Omonrice 12: 69-74 (2004)

# HEALTHY RICE CANOPY FOR OPTIMAL PRODUCTION AND PROFITABILITY

**Nguyen. Van Quyen[1], Pham Sy Tan[1], Chu Van Hach[1], Pham Van Du[1] and X. Zhong[2]**

## ABSTRACT

*Poor rice crop management, especially nutrient application and seeding rate contributes to pest problems and yield fluctuations. In many cases, rice growers did not get benefit because of high inputs for nitrogen fertilizer and fungicides. Therefore, it is essential to aim for growing rice crops with reduced nitrogen application and pesticide use besides maintaining the yield sustainability. The close relationship between certain physiological straits as well climate inside the rice canopy and disease development in response to nitrogen and seedling density suggested "the healthy rice canopy" concept as a viable and productive approach. The main objective is to link the crop and nutrient management tidily together for producing rice crops with better growth, grain yield and disease resistance. To have access to this, various physiological straits of rice crops such as tillering ability, leaf area index, leaf angle etc that might contribute to the changes in microclimate inside the canopy and disease development were reviewed. The recent study on the healthy rice canopy in the Cuulong Delta Rice Research Institute was also briefly discussed.*

**Key words:** canopy index, healthy rice canopy, leaf angle, leaf area index.

## INTRODUCTION

Rice is the most important food grain in the diets of hundreds of millions of the world's inhabitants. In Asia, Africa and Latin America, it is the staple product with annual per caput rice consumption of over 100 kg (Zelendsky 2001). Food grain demand is continuously increasing to meet the populations rising.

The remarked increase in the grain yield of rice plants, especially after the 'Green Revolution', was due mainly to the release of improved high-yielding varieties with the characteristics of high response to nitrogen fertilizer and high tillering ability. However, canopy structure of modern varieties with luxuriant vegetative growth and dense foliar canopy has also created lodging and disease problems that cause crop yield fluctuation and reduced benefit because of high inputs to prevent diseases. Therefore, it is essential to aim for growing rice crops with reduced N application and pesticide use besides maintaining the yield sustainability. The close association between certain physiological traits as well as climate within canopy and disease development in response to N suggested the "healthy canopy concept" as a viable and productive approach (Zhong et al 2003). The 'Healthy rice canopy' is a newly developing concept, which may be initially referred to an idealized canopy with critical physiological traits deemed favorable for growth, grain yield, and disease resistance.

## RATIONALE FOR THE HEALTHY RICE CANOPY

The modern rice varieties suffer from many diseases caused by fungi, bacteria, virus etc. Estimation of losses due to different diseases under various farming systems has not been fully evaluated but in general, it has been estimated to be 10 to 15 percent annually. In certain cases, individual diseases have been reported to cause tremendous losses, even up to 100 percent (Singh 1999). The dense canopy that results from excess tiller production, a typical feature of improved varieties, creates a humid microenvironment

[1] Cuu Long Delta Rice Research Institute, Vietnam

[2] Rice Research Institute, Guangdong Academy of Agricultural Sciences, China

favorable for disease; especially endogenous pathogens as sheath blight and stem rot that thrive in N-rich canopies (Mew 1991).

Although fungicides can be used to eliminate yield loss, farmers must make two to four applications, even more, to ensure a disease-free crop where blast or sheath blight has become endemic. In some cases, farmers do not get benefit because the net income did not compensate for the cost of input, particularly N fertilizer and pesticides. It seems to be a fact that the more N fertilizer farmers apply the more pesticide farmers have to use. This specially becomes a reality with the farmers in some intensive rice cropping systems.

Lodging is also another constraint to achieving higher yields for current varieties when N supply is high, or when stems are infected by diseases such as sheath blight and stem rot. Thus, crop and nutrient management for better canopy should link tidily together for minimizing the input and maximizing profit for farmers. Many researches on nutrient and crop management are taking separately that the interacting effects and the combination of nutrient and crop management for healthy canopy are not always achieved.

In the following sections, the literature relevant to the evolution of the healthy rice canopy concept is reviewed. Recent work on the interactions between nutrient management and disease in CLRRI is also briefly discussed.

**Plant architecture**

Plant architecture includes plant height and leaf angle. It affects light extinction coefficient (K), relative humidity; temperature inside the canopy and plant contact frequency. Although plant height of rice cultivar is a varietal character, it is also affected by environmental conditions (Yoshida 1981). A higher plant density as well as higher nitrogen application normally led to a higher plant height because the competition for light. In the high-density rice field, individual plant trends to prolong their culm to get light. As a result, plant height of the rice crops is more. Short stature reduces the susceptibility to lodging and increases the harvest index (Tsunoda 1962). Shorter culms also require less maintenance respiration and contribute to an improved photosynthesis-respiration balance (Tanaka et al 1966).

Erect leaf angle is a desirable trait for high-yielding varieties because light is used more efficiently at high LAI in an erect-leaved canopy (Yoshida 1976). Whereas, droopy leaves increase the relative humidity and decrease the temperature inside the canopy due to reduced light penetration and air movement (Akiyama and Yingchol 1972) and such a microclimate provides a more favorable environment for many diseases and some insect pests of rice (Yoshida 1976). However, other workers (Duncan 1971, Monteith 1965, and van Keulen 1976) who worked with crop photosynthesis models indicated that the leaf inclination is not too important when the LAI is less than 4 and droopy leaves are even slightly better than erect leaves when the LAI is less than 3. To date, the work done on the relationship between plant height as well as leaf angle and disease development is scarce.

At the moment, crop management, especially nitrogen application and seeding rate, for the healthy rice canopy is aimed at short and stiff culms and erect leaves until the optimum leaf angle is defined.

**Tiller number and leaf area index**

Tillering plays an important role in determining rice grain yield since it is closely related to panicle number per unit ground area. Too few tillers result in too few panicles, but excess tillers cause hight tiller mortality, small panicles, poor grain filling and consequent reduction in grain yield (Peng et al. 1994). Modern rice varieties tiller profusely under favorable conditions, but only about 50 percents of those produce panicles. Unproductive tillers compete for resources with tillers those later produce panicles. Reduced tillering is not only thought to facilitate synchronous flowering and maturity, more uniform panicle size, and efficient use of horizontal space (Janoria 1989), but also reduce disease pressure (Mew 1991).

Leaf area index (LAI) is an important parameter of rice canopy because it is directly and positively related to crop photosynthesis.

However, increasing LAI cause increased shading and tiller mortality and is associated with reduced tillering rate in rice crops (Lei and Wang 1961; Tanaka et al 1966; Yoshida and Hayakawa 1970; and Graf et al 1990). Based on LAI and leaf nitrogen content, canopy index (CI) has been early proposed as a prime quantitative parameter for the healthy rice canopy. It is evaluated as,

CI = LAI x leaf N content

Both LAI and leaf N content are measured at heading stage, and critical canopy index (CCI) was primarily suggested as 39.4 (Jiang et al. 1993).

Additional tillers become unproductive and led to excessive LAI and vegetative growth, and a favorable environment for disease development resulting in a higher percentage of unfilled grains. In the other hand, Zhong et al. (2002) revealed that LAI and plant N status are two major factors that influence tiller production in rice crops. To achieve a CCI in the healthy rice canopy, reduced tiller number for optimization of LAI in high-tillering varieties and precise N management must be clarified.

**Plant nutrients and disease**

Nutrient management is one of the most important practices for high rice production, but nutrient management may affect response of rice to pests as well as development pattern of pest populations due to the change of environments within rice canopy. Among the nutritional factors that influence the level of pest damage in a crop, total nitrogen has been considered to be the most critical. Ou (1985) documented that blast disease was more severity due to higher N application. Savary et al. (1995) figured out the relations of leaf N content, leaf wetness, plan contact and sheath blight (Figure 1). The impact of nitrogen on the outbreak of insect pests and disease, particularly rice blast red-stripped disease, was clearly confirmed in the investigations by Chau et al. (2003). Likewise, the effects of phosphorus, potassium, and silica on ShB are also revealed by Kannaiyan and Prasad (1979), Kannaiyan and Prasad (1978), and Rodrigues et al (2003), respectively.

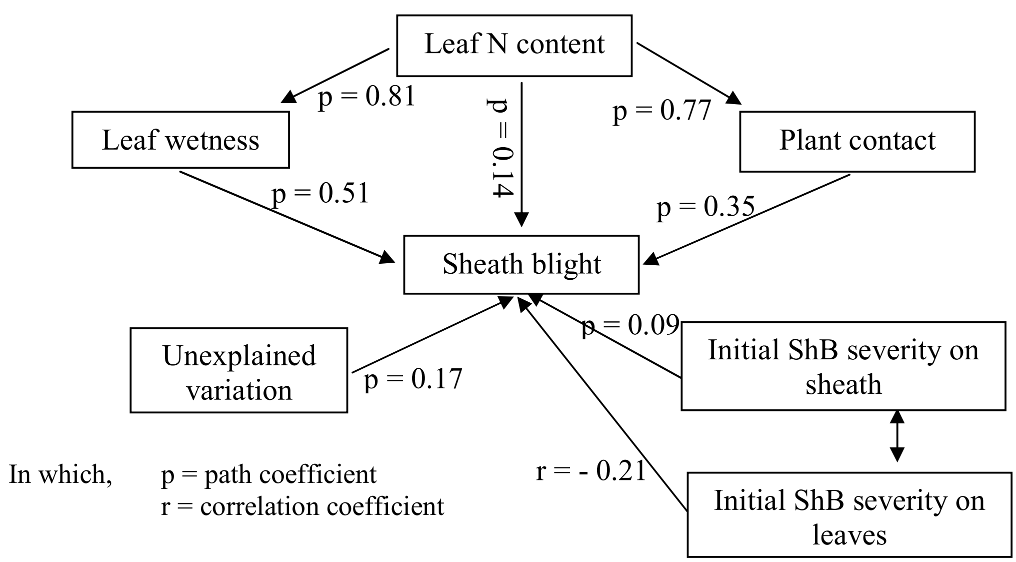


Fig. 1. Effect of Leaf N Content on sheath blight (ShB)

Clearly, nutrient management for rice crops, especially N plays an important role in controlling diseases. Plant nutrients not only influence the nutritional condition for disease development, but also affect crop resistance to diseases. Therefore, under nutrient management aspect the healthy rice canopy is firstly emphasized on a balanced and precision nutrient application.

**Initial crop management strategies for the healthy rice canopy**

Crop management for the healthy rice canopy is basically aimed at optimization of conditions for the best crop growth and yield production as well as disease resistance. Various factors affecting rice crops in terms of growth and disease development are outlined in Figure 2 (Zhong 2003).

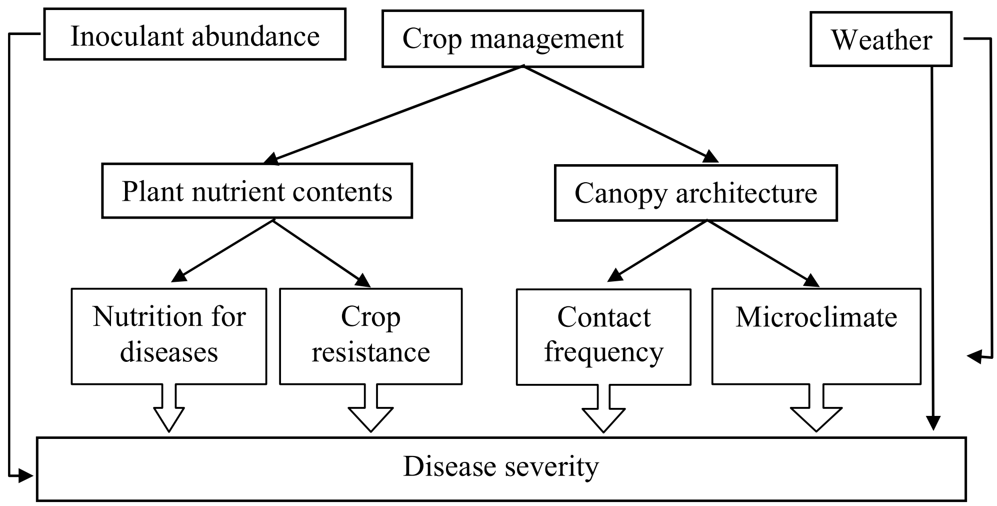


Fig 2. Relationship between rice crop and its environment

This diagram is useful for understanding and recognizing the key factors to make plan of crop management for healthy canopy. Present attempts for the healthy rice canopy are focusing on the following points:

- Optimum LAI and stem number.
- Optimum leaf N concentration.
- High productive tiller percentage.
- Erect leaves with low extinction coefficient
- Good light penetration and ventilation inside the canopy.
- Minimum disease and pest infestation.

To have access to this, plant spacing and nitrogen management for quantitative description of the healthy rice canopy is current work done at the International Rice Research Institute (IRRI), Philippines, the Cuulong Delta Rice Research Institute (CLRRI), Vietnam and elsewhere in China.

**HEALTHY RICE CANOPY: A reality and prospect**

In real terms the work on the healthy rice canopy was stared in wet season 2003 at CLRRI when integrated effects of different seeding rates and N application levels on rice production and disease were tested. Application of N fertilizer 80 kg per hectare significantly reduced the severity of sheath blight (ShB), red strip (RS) and leaf blast (LB) and gave more rice yield than that of 120 kg N per hectare. This is consistent with the results of Tang et al (unpublished data) who found that the yield loss due to ShB was significantly higher under higher N fertilizer application than under lower N application. Disease severity was also more at higher seeding rate (250 kg/ha) as compared to 100 or 75 kg per hectare though the differences were not statistically significant. It was interesting to note that leaf angle (LA) at the critical growth stages (e.g. panicle initiation and heading) was smaller with lower N level (80 kg/ha) and/or lower seeding rate (70 and 100 kg/ha) than higher N level (120 kg/ha) and/or higher seeding rate (250 kg/ha). This means that rice leaves were more erect with lower N application and lower seeding rates. Leaf area index (LAI) was significantly influenced by N levels, whereas seeding rates had a little effect on LAI. This result was consistent with the findings by Zhong et al. (2002). Increase in N input level significantly increased LAI, but did not increase the panicle numbers (data not shown). Thus, LAI value (7.05) at heading stage at higher N application (120 kg/ha) may be thought as an excess LAI for Jasmine-85 cultivar in the wet season at CLRRI conditions. The effect of treatments on microclimate inside the canopy was also recorded in the second replication. The difference in canopy temperature among treatments had reached 0.64 $^{o}$C, whereas, the difference in canopy relative humidity was as high as 7% across treatments.

In a word, precise N application (80 kg/ha) with the help of LCC and reduced seeding rate (100 kg/ha or even 75 kg/ha) produced a more healthy rice canopy and more grain yield. From the pioneering results, the "healthy rice canopy" concept, thus, will go a long and promising way in growing rice profitably.

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***SUMMARY IN VIETNAMESE***

**Nghiên cứu về sự phát triển của một ruộng lúa khỏe nhằm tối ưu hóa năng suất và lợi nhuận**

Kỹ thuật canh tác lúa không hợp lý, đặc biêt là việc quản lý phân bón và mật độ sạ thường làm tăng mức độ sâu bệnh và sự bấp bênh về năng sất lúa. Trong nhiều trường hợp nông dân không thu được lợi nhuận từ việc trồng lúa vì phải chi phí nhiều cho phân bón và thuốc trừ sâu bệnh. Như vậy, câu hỏi được đặt ra là làm thế nào để giảm được việc sử dụng phân bón và thuốc trừ sâu bệnh mà vẫn duy trì được sự ổn định năng suất lúa. Dựa vào mối quan hệ chặt chẽ giữa các đặc tính sinh lý của cây lúa, cấu trúc tán lá lúa, tiểu khí hậu ruộng lúa và sự phát triển của bệnh do tác động của việc bón phân đạm và mật độ gieo cấy đã gợi mở khái niệm "ruộng lúa khỏe". Mục đích của kỹ thuật này là kết hợp chặt chẽ giữa việc quản lý dinh dưỡng và cây trồng để tạo ra một ruộng lúa phát triển tốt, năng suất cao và có khả năng tự chống chịu bệnh tốt hơn. Để tiếp cận và phát triển kỹ thuật này, những nghiên cứu về các đặc tính sinh lý về dạng hình của cây lúa chẳng hạn như khả năng đẻ chồi, diện tích lá, góc độ lá v.v. có ảnh hưởng tới tiểu khí hậu của ruộng lúa và sự phát triển của sâu bệnh đã được lược sử lại. Những nghiên cứu ban đầu về sự phát triển của một rộng lúa khỏe tại Viện lúa ĐBSCL cũng được báo cáo vắn tắt trong bài này.