in soil solution depends on soil moisture content, so they are less available in aerobic soil (Wade *et al.,* 1998). In addition, the roots of plant under aerobic conditions are normally deeper, which favors better water and nutrient uptake at depth in the layers of the soil profile.

When a soil is submerged, a series of electrochemical and chemical changes occur, which influences the capacity of the soil to supply P. Moreover, oxygen is displaced by water and rapidly depleted (Kennedy *et al.,* 1992). During soil submergence, the pH increases in acid soil, while it decreases in sodic and calcareous soils. The pH changes in soil solution influence nutrient forms and availability, especially phosphorus. Phosphate is released from ferric phosphates as pH increases in acidic soils, while phosphate is liberated from calcium phosphates as pH decreases in alkaline soils (Ponnamperuma, 1972). Rice roots in flooded soil are directly affected by oxygen deficiency. To grow under anaerobic conditions, rice roots transmit $O_2$ to respiring tissues through longitudinal gas channels (known as aerenchyma) found in the root cortex. Aerenchyma development and $O_2$ flux to root tips increase in response to anoxia in the soil (Colmer *et al.,* 1998). However, to prevent radial oxygen losses the formation the aerenchyma is usually associated with the formation of a physical barrier in the outer cortex of the root (Colmer and Bloom, 1998). These physiological changes in the process of acclimation to anaerobic condition may hinder nutrient uptake by the rice roots.

Under rainfed lowland rice ecosystem, the periodic occurrence of aerobic soil condition seems a major adverse effect on phosphorus uptake by plants in low phosphorus soils (Huguenin-Elie *et al.,* 2003). Kirk and Du (1997) have found that rice plants adapt to low phosphorus supply in anaerobic condition by increasing root surface area, aerenchyma, root porosity and root dry mass. The fluctuations in soil-water condition may impair root activity, thus restricting nutrient uptake (Samson and Wade, 1998). However, the function and response of the root system in nutrient uptake under changed water regimes is not well understood. By contrast, functioning of the roots with respect to nutrient uptake under either fully aerobic or anaerobic conditions is reasonably well understood. Therefore, this research proposes to examine how rice plants respond to varying levels of nitrogen and phosphorus supply when exposed to changes from aerobic to waterlogged conditions in the root zone. Specifically, it will be focus on how rice roots adapt to changes from aerobic to anaerobic conditions in low phosphorus supply and how these in turn affect on nutrient uptake, plant growth and yields.

The research is also expected to fill a gap of knowledge in understanding the morphological and physiological adaptations of the rice root system to changing root rhizosphere conditions that affect nutrient and oxygen supply. Understanding the adaptation of rice to changes in water-soil regimes may provide insights for developing nutrient management technologies that will increase productivity of rice in rainfed lowland system. Eventually, it will help farmers to manage the nutrients supply, transplanting or direct seed sowing times of rice crop as well as seedlings preparation in the beds when there is no standing water on the paddy fields. These practices will reduce labor cost and waste crop lands in rainfed lowland rice systems of many countries, but which is of widespread importance in South and Southeast Asia.

The overall aims of this study is to know how growth, yield, and nutrients (N and P) uptake of rice plants under the condition of changing from aerobic to waterlogged soil, which associated with different levels of N and P applications during growing season of rainfed lowland rice. It will pursue the following objectives:

1. To determine the growth, nutrients (N and P) content at different growing stages and grain yields of rice when grown under changing between aerobic and waterlogged soils associated with different levels of N and P applications (Chapter 3).
2. To examine the morphological and physiological adaptations of rice roots to aerobic and anaerobic conditions in low P application (Chapter 4).
3. To determine growth of rice plants in low P application under different soil-water conditions before transplanting (Chapter 4).