Chapter 5

DISCUSSION

5.1 Evaluation of component crops in intercropping system

Rice

Viney, indeterminate, late-maturing rice bean used as intercrop sown either at the same time or two weeks after rice severely depressed the dry matter and grain yields of rice but when the bean was sown late into rice (4 weeks after rice sowing), yield was not so depressed although lower than monoculture yield. Grain yield of intercropped rice was greatly reduced due to suppressive effects of rice bean. Rice bean strongly competed for resources like nutrients, light, and water. Rice from the intercrop treatment with the bean sown late into rice had yield although low, possibly due to lesser competition with rice bean. Rice was already at maximum tillering stage, and probably rice had already used up most of the soil N when rice bean was introduced.

Such a response is consistent with a recent study in India by Mandal et al. (1990) where the result showed that upland rice was less competitive in intercrop with rice bean and blackgram. The yield of upland rice in the intercrop was only 31% of its monocrop yield. When the sowing of rice bean was delayed 30 days after rice sowing, the depression in rice yield lessened. The authors suggested that deferred sowing of the legume lessened the competition from the legume on rice by diverting demand for nutrients, water, etc. at different periods.

Rice bean

Rice bean grew vigorously in both monocrop and intercrop treatments except in the intercrop treatment where it was sown late into rice. In the other treatments, it was observed that rice bean was very suppressive to rice. It dominated the area in the treatments with simultaneous sowing so with intermediate sowing. Rice had little effects on rice bean growth and yield.

In late sowing treatment, rice bean could no longer cover the rice plants but some of the beans still climbed up the rice plants. Rice was already taller, thus slightly covering the rice bean plants that may render the rice bean plants less competitive in the systemAt stage V20, rice was already harvested. It can be observed that rice bean plants recovered. Owing to the indeterminate characteristic of rice bean in which it continues vegetative growth along with pod development, when the rice plants were harvested, clearly there were no more competitive effects of rice on rice bean. Dry matter production showed no significant differences from stage V20 and onwards (Table 4).

Within two weeks after sowing, rice bean canopy already started to cover the soil. This is of advantage for upland areas because rate of ground cover was fast, this may help to reduce soil erosion. The indeterminate nature of rice bean would also contribute to its effectivity as ground cover.

5.2 Intercropping system evaluation

In this study, intercrop efficiencies with respect to sole crops were evaluated in terms of land equivalent ratio (LER). LER considers intercop productivity or defines yield as a function of area.

Rice and rice bean yields in the intercrop system with rice bean sown late into rice, measured in terms of LER for grain, dry matter and total nitrogen yields, indicated a clear advantage of intercropping, compared with their monoculture yields or with the other intercropping treatments.

Although the intercrop total grain yield was lower than monoculture rice yield, the LER value is more than one. The LER value of 1.49 means that it would require 1.49 hectares of monoculture production to produce the same quantities of the same commodities as one hectare of intercrop production. Or, it indicates the intercrop to be 49% more efficient at producing these particular crops; it also indicates a biological advantage for such an intercropping scheme over the monoculture. This value weights the component crop according to the area in the intercropping system. That is, it compares the rate of yield of intercrop with rate of yield of the monoculture.

The total yields of shoot dry matter and total nitrogen of both rice and rice bean when intercropped were also all above their respective monoculture and intercrop yields which also imply beneficial effects of intercropping for both species.

5.3 Nitrogen fixation

The nitrogen-fixing ability of the legume has been indicated to be the basis for attaining advantages in legume/nonlegume intercropping systems (Rerkasem et al., 1988; Vandermeer, 1990; Willey, 1979).

Rice bean in this study derived more proportion of its nitrogen from fixation when intercropped with rice than when it was grown in monoculture. The later the bean was sown into rice, the more proportion of its nitrogen were derived from fixation when compared with their respective monoculture nitrogen fixation. This is in line with the study of Rerkasem and Rerkasem (1988) in which rice bean derived a larger proportion of its nitrogen from fixation when intercropped with maize than when it was grown in monoculture. It was observed that the amount of nitrogen in the intercrop that exceeded in the maize crop, which represented available mineral nitrogen, could be accounted for by the amount fixed by rice bean. The intercrop advantage in this study, in terms of dry matter, grain, and nitrogen yields, was associated with an enhancement of nitrogen fixation by the legume.

From the current study, results indicated that both upland rice and rice bean contributed towards the observed intercrop advantage. Utilization of nitrogen sources at different times by the two species may be responsible for the observed effect. In the intercrop treatment where rice bean was sown late into rice, the Pfix value reached maximum of 100% at stage V20. This may indicate that uptake of mineral nitrogen by rice may have stimulated the rice bean to depend more on fixation. When rice bean was at stage V20, rice was already harvested which means that rice had already used up most of the soil nitrogen thus, depriving the rice bean from available mineral N, which then stimulated the rice bean to derive more of its nitrogen requirements from fixation.

5.4 Effects of rice bean cropping systems on a subsequent corn crop

The capacity of leguminous crops to utilize atmospheric nitrogen can have desirable consequences: the crops may have high protein content, they do not require as much nitrogen fertilizer as other crops and, in some cases, they can enrich the soil with nitrogen to the benefit of other crops grown with or after them (Bandyopadhyay and De, 1986; Wahua and Miller, 1978; Weil and Samaranayake, 1991). Residual effects on a subsequent crop following the growth of legumes are frequently attributed to N2 fixation (Peoples et al., 1989) although there might be other benefits such as improvements to soil structure or control of pests or diseases.

All the preceding bean treatments significantly yielded higher corn grain, shoot dry matter and total nitrogen than sole rice. This could be attributed to the residual N from the rice bean plants. Possible mechanisms of residual N may be due to sloughing off of nodules and root system decay, leaching from leaves, and decomposition of fallen leaves. Mineralization of nitrogen and making this available to the following crop may contribute to the N requirements of corn thus favoring good growth. Bandyopadhyay and De (1986) also observed the same response in a study on the residual effects of intercropping sorghum with legumes (groundnut, mungbean and cowpea) to following wheat crop. Wheat yield after the intercrop of sorghum with legumes was more than after sole sorghum. They noted that death and decay of legume root nodules benefited the sorghum grown concurrently and part of it was carried over to be utilized by the subsequent crop of wheat.

5.5 Nitrogen balance in rice-corn, and rice/rice bean-corn cropping systems

A simple diagrammatic representation on the nitrogen balance of the cropping system is shown in Figure 5.

Budgets of N were drawn up for rice-corn and rice/rice bean-corn cropping systems based only on above-ground plant biomass over the crop growth cycle and inputs of fixed N. No account was taken of possible losses of N from the system through volatilization, denitrification, immobilization, and/or leaching, or inputs of N in the soil from root biomass, organic matter, rainwater, dust, animal droppings, irrigation water, etc. It was therefore assumed that all of the N of crop residues was returned to and retained within the soil after harvesting of seeds.

Box 1 of the diagram shows the inputs and losses of N in the system (amount of N not determined are in broken lines). Differences in nitrogen inputs from N2 fixation could be observed basing from the various treatments imposed to the system. Intercropping treatments favored better fixation than monocropping system. Estimates of N2 fixation determined from ureide analysis indicated the enhancement of N2 fixation in intercropped rice bean, especially in the treatment where the bean was sown late, 30 days after sowing rice.

Removal of N from the system through seed N yields of both rice and rice bean crops are considered. The nitrogen balance (NB 1) at Year I (Box 2) after the first cropping (rice monocropping and rice/rice bean intercropping systems) is calculated basing from the amount of seed N yields of the rice crop; for Year II (Box 3), the residual N from the first cropping followed by corn is being considered.

In this study, after seeds were harvested (from first experiment), the nitrogen balances after rice/rice bean intercropping were positive, and monorice had a negative balance. Basing from the amount of nitrogen fixed alone then subtracting the amount of seed nitrogen, the balance is positive although lower but actually the apparent advantage of intercropping in the balance is higher considering the

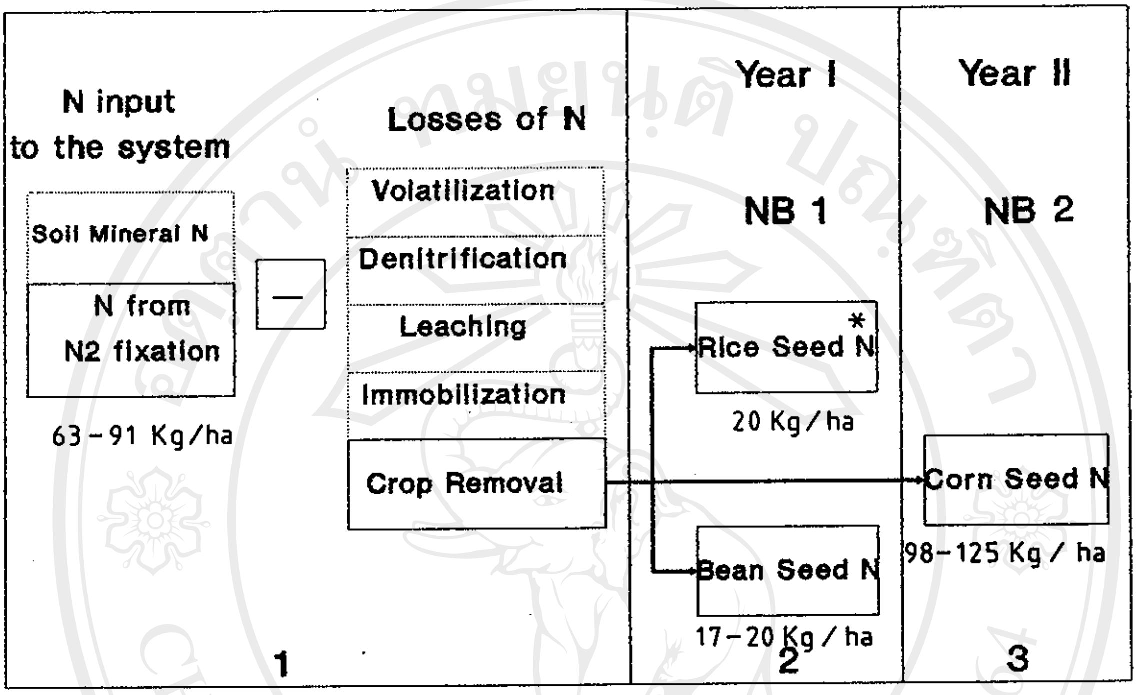

Figure 5. Simple diagrammatic representation on the nitrogen balance of the cropping system. (---) Represents the amount of nitrogen not determined; NB Nitrogen balance; * No rice yield from the other intercrop treatments (in simultaneous and late bean sowing).

amount of mineral nitrogen in the soil. It is also said that there is always an underestimation in the amount of nitrogen contributed by the legume. For example, the proportion of the total root system that might be decomposing, and thereby releasing mineral N to the soil during growth, is not estimated. Leaf fall during legume crop crop development and nodulated roots can each contain certain amounts of nitrogen, may each contain up to 40 kgN/ha (Peoples and Herridge, 1990), can also contribute to the N-balance of the system. Levels of fixation achieved by many crops in the field may be high, but are not always sufficient to offset the N removed with the harvested seed (Peoples and Herridge, 1990).

For the N balance after rice/rice bean intercropping and corn cropping sequence, all balances are negative, with the highest negative balance after the preceding monorice treatment. Much of the unexpected benefit probably result from the use of a cereal-cereal cropping sequence as the "bench mark" comparison from the performance of a cereal-legume intercropping and cereal sequence. Even when most of the N is removed in legume seed or cereal seed, and there is little or no net gain or negative N in the soil, a much higher loss of N would be expected from a nonleguminous/nonfixing crop when its seed is harvested (Peoples and Herridge, 1990). Apparently, the sole rice crop exhausted soil N much more than the bean monocrop and rice intercropped treatments.

The balance from the previous intercropping treatment with intermediate sowing of the bean (bean sown two weeks after rice) was the least negative balance. Whereas the real balance of the intercropping treatment is -29.5 kgN/ha, the residual N could be assessed by comparing seed N yields of rice-corn versus rice/rice bean-corn sequence (Table 13). The seed N removed from the former is 61.6 kgN/ha and the N loss of the later through removal of corn cobs and seed is -29.5 kgN/ha. Therefore the apparent benefit is 32 kgN/ha.

Considering that rice bean has a lower nitrogen harvest index (Rerkasem and Rerkasem, 1989), and owing to its indeterminate growth characteristic, the higher is the amount of residual N that could be returned to the soil. However, often the proportion of legume N mineralized is usually reduced by the mobilization and reallocation of N to reproductive parts during seed filling and senescence (Peoples and Herridge, 1990).

The nitrogen balance of the cropping systems, when considered in the long run would not be sustainable because it would mean soil fertility depletion and would render the soil unproductive. Even if the real balances of the systems are negative (basing only from the amount of N fixed by the legume) knowledge on how to quantify the amount of N fixed from the atmosphere through nitrogen fixation by legumes would be useful in the management of cropping systems. It would be useful in the sense that the understanding of nitrogen balance (input-output) in cropping systems, will lead to the management of nitrogen to minimize cost of nitrogen fertilizer and level of effectiveness of the nitrogen fixing symbiosis in intercropping systems could be identified and its limitations also identified and remedied (Rerkasem and Rerkasem, 1989).

Moreover, the development of sustainable farming systems would require an understanding of the amount of N2 fixed by legumes as influenced by cultural practices, thus allowing development of efficient agricultural production systems. Measurement of N2 fixation allows proper assessment of the potential benefits from the input of fixed nitrogen or sparing of soil N by the legume. And also, ecological considerations require an understanding of the relative contribution of N2-fixing components to the N-cycle (Peoples et al., 1989).

5.6 Economic considerations

Yield comparison of component crops in four cropping systems and the gross economic return of such systems are shown in Tables 14 and 15, respectively. Results in Table 15 show that rice/rice bean (with late bean sowing) intercropping and corn cropping sequence was significantly more profitable and the probability of break-even is better than monorice and corn cropping sequence. Under a different price structure, the same yield of the same commodities could generate different relative incomes. However, the diversity and nature of interplanted crops may add to income stability. Thus, rice/rice bean intercropping and corn cropping sequence, which produced a higher rate of return (relative to the other systems under the local price structure), may also provide more security than rice bean or rice-corn sequence because of more stability across agronomic conditions.

In addition to high profitability and stability, the price of rice bean seeds are 2 and 3 times higher than that of rice and corn, respectively, due to its higher nutritive value (20.9 g protein per 100 seed), thus, the farmers can expect a higher economic return from rice/rice bean intercrop and corn sequence.

Table 14. Component crop yields (t/ha) of four cropping systems.

Cropping system	Rice	Rice bean	Corn
Monorice - corn	2.75	-	5.40
Monorice bean[1] - corn	-	.63	8.52
Monorice bean[2] - corn	-	.61	7.53
Rice/rice bean[2] - corn	1.67	.52	7.34
LSD 0.05	1 *	NS	.90 **

Table 15. Gross return[a] (Bht/ha) of four cropping systems.

Cropping system	Rice	Rice bean	Corn	Total
Monorice - corn	9624	-	15650	25280
Monorice bean[1] - corn	-	5054	24700	29760
Monorice bean[2] - corn	-	4854	21840	26690
Rice/rice bean[2] - corn	5838	4146	21290	31270
LSD 0.05	3482 *	NS	2596	3573 *

1. Rice bean sown at the same time with rice.
2. Rice bean sown four weeks after rice.
a. Yield x price/kg, where, price/kg (Bht/kg): rice = 3.5; rice bean = 8; corn = 2.9 (OAE, 1990)

Note: Expenses in each cropping system are considered the same so can be ignored for purposes of calculations.