Chapter 5

DISCUSSION

1. The possibility of *Sesbania*-Rice intercropping

The result from field survey in the Mekong Delta of Vietnam revealed that farmers in rice-based intensive cropping systems were concerned about the decrease in soil fertility due to continuous farming and the dependence on chemical fertilizer. They are willing to grow green manure crops if the appropriate methods are made available for specific conditions. Fortunately, the experiences of farmers currently practicing *Sesbania sp.*-rice intercrop for years in Phong Hoa, Lai Vung (Dong Thap) would be very useful and could be seen as the guideline for further research, though with some necessary modification and improvement. Data from the field survey also indicated that *Sesbania sp.* could be introduced to the rice-based cropping systems by intercropping with the main rainy season rice (from July to November). Figure 13 shows the fitness in growing periods between *Sesbania rostrata* in the field experiment and the current cropping pattern in the target area where the environmental conditions were similar, except in soil fertility. This implies that the intercropping of *S. rostrata* with rice in paddy field is feasible. However, when *S. rostrata* is grown in a large scale, it is necessary to pay attention to some major insect pests which appear during the flowering period of *S. rostrata*, such as Blister beetle (*Mylabris phalerata*), pod-sucking bug (*Riptortus sp.*) and Redbanded shield bug (*Piezodorus hybneri*). Fortunately, these pests do not feed on rice.

2. Interactions between *Sesbania* and rice:

2.1. Competition for light:

Light and N are the main factors influencing the production efficiency of cereal-legume intercropping systems (Ofori and Stern, 1987). Competition for N is not a problem in this case because *S. rostrata*, with the symbiotic rhizobium, can fix nitrogen from the atmosphere and utilize it during the growing period. By this way, *S. rostrata* does not compete with rice for soil nitrogen. *S. rostrata* has been reported as one of the most powerful nitrogen fixing legumes as discussed in Chapter 2 (Section 3.4). Therefore, in this study the emphasis was placed on the competition for light.

Results from this experiment reveal that the decrease in light interception on top of rice in intercrop, caused by *Sesbania* canopy, resulted in delay of panicle formation; the decrease in leaf area index and tillering ability; and severe reduction in rice yield through the reduction in all yield components and harvest index. The earlier the time of *Sesbania* establishment, and the higher the proportions of *S. rostrata* intercropped, the stronger the shading effects were on rice. Matsushima (1970) experienced a similar result by reporting that heavy shading before heading changes the hull size and decreased the 1000-grain weight of rice (adapted from Yoshida, 1983). Yoshida (1983) also pointed out that shading during the vegetative stage affects slightly the yield and yield components. However, during the reproductive stage, shading has a very pronounced effect on spikelet number and yield, while shading during the ripening stage decreases the percentage of filled grains and grain yield considerably. More specifically, Stansel (1975) stated that, for rice, the most critical period of solar energy requirement is from panicle initiation until about 10 days before maturity (adapted from De Datta, 1981). De Datta (1981) also presented that the amount of solar radiation received from panicle initiation until crop maturity is important for the accumulation and partition of dry matter in rice. Thus, shading does not affect only the photosynthesis and assimilation processes, but also on the partition of assimilation materials into different parts of rice plants. Low light interception results in low photosynthates, and less assimilation materials accumulated in grains than in straw. Strong evidences of shading's negative effects, can be seen here, are: significant decreases in total dry matter of intercrop rice; extremely low harvest index; and low grain and N yields of intercrop rice sown simultaneously with *S. rostrata* (as shown in the results). Both source and sink of rice in these treatments were limited by shading.

2.2. Effects on growth and yield:

S. rostrata proved to be a strong competitor. In intercropping with rice, the earlier the time of *Sesbania* establishment the more severe is the depressive effect of *S. rostrata* on growth and yield of associated rice. Plant height, tiller number, leaf area index, dry matter, all yield components and grain yield of intercrop rice were severely reduced by the depressive effects of simultaneous sown *S. rostrata*. The competitive ability of *S. rostrata* decreases greatly when establishment was delayed and its population was low in intercrops. A thirty-day delay in the sowing date of *S. rostrata* did not interfere with intercrop rice during the vegetative stage. Therefore, tiller number and total dry matter of intercrop rice were not much reduced. Shading of 33% sunlight by *S. rostrata* with half population around the flowering stage of rice (Figure 8) caused a significant decrease in grain yield of rice in intermediate sowing treatment. However, shading by 15%, during the flowering period in intermediate sowing treatment with low density (25%) of *S. rostrata*, did not significantly reduce dry matter and grain yield of rice. Late sowing of *S. rostrata* had no effect on growth and yield of intercrop rice.

In contrast, the earlier the time of *Sesbania* establishment, the better the growth rate and the higher the dry matter yield of *S. rostrata* was obtained. This can be explained by photoperiod sensitivity of *S. rostrata*. When sown late, *S. rostrata* flowered and then matured early due to shortening daylength. Growth rate of *S. rostrata* was high during the flowering period of 30-40 days from the on-set to the end of blooming (Figure 10 and Table 5). The strong influence of daylength on flowering behavior of *S. rostrata* has been reported by Becker et al. (1988). Plant height, dry matter, yield components and seed yield of *S. rostrata* were recorded as highest in the early establishment (sown at the end of June) and in sole cropping.

3. Productivity of intercropping

3.1. Dry matter and seed yield:

Total dry matter of rice and *S. rostrata* represent the amount of vegetation from each system which can be partly, or mostly, returned to the soil. *S. rostrata* was very competitive when sown simultaneously with rice. *Sesbania* could produce as much as 17 t/ha of dry matter in pure culture when sown early (simultaneous sowing) -more than double that of rice- but late sowing produced much less biomass (Figure 12). Becker et al. (1990) in a seasonal study on the performance of *S. rostrata* reported that the maximum dry matter of 15 t/ha is obtained when *S. rostrata* is sown in July, and the minimum of 3 t/ha in December. In these treatments, *S. rostrata* dominates the niche throughout the growing season. The greater the proportion of *S. rostrata* intercropped, the stronger is the depressive effect on dry matter and grain yield of rice. Clipping can be introduced to reduce the competition from early established *S. rostrata* on rice at about 30 days after transplanting, when the shading effect becomes severe (Figure 8). Residuals from clippings can be readily incorporated as green manure during the growing season. However, effects of clipping on the regeneration and nitrogen fixation abililty of *S. rostrata* then need to be explored further.

In terms of seed yield of the whole system, all treatments gave similar total yields except the *S. rostrata* sole crop with late sowing date (Figure 12). With early sowing (simultaneous), *S. rostrata* yielded as much as rice in sole cropping and was the main contributor to total seed yield of intercrops. In contrast, rice was the dominator in intercrops with late sowing of *S. rostrata*. In the second sowing date (intermediate), rice and *S. rostrata* had equal share in total seed yield depending on the proportions of population.

Among three sowing dates, intermediate sowing of *S. rostrata* clearly showed the advantage of intercropping. Average RYT values were highest and total dry matter and seed yield of intercrops were over those of both sole rice and *S. rostrata*. In which, the combination of 75 : 25 percent of rice to *S. rostrata* was prominent. ATER value of 0.91

for seed yield was acceptable when time of growing was taken into account (Table 9).

3.2. Nitrogen yield:

Once again, *S. rostrata* proved its high potential in N-contribution to the systems due to its good growth and high capacity of fixing nitrogen. Total N-yield in intercrops was mainly from *S. rostrata* due to its high N-content and shoot dry matter.

The RYT-values for nitrogen yield were greater than 1.0 in the early establishment (e.g., simultaneous and intermediate sowing) (Table 14). This suggests that there are beneficial effects of intercropping in terms of nitrogen nutrition. Higher total N-uptake by intercrops than by sole crops has been reported by Dalal (1974) (adapted from Francis, 1989).

4. Nitrogen contribution:

4.1. Nitrogen fixation:

Nitrogen fixation was calculated by using N-difference method in which rice was used as a non-N_2-fixing reference plant. The major assumptions are that (1) the *S. rostrata* and rice assimilate the same amount of N from soil solution; (2) the amount of N-uptake by sole rice crop is considered as soil N-budget which would be shared by component crops in intercropping treatments. This simple procedure is commonly used when only total N analysis is available (Peoples et al., 1988). Although there is high level of variability in the estimates of nitrogen fixation obtained from different non-N_2-fixing species, Pareek et al.

(1990) reported an acceptable agreement between the estimates of nitrogen fixation from *S. rostrata* and *S. cannabina* by N-difference method and the ^{15}N dilution method using *Echinochloa* and rice as the non-N_2-fixing reference plants.

The average amounts of nitrogen fixed by *S. rostrata* in sole cropping at the ages of 60, 90 and 120 days-old (i.e., late, intermediate and simultaneous sowing, respectively) in this study were about 115-375 kgN/ha. These values were a little low in comparison with the findings of Dreyfus et al. (1983) and Rinaudo et al. (1988) in Senegal (190 kgN/ha), Ladha et al. (1989) in the Philippines (267 kgN/ha) by N (Kjeldalh) balance and Pareek et al. (1990) (240-458 kgN/ha) by ^{15}N dilution method for 50-65 day-old *S. rostrata* (adapted from Ladha et al. 1990). The differences may be accounted for by the different plant density, soil fertility, and method of estimation. It is also said that the amounts of nitrogen fixed in table 15 are always underestimated. The proportion of total root systems and the amount of leaves littered during the growing period, which may contain up to 40 kgN/ha (Peoples and Herridge, 1990, adapted from Pantollana, 1992), were not taken into account.

However, these figures represent the relative comparison among different mixtures and sowing dates. In early establishment of *S. rostrata* (simultaneous) no difference in nitrogen fixation was detected in sole cropping and intercropping. Delaying establishments by 30 and 60 days reduced nitrogen fixation of *S. rostrata* by 47 and 76%, respectively, compared to sole crops with the same sowing dates. Intercrop *S. rostrata* with late sowing shows very low potential of N-fixation.

4.2. N-balance:

The simple N-balance in this section was adapted from the calculation done by Pantollana (1992). The budgets of N were drawn up for each cropping system based only on the above ground plant biomass at the end of growing season and the input of fixed N.

The balance was estimated from the difference between N-input from N_2-fixation and N removal by crops. No account was taken of possible N losses from the system through volatilization, denitrification, immobilization, leaching, soil mineral N and all other external inputs of N to the soil. The main aim of this calculation was placed on the potential contribution of intercropping to the sustainability of the systems, in terms of N nutrition. The calculation was based on two assuming situations. Firstly, assuming that all crop residues are returned to the soil, only seeds are removed. Secondly, all stems of *S. rostrata* are assumed to be used as firewood, like the current practice of farmers in the Mekong Delta of Vietnam.

The results from table 15 implied that N gained in intercrops was mainly due to *S. rostrata,* and the main proportion of nitrogen yield was from stems. Therefore, removal of stems of *S. rostrata* led to the negative balance even in sole cropping. However, the absolute values revealed that intercropping with *S. rostrata* could alleviate the depletion in soil nitrogen.

It also said that the N-difference method used to estimate the amount of N-fixed by a stem nodule legume, such as *S. rostrata,* had a certain limitation. The assumption that *S. rostrata* and rice assimilate the same amount of soil-N can be disproved because the root systems and the capacity for extracting soil-N of the two species may be very different. Additionally, the performance of each species in sole and intercropping may not be identical. Moreover, bearing nodules on stems, *S. rostrata* may not be easily examined by a simple method. It is necessary to develop the appropriate but applicable methods for estimating the N_2-fixation by this prominent stem nodule legume.

In this experiment, the intercropping *S. rostrata* with rice might create difficulty in harvesting rice. In practice, the problem could be solved by adjusting the row arrangement for *Sesbania*, while still keeping the *Sesbania* density at a reasonable level. Strip intercropping of *S. rostrata* and rice (e.g. 5-6 rows of rice and 1 row of *S. rostrata*, as practiced by some farmers in the Mekong Delta of Vietnam) may need to be evaluated. Insect pest's effect on *S. rostrata*, especially, Blister beetle, should be considered when *S. rostrata* is produced in large scale. On-farm studies are needed to validate the feasibility of the results with some modifications.