CHAPTER 5

DISCUSSION

5.1 The role of food legumes in farming systems

5.1.1 Food legumes and human activities

According to result of survey in 1995, a considerable amount of food legumes was used in farmer's meals, and about 40 % of farmer's daily meals had food legumes (Table 6). When asked on the role of food legumes in human nutrition, majority of farmers said that food legumes play an important role in their diets (Table 7) in terms of quality and quantity. Living in the mountainous region with the difficulties in transportation and other economic aspects, the people had to produce themselves everything they need, in which food and foodstuff were the most important things. In this condition, food legumes with their capacity of wide adaptability that may be grown everywhere in the soil conditions of the smallholder households, can meet partly nutritional requirements in daily meals of the indigenous people in the region. In regard with the role of food legumes in human nutrition in Asia, Wijeratne and Nelson (1987), Nelson *et al.*, (1979) also reported that a large number of traditional food preparations of Asian people are made from various species of food legumes. Most farmers in three surveyed villages said that foods prepared from food legumes such as sprouted beans, soy curd, soy sauce have been the traditional and very popular foods in their diets, and processing food legumes for these traditional foods has been their familiar activity. The people like to use foods made from food legumes, because they have two advantages to be: (i) reasonable price and (ii) high nutritional quality. At the time of survey in 1995, the price of soy curd in the local markets was about 4000 dong kg^{-1}, sprouted beans was 1500 dong kg^{-1}, while the price of beef was 22000 dong kg^{-1}, pork was 15000 dong kg^{-1}. In respect to aspects of nutrition, the traditional foods made from food legumes are rich in protein with high quality (Wijeratne and Nelson, 1987). Almost all farmers in three surveyed villages said that apart from seeds, edible vegetable parts of some species of food legumes such as black gram, soybean were also utilized as green vegetable sources in their daily meals. The result of survey also showed that 100 % of farmers in three surveyed villages grew food legumes (Table 6). The smallholder farmers grow food legumes with different species in the small plots surrounding their house or on the marginal lands in order to create food source for themselves. The small scale production with low inputs were essential features of the self-sufficient economy of the farmers in the mountainous regions, especially for ethnic minority groups. (Dau et al., 1991; Sam, 1994). Food legumes with considerable diversity in species and responses with environmental conditions can be grown in the different conditions of environment.

On the other hand, the human production activities have been related closely to food legume production for a long time. Every year, when the spring comes with the temperature starts increasing and soft rains appear, the farmers start growing food legumes. And growing food legumes in March became traditional activities in agricultural production of the farmers in most provinces of the region. Even if this activity entered the folk-songs and proverbs of the indigenous people, for example, " When glow-worms fly out, bombax flowers fall down (occur in March), sesame is seeded", or "March is growing season of beans".

The labor distribution and utilization are cardinal aspects of human activities in agricultural production. With the development of food legume production, labor use became more efficient in terms of the working time and labor sources (Table 7). Crop management practices in food legume production such as sowing, weeding, harvesting and processing can be done by all sources of labor from children to old-age people in the households. On the other hand, the labor forces were also used year-round if food legumes are introduced in the production. Because during the spring from February to April the rainfall is not enough to grow other crops, and this period is often fallow period if food legume were not grown. With the fallow-cereal crop systems that is still existing in some locals, the labor sources were not utilized during fallow period.

In the conditions of suitable crop management with inputs of fertilizers and pesticides, food legume production was profitable. The results of survey (Table 6) and calculation of economic return in the field experiment (Table 19) indicated that farmer's income can be increased by growing food legumes with conditions such as price, consumption markets, agronomic conditions are improved and stable. However, in fact, the farmers just want to grow more food crops than food legumes. Because one of the most important reasons was lower and more unstable productivity of food legumes than cereal crops (Table 9). The pest damages along with variation of the weather conditions in the status of low input production were main reasons for low and unstable productivity of food legumes. Besides, low price, lack of capital and poor consumption markets were limiting factors for growing food legumes in the region (Table 10).

5.1.2 Food legumes as a feed source for livestock

Majority of farmers considered food legumes as a valuable source of feed for livestock (Table 7), and about 50-70 % of farmers in three surveyed villages used food legumes for their animal production (Table 6). When asked on the role of food legumes in animal production, farmers said that although amount of food legumes used for animal feed at present was not so large because of their economic limitations, but food legumes were still considered as a high-quality source of feeds for their animals.

Legume seeds are sources of energy, fibre, amino acids, minerals and essential fatty acids. The amino acid pattern in legumes is normally high in lysine and low in sulfur amino acids. Tryptophan is al so marginal in many legumes. However, legume proteins are generally considered to be high protein quality. Batterham and Egan (1987) also reported that for ruminants, legumes appear to have an advantage relative to cereals in that they can cause little disruption to the microflora of the rumen when introduced in high qualities. And food legumes contain relatively low level of starch and high level of fibre compared to cereals. This results in slower fermentation by rumen microflora, and consequently reduced build-up of volatile fatty acids and lactic acids. This in tern results in minimal effects on rumen pH compared to that which occurs with the sudden introduction of cereal grain to the diets. However, the major limitation of the feeding of legume proteins is the concern about levels of antinutritional factors in these seeds to be: (i) protease inhibitors and (ii) metabolic inhibitors (Batterham and Egan, 1987).

5.1.3 Food legumes in cropping systems

In the Northern mountainous region of Vietnam, Food legumes were traditional crops. Results of survey showed that food legumes were grown mainly in the uplands during the dry season from March to June with different cropping patterns (Fig. 3). However, in the lowland with irrigation, some species of vegetable beans were also grown as the winter vegetables after two crops of water rice.

Since food legumes are known as considerable diversity in their response to water deficits and these differences are often reflected in their utilization in cropping systems in rainfed areas, so they are cultivated over a wide range of environments as rainfed crops on a small scale by smallholder farmers (Wood and Myers, 1987; McWilliam and Dillon, 1987). On the other hand, whenever a legume and a non-legume are grown together in a cropping system, the legume is expected to provide most of its nitrogen through symbiotic nitrogen fixation, and also to supply some of nitrogen requirement of the non-legume crops. Thus, it may substantially reduce the input of fertilizer N required to growth the non-legume crops (Myers and Wood, 1987). In the mountainous region of Northern Vietnam, food legumes such as Soybean, peanuts, mungbean, cow pea or black gram are often grown intercropping with corn or cassava (Fig 3). This practice proved advantages in terms of economic return and soil protection from erosion and soil fertility maintenance (Dau *et al.*, 1991). Almost all farmers said that residues from food legumes after harvesting contributed to improving soil fertility, especially in terms of soil nitrogen and organic matter content (Table 7). Myers and Wood (1987) also reported about provision of fixed nitrogen of food legumes to another crops. The authors concluded that a considerable amount of N in crop residues (83-141 kg N ha^{-1}) of food legumes can supply for next crops if the residues are returned to the soil.

According to the results of survey as shown in Table 7, majority of farmers said that legume and nonlegume rotation decreased damages caused by pests for subsequent crops. McWilliam and Dillon (1987) also supposed that advantages of growing legumes are to break the cycle of cereal cropping and reduce the incidence of soil-borne diseases Because each species of plant requires variously on mineral nutrients for its growth. The continuous cropping to cereals or other non-legume crops often leads to depletion some specific mineral nutrients and decrease the yield (White *et al.*, 1969). This situation will be improved if food legumes are introduced in the rotation with cereal crops. On the other hand, growing the same crops continuously in the same field often encourages accumulation of diseases and insects and should be avoided. It is best to rotate legumes with cereals, because this cropping system will use fully land, labor and water resources.(Na Lampang, 1985)

5.1.4 Food legumes and soil environment

Intercrops of food legumes and non-legume crops contributes to protection of soil from erosion during rainy season. The climate conditions in the region indicated that rainy season from May to October often concentrates more than 80% of total annual rainfall. Therefore, soil erosion seriously takes place in this period. The result of survey indicated that intercrop of food legumes with corn or cassava was popular cropping systems in the region (Fig. 3). Most farmers supposed that these intercropping systems were the best way to exploit land resources as well as to protect the soil from erosion (Table 7). Because with the rapid growth, short stems and large leaf area index, food legumes can create rapidly large coverage resulting in preventing the soil from erosion. Bruce *et al.* (1987) also indicated that leguminous crops are significant for protecting the soil from erosion, especially on the slopping lands, because they increase organic matter in the surface soil as well as water infiltration and soil aggregation (Bruce *et al.*, 1987).

The fertility of most cultivated lands in the region have reached a critically low level and is still declining seriously by erosion (Siem and Phien, 1992). In some areas, especially steep land areas, crop yields have already declined below their former level and are continuing downward. Depletion of soil fertility was inevitable under the methods of exploitative farming long. The result of survey in three villages showed that most farmers supposed that growing food legumes increased soil fertility (Table 7). Whyte *et al.* (1969) also reported that food legumes, although a large amount of nitrogen contained in the seed removed from the field, their residues after harvesting also contribute considerably to improve soil fertility in terms of organic matter, nitrogen content as well as soil structure.

5.2 Responses of soybean and peanuts to soil improving measures

5.2.1. Responses to P

Low available phosphorus content in the soils was one of the most important factors limiting yields of food legumes in many Asian countries (Craswell *et al.*, 1986; Dickson *et al.*, 1986; Tiaranan *et al.*, 1987).

The results of survey and soil chemical analysis in three villages al so indicated that almost soils in the mountainous region of Northern Vietnam were very poor in available phosphate. The available phosphorus content in the soil ranged from 3.7 to 5.1 ppm (Table 4). While, the critical level of available phosphorus content in the soil for food legumes is considered to be around 8 ppm (Tiaranan *et al.*, 1987).

The effects of P application on growth, development and yields of soybean and peanuts were presented in the results of the field experiment (Chapter 4), and indicated that in this soil conditions, P was the most important mineral nutritional element for increasing the yields in both species, because P application gave the highest yield increse as compared with N or L applied alone (Fig. 15). However, responses to P in soybean and peanuts were obvious different. Soybean responded to P more strongly than peanuts. For example, applying P increased significantly LAI at R6.5 in both species (Fig. 6), but this increase in soybean (90 %) was greater than that in peanuts (60 %). With respect to nodulation, nodule number was increased by 180 % in soybean, but only by 110 % in peanuts when P was applied (Fig 7). Effect of P on dry matter yield also varied among two species, i.e., P application increased dry matter yield (at R6.5) by 110 % in soybean, but only 80 % in peanuts (Fig. 9). Seed weight was also increased markedly by applying P (Table 20), but the increase in soybean was greater than in peanuts. Especially, effects of P on growth and development of plants were presented most clearly in the effect on economic yields. Applying P increased economic yield by 95 % in soybean, but 65 % in peanuts.

Liming considerably decreased effect of P on growth and development in both species. For example, liming decreased effect of P on nodule dry weight in both species, but this decrease was different between soybean and peanuts, i.e., the increase of nodule dry weight (at R6.5) as a result of P application ranged from 100% (with L) to 380 % (without L) in soybean, but from 250 % (with L) to 500 % (without L) in peanuts. With L, applying P increased dry matter yield at R6.5 by 80 % in soybean and 60 % in peanuts, but without L, these increases were up to 110 % and 80 %, respectively. Effect of P on the economic yields of both species decreased considerably in presence of L, i.e., in the limed soil, applying P increased the yield only 30-35 % in both species, whereas in the unlimed soil, this increase was up to 95 % in soybean and 65 % in peanuts. These results may be explained by increasing available P concentration in the soil due to liming acid soil. Because liming acid soil released more available P into soil solution to supply to plants by precipitating Fe and Al (Haynes and Naidu, 1991). As the result, effects of applying P on growth and development of plants were decreased.

On the other hand, effects of P on gowth, development, and yields in soybean and peanuts were also decreased obviously when N and L were applied. For example, with N and L, applying P increased dry matter yield by 95 % in soybean and 60 % in peanuts, but without N and L, these increases were up to 112 and 85 %, respectively (Fig. 9). It was the same orientation for filled pods as well as economic yields, i.e., with N and L, applying P increased the economic yields by 75 % in soybean and 50 % in peanuts , whereas these increases were 95 and 70 %, respectively, in the absence of N and L (Fig. 12). Thus, the responses of the plants to P were decreased considerably when N and L were applied together. This may be also due to decreasing effects of P on plant growth when L was applied.

Effects of P on growth and yield in soybean and peanuts also depended strongly on N, however there was a difference among two species, in terms of effect of

N on P. For example, in peanuts, N decreased effect of P on economic yield, i.e., with N, applying P increased the yield by 37 %, whereas without N, this increase was 70 %, but in soybean, N decreased negligibly effect of P on the yield (Fig. 12).

5.2.1 Responses to acid soil and liming

The results of survey and soil chemical analysis indicated that, in general, soils in the region were acid, low mineral nutrient content, especially N and P (Table 4). The average soil pH ranged from 4.6 to 5.2, while the critical level of soil pH for leguminous crops is around 5.5, and it can be various depending on species (Tiaranan *et al.*, 1987).

Soil acidity affected both nodulation and growth of plants. Firstly, soil acidity factors including low pH, low Ca, high Al and Mn have been considered as inhibitors for legume nodulation (Munns, 1980). The results of the field experiment in the tables 13 and 14 pointed out that in the natural soil condition (pH 4.7), the nodule formation was limited considerably in both species. This was illustrated by lower nodule number (Fig. 7) and nodule dry weight per plant (Fig. 8) in the control treatment than other treatments with liming. However, In terms of nodule formation, response of soybean and peanuts to acid soil was different. Peanuts responded more strongly to acid soil than soybean, because at V4.5 (30 DAS), nodule had not formed yet in the unamended soil, while nodules were observed at V4.5 in soybean (Fig. 7). The results of effect of acid soil on nodulation of soybean and peanuts in this experiment were similar to conclusions of Abruna (1980), Munns (1980), Mengel *et al.* (1987) and Borkert and Sfredo (1994). Because low soil pH often relates to high exchangeable aluminum and manganese that cause toxicity to plants, and especially to activities of Rhizobium bacteria. The symbiosis is particularly sensitive to Al and Mn toxicities (Munns, 1980; Borkert and Sfredo, 1994).

The results of the field experiment also indicated that low soil pH had adverse effects on indicators of growth and development such as plant height, LAI, dry matter yield, N concentration in the plant as well as economic yield and its components in both soybean and peanuts. The reason why plants are sensitive to soil pH is that the soil pH affects the concentration of different ions in the soil solution, and so their availability to the plants (Russell, 1973). Borkert and Sfredo (1994) also reported that low soil pH can affect directly or indirectly plant growth, and among indirect effects, the relationship between soil pH and availability of mineral nutritional elements in the soil such as N, P, Ca, Mg and Mo must be concerned. In general, low soil pH leads to reducing availability of these elements to plants. On the other hand, the high exchangeable Al content in the acid soils limited growth of root systems. Al-injured roots are generally short, stubby, with thickened root tips, and a reduction of lateral branching. The reduction in cell division resulted from the interaction of Al with the DNA in the nucleus preventing complete replication of the genetic materials. Aluminum toxicity has also been associated with reduced nutrient uptake and translocation in the plants (Mengel *et al.*, 1987).

In order to improve the soil pH, the best way is liming. The results of the field experiment indicated that there was no obvious difference in responses of soybean and peanuts to L, in terms of economic yields, and the economic yields were increased about 55 % in both species when L was applied. This increase of economic yield was due to improved plant growth and nodulation when L was applied. Liming acid soil increased considerably LAI in both species (Fig. 6, Table 12), leading to increasing leaf area duration (LAD) resulting in increasing significantly dry matter accumulation (Fig. 9, Table 15). Nodulation presented by nodule number (Fig. 7) and nodule dry weight (Fig. 8) were also increased markedly by liming. This resulted in significantly increasing plant N content (Table 16) and N yields (Table 17). Increases of dry matter accumulation along with high LAI and plant N content at later stages (R4.5-R6.5) were determinate factors for increasing pod and filled pod number as well as seed weight. These results were similar to results stated by Sinha (1987), Mengel *et al.* (1987), Abruna (1980), Borkert and Sfredo (1994), Gani *et al.*, (1991).

Liming acid soils increased the growth, development as well as yield and its components of soybean and peanuts, partly because it accelerated organic-matter mineralization in the soil and released more inorganic phosphates to the crops. According to Borkert and Sfredo (1994), in most mineral soils one half to two third of the total phosphate in the A horizon may be organic phosphate. And in acid soils, increasing the soil pH generally causes mineralization of P phytate, there by increasing P availability to plants. On the other hand, liming increased soil pH, resulting in improving availability of other mineral nutrients such as N, S and other microelements such as Bo, Mo that are very necessary for development of both of legumes and Rhizobium bacteria. Besides, liming made better root growth of the crops, leading to increasing ability of mineral nutrient uptake of the plant roots (Russell, 1973). Plant growth is often limited by Al toxicity in acid soils and this is characterized by a marked reduction in shoot and particularly root growth. Al toxicity disrupts mineral nutrition and limits the ability of roots to absorb and translocate phosphate to plant tops. Thus, Al toxicity prevents the plants from using available soil phosphate effectively. Liming results in precipitation of exchangeable Al and enables the plants to make effective use of available soil phosphate, and increase in phosphate adsorption by plants (Haynes and Naidu, 1991).

5.2.3 Responses to N

Even though legumes supposedly receive their nitrogen from symbiotic fixation, there are two cases in which inorganic nitrogen fertilization is necessary: (i) symbiotic fixation by rhizobium is negligible and (ii) when the soil is severely deficient in nitrogen (Sanchez, 1976). In the condition of the acid soil, the N deficiency becomes more serious for food legumes, because the activities of Rhizobium bacteria are limited, and the formation of nodule can not be realized (Munns, 1980).

Low nitrogen content in the soil was one of the most typical characteristics of cultivated lands in mountainous region of Northern Vietnam, especially in the slopping lands of the bear hilly areas. The low nitrogen content often relates to low organic matter content in the soil. In general, the cultivated lands in the region have been subjected to serious erosion during rainy season, and along with inappropriate cultivation, soil organic matter content decreased rapidly, leading to low nitrogen content (Siem and Phien, 1992). The results of soil chemical analysis (table 4) indicated that the nitrogen content in the soil in the region ranged from 0.12 to 0.17 %. The nitrogen deficiency in the soil was one of the major obstacles for growth of crops. Majority of farmers said that application of animal manures or mineral N fertilizer increased the yields of food legumes. However, the farmers often concentrated almost N fertilizer for cereal crops, so food legumes were applied very little or no N fertilizer.

Shinha (1987) and Borkert and Sfredo (1994) reported that a large amount of N are required for good soybean production. In fact, the high yields were obtained only when nitrogen to 150 kg ha^{-1} or more was applied. About 100 kg N is used by the soybean crop for each 1000 kg grain produced (Hardy *et al.*, 1980). However, mostly nitrogen application had adverse effects on nodulation and N fixation. The results of the field experiment in effects of N on nodule number (Fig. 7) and nodule dry weight (Fig. 8) agreed with this conclusion The treatments with N application had lower nodule number and nodule dry weight than those without N application. However, there was a difference between two species in response to N, i.e. N decreased nodule number by 60 % in soybean, but 80 % in peanuts (at R6.5) as compared with the control. One of the reasons leading to decrease of nodulation and N fixation when a large amount of N is applied is relation between N application and uptake of some microelements by plant and Rhizobium bacteria. There are some microelements such as Cu, Mo, etc., which are needed for both plants as well as Rhizobium. When high levels of N are applied, it leads to enhanced vegetation growth, and in turn may cause greater uptake of these microelements. This could lead to the deficiency of the microelements for the Rhizobium and consequently suppress nodulation or makes the nodule ineffective for nitrogen fixation (Hallsworth, 1972; cited by Shinha, 1987).

However, N fertilizer increased significantly growth and development of both species. But responses of soybean and peanuts to N were different. For example, applying N (with two times: basal dressing and top dressing at flowering stage) increased dry matter yield by 20 % in soybean, but 50 % in peanuts. Pods $plant^{-1}$ were increased by 35 % in soybean and 70 % in peanuts when N was applied. Applying N also increased filled pods $plant^{-1}$, but this increase was different among species, i.e. 35 % in soybean and 80 % in peanuts. Peanuts responded more strongly to N than soybean, i.e. with N, yield was increased by 40 % in soybean, but up to more than 70 % in peanuts (Fig. 15).

Supplying enough N to plants, especially at later stages after flowering contributed considerably to formation of pods, filled pods and seeds, resulting in increasing obviously these indicators. Because, according to Watanabe *et al.* (1986), supplying N to plants after flowering may increase carbon assimilation by augmenting photosynthesis. It might also increase N assimilation to meet N requirements for seed development. The combined application of N and P , N and L or N, P, and L gave higher yield than when N was applied alone. The similar results were also showed by Hardy *et al.* (1980), Mengel *et al.* (1987), Sunarlim (1987), Cattelan and Hungria (1994).

5.3 Implications of the study in the socio-economic context of farming systems

The results of surveys and field experiment indicated that N, P, and L were soil nutritional factors limiting growth, development of soybean and peanuts, and applying N, P or L increased significantly economic yields in both species (Fig.5). However, profitabilities varied with different soil treatments depending on yield increase as well as costs for fertilizers applied.

Liming alone increased profit by 0.8 million d. ha^{-1} in soybean and 1.5 million d. ha^{-1} in peanuts, whereas applying P alone increased profit by 0.4 million d. ha^{-1} in soybean and 0.8 million d. ha^{-1} in peanuts, applying N alone decreased profit about 0.3 million d. ha^{-1} in soybean and increased by 1.2 million d. ha^{-1} in peanuts (Table 22). The highest profit was obtained when N, P, and L were applied together (1.7 million d. ha^{-1} in soybean and 3 million d. ha^{-1} in peanuts). Adding P or N with L increased the yield in a much lower proportion than that to the cost.

In terms of economic return, the highest rate of return was obtained with liming, i.e., 1 d. for liming gave a return of 5.4 d. in soybean and 10 d. in peanuts, while N and P application gave much lower returns (-0.28 and 0.35 d. in soybean; 1.3 and 0.7 d. in peanuts, respectively). This was due to N and P had much higher price than L (150 d. kg^{-1} burnt limestone, 3000 d. kg^{-1} urea, 1300 d. kg^{-1} superphosphate). It was clear that applying N for soybean was not profitable, but for peanuts, a considerable profit was obtained when N was applied. When N, P, and L were applied together, the rate of returns were 0.74 d./1d. in soybean and 1.3 d./1d. in peanuts.

Thereby, with poor farmers who have limited capital, the best way for increasing profits was liming. But with richer farmers, N, P, and L could be applied together to gain the highest profits. On the other hand, support from the government as well as local authorities could be in the form of provision of credit to farmers to increase inputs for production.