# DISCUSSION

## I Soybean Yield

Soybean yield was slightly increased by nitrogen treatment (P=0.18). In the treatment without nitrogen applied to either rice and soybean, the seed yield was 1.69 t/ha, compared with 1.91 t/ha in the treatment with highest nitrogen, 300 kg N/ha applied to rice plus 50 kg N/ha to soybean. The soybean dry matter and total nitrogen uptake, however, were significantly increased by increasing nitrogen levels. Furthermore, close relationships were founded between shoot dry matter and yield (r=0.88), and total nitrogen uptake and yield (r=0.90) in this experiment.

In the other studies (Welch 1973) seed yield often showed no response to fertilizer or residual nitrogen. In those cases combined nitrogen in the soil was probably not so low that limited nitrogen fixation which could supply fixed nitrogen for plant vigorous growth.

## II Nitrogen Fixation

Lower shoot dry matter and total nitrogen uptake were related to low levels of soil combined nitrogen and available soil nitrogen (Fig. 2). In this experiment, the treatment without nitrogen applied to both rice and soybean resulted lower in shoot dry matter accumulation and nitrogen uptake than that with nitrogen fertilizer application (Table 2). This may imply that in soils in low combined nitrogen, soybean at the early stage could not absorb enough nitrogen from the soil, causing a nitrogen stress to soybean. This early stress depressed soybean growth and subsequently limited nitrogen fixation, which reflected in the low amount of nitrogen fixed in treatments with low levels of combined nitrogen (Table 4). This indicated that due to early depression of soybean growth and reduction of nitrogen uptake from soil, plant was not able to fix as much nitrogen from the air as that grown with moderate levels of combined nitrogen. This result was consistent with the common observation (Streeter 1987) that early nitrogen deficiency can depress growth and photosynthesis, which may subsequently limit nitrogen fixation, and that fixed nitrogen alone is not sufficient for maximum nitrogen apply in soybean. Hansen (1984) found that soybean relying entirely on symbiotic nitrogen only had

only half nitrogen uptake of those given some combined nitrogen.

Residual nitrogen form 100-300 kg N/ha to rice or 25-50 kg N/ha starter nitrogen to soybean were sufficient for maximum nitrogen uptake and fixation. Further increase in nitrogen fertilizer, as when the starter nitrogen was added plus the nitrogen applied to rice, proved to be unnecessary. At the highest level of combined nitrogen, i. e. 300 kg N/ha applied to rice plus 50 kg N/ha starter nitrogen to soybean, where available soil nitrogen was also high, shoot dry matter and total nitrogen uptake was similar with that of moderate nitrogen treatment (Table 2). This means that moderate level of combined nitrogen was enough for soybean growth and further increase in combined nitrogen does not affect plant growth. This agrees with the result reported by Herridge (1984) on effects of nitrate on nitrogen fixation of soybean stating that oversupply nitrate had no effects on total nitrogen uptake.

However, this high levels of combined nitrogen depressed nitrogen fixation(Table 4) through inhibiting nodule formation and the proportion of plant nitrogen fixed (Fig. 3, Table 3). This result was in accordance with studies conducted by Hansen (1988) on

symbiotic performance of soybean grown at different nitrogen regimes which stated that high nitrogen level caused low nitrogen fixation. The reasons that high combined nitrogen affects nitrogen fixation has been summarized by Marschner (1986) in two aspects. One is through the action of nitrate reductase on nitrate, and synthesis and accumulation of nitrite ($NO_2^-$), which leads to a decline in the nitrogenase activity. The other is through limiting energy sources. When high nitrogen is supplied to the plant, a considerable proportion of carbohydrate is required for amino acid and protein synthesis, a corresponding low proportion of carbohydrate is available for the nitrogen fixation, thus nodulation is inhibited and nitrogenase activity of the nodule declines, nitrogen fixation is low.

## III Soybean Nitrogen Balance

The advantage of growing soybean in agricultural systems reflects its potential capacity to fix large amounts of atmospheric nitrogen. If the soil nitrogen status is to be improved as a result of soybean cropping, nitrogen fixed by soybean must exceed nitrogen removed in the harvest. In this study, after seeds were harvested, there was a small amount of nitrogen left in soil at moderate nitrogen levels, and in low nitrogen level, nitrogen fixed was equal to

nitrogen removal, but negative nitrogen balance was found in high nitrogen level as shown in Table 6. Similarly, in the high nitrogen soil, Bergersen (1985) found that the amount of nitrogen fixed by soybean was insufficient to compensate the nitrogen removed by seeds, but there was positive nitrogen balance if soil combined nitrogen was reduced by previously growing a crop of oats, which lead to an increased in an increase of nitrogen fixation.

However, when straw was also removed, which a normal farm practice in Chiang Mai, a negative nitrogen balance was found in each treatments. In this case, soil nitrogen pool was depleted in all treatments. Therefore, soybean crop in rice based cropping systems may also reduce soil nitrogen.

## IV Economic Considerations

Nitrogen balance was improved after rice-soybean cropping system when high rates of nitrogen fertilizer was applied to the rice crop, However, in term of both nitrogen balance and economic (Table 7), considerations, 100 kg N/ha applied to rice crop plus without nitrogen to soybean appeared to be the best nitrogen application rates for rice-soybean cropping system.

Table 7 Net income comparison of rice-soybean cropping system*

| Treatment | | Rice** | | Soybean** | | Total | Fert. Cost | | Total | Net income |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Yield (t/ha) | income (฿/ha) | Yield (t/ha) | income (฿/ha) | (฿/ha) | Rice (฿/ha) | Soybean (฿/ha) | (฿/ha) | (฿/ha) |
| R0 | S0 | 2.88 | 11520 | 1.69 | 13528 | 25048 | 0 | 0 | 0 | 25048 |
| | S25 | 2.88 | 11520 | 1.83 | 14632 | 26152 | 0 | 407 | 407 | 25745 |
| | S50 | 2.90 | 11600 | 1.84 | 14688 | 26288 | 0 | 815 | 815 | 25473 |
| R100 | S0 | 5.04 | 20160 | 1.80 | 14432 | 34592 | 1630 | 0 | 1630 | 32962 |
| | S25 | 5.02 | 20080 | 1.84 | 14728 | 34808 | 1630 | 407 | 2037 | 32771 |
| | S50 | 5.06 | 20240 | 1.86 | 14880 | 35120 | 1630 | 815 | 2445 | 32675 |
| R300 | S0 | 3.33 | 13320 | 1.82 | 14560 | 27880 | 4891 | 0 | 4891 | 22989 |
| | S25 | 3.36 | 13440 | 1.84 | 14728 | 28168 | 4891 | 407 | 5298 | 22870 |
| | S50 | 3.36 | 13440 | 1.91 | 15304 | 28744 | 4891 | 815 | 5706 | 23038 |

* All cost other than fertilizer same in each treatment, so can be ignored for the purpose of calculations.

** Price: rice = 4 ฿/kg, soybean = 8 ฿/kg, urea = 7.5 ฿/ha (Student Case Study, 1989).