CHAPTER 2

LITERATURE REVIEW

2.1. The role of food legumes in farming systems

2.1.1. Farming systems and farming systems research concept

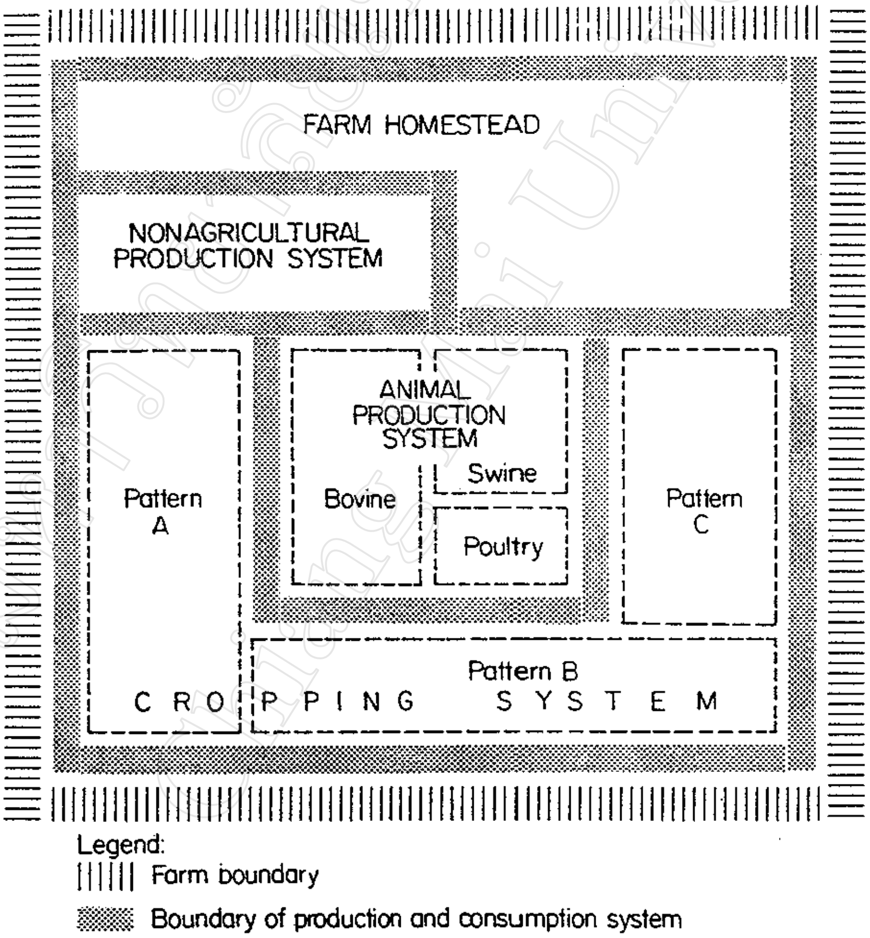

Fig. 1. Farm household system with 4 production-consumption systems

Source: Zandstra *et al.* (1981)

Farming system is a complex including components of farm production and consumption processes as well as interaction among them and between the farm and its environment in a certain farm boundary that, up to now, farm household has been considered important systematic unit in farming systems research. According to Zandstra *et al.* (1981), generally, the farm household unit is a combination of production and consumption activities (Fig. 1).

Farming systems research uses informations about the farm's various production and consumption systems- the animal production system, the cropping system, the secondary production activities that add value to primary products- and about the farm's environment- biophysical, institutional, socio-economic- to identify ways to increase the efficiency with which the farm uses its resources.

Food legumes are a component in cropping systems, and an important component of the farming systems of Asia, both ecologically and interms of human and animal nutrition (Byth et al., 1987)

2.1.2. Role of food legumes in human nutrition and animal feeds

Food legumes are considered secondary crops in Asian farming systems, but they play a vital role in providing protein, fat and vitamin in the diet of the 2.5 billion inhabitants of the region (Moonmaw *et al.*,1977, cited by Craswell *et al.*, 1987).

Singh (1993) pointed out that food legumes are important crops on the following counts: (i) they are rich in protein, (ii) the amino acid profile of their protein is complementary to that of cereals, (iii) these crops possess biological nitrogen fixation ability, (iv) they are adapted to harsh and marginal agro-ecological conditions, (v) they fit into varying cropping patterns, and (vi) these crops constitute an important source of nutrition and income for resource-poor farmers.

McWilliam and Dillon (1987) indicated that food legumes play a particularly important role in Asia, both in the nutrition of human and animal feeds and as a sound ecological component of farming systems of the region. Authors affirmed that food legumes represent a vital component of the diet in the countries of Asian region. Food legumes provide a concentrated source of high quality protein (Protein content varies from 20% to 35%), and are available supplement to the cereal-based diets, especially in areas where animal protein (milk, meat, fish) is less available. Peanuts and soybean are also important sources of vegetable oil and residue or cake remaining after oil extraction provide valuable high protein concentrate for animal feed. The growth in demand for vegetable oil and livestock products is a major reason for the concern expressed in recent years by some governments about the low level of production of food legumes in Asian countries.

Rao and Oppen (1987) showed that food legumes- pulses, groundnuts and soybeans- are an important source of protein and fat in the diets of people, especially in low income countries. In Asia and Africa, vegetable protein sources contribute 80% of total protein intake.

McWilliam and Dillon (1987) cited the reports of the FAO/WHO/UNU Expert Consultation on energy and protein requirements of human diet to indicate that required level for good quality digestible protein is 0.75 gr/kg/day for both sexes. This level can be satisfied by cereal-based diets of 300 gr rice per day. The addition of food legumes to the diets reduces requirement for cereals and provide a more concentrated and better quality protein. Nelson *et al.* (1979) showed that the diets of many millions of people in various parts of the world is deficient in protein and calories, and the best answers to this shortage is whole soybeans.

In regard to quality of protein, recent investigations by the Massachusetts institute of technology, the institute of nutrition in central America and Panama and Tokushima university in Japan supposed that the nutritional quality of isolated soy protein can compare with protein of meat, milk, eggs and fish (Schwarz and Allwood, 1979). The potential for protein production from a unit of land area is greater for legumes compared to animal sources. Legumes have high quality protein, and the deficiency of the essential amino acid, lysine, in cereal protein is complemented by legume protein which are richer in lysine content. Thus, blending of legumes with cereals results in increased protein density so that relatively lower volumes are required to meet the protein requirements of people (Wijeratne and Nelson, 1987).

Betterham and Egan (1987) showed that food legumes are a valuable source of feed for livestock. The whole seed of most legumes is a rich source of energy and amino acids. For the oilseed legumes, peanuts and soybeans, the meal is a by-product of oil extraction and is used as a protein concentrate. There is also considerable potential to use the residues left after harvesting the seeds as sources of fodder for livestock. Furthermore, most food legumes provide forage materials and residues for use as animal feeds.

2.1.3. Role of food legumes in cropping systems

Cropping systems are commonly described simply by the dominant cropping patterns they include, and all components required for the production of the crops in these cropping patterns and their relationships with the environment (Zandstra *et al*, 1981)

Whyte *et al.* (1969) showed that apart from direct contribution to economic return of farmers, legumes have benefit effects on soil fertility by improving the nitrogen and organic matter status of the soil and by bringing up minerals through their root systems from the lower soil horizons. On the other hand, one very important attribute of legumes in tropical countries is the provision of protection for the soil against the sun and the rain.

Clegg (1982, cited by Myers and Wood, 1987) found that sorghum grown after sorghum required 55 kg N/ha of fertilizer N to achieve the same yield as sorghum grown after soybean. Giri and De (1980, cited by Myers and Wood, 1987) also indicated that pearl millet produced more grain after groundnut, cowpea or pigeon pea, compared with pearl millet after millet.

Many studies in various Asian countries showed that in most cases, the food legumes are grown in association with other crops in some types of cropping systems such as mixed cropping with cereals in the Himalayan range, intercropping with sugarcane in Fiji, or double cropping with peas, beans, and rice in Burma (Patanothai, 1987). The use of food legumes in crop rotation is one of the most important means in maintaining organic matters in the soil (Thompson, 1957). On the other hand, A rotation of cereals and food legumes is likely to break the cycle of cereal cropping resulting in reduction of the incidence of soil-born diseases and use of their residues after harvest as a valuable source of animal feeds (McWilliam and Dillon, 1987).

The field experiments carried out in Northern mountainous region of Vietnam from 1983 to 1987 of Agricultural University No 3, Bac thai showed that food legumes such as soybean and peanuts mixed with food crops such as cassava and corn had beneficial effects on soil fertility as well as protect the soil from erosion in the rainy season. For example, peanuts mixed with cassava or corn supplied about 10 tons ha^{-1} of plant residues per crop to the soil, and soil loss was decreased about 3-5 times (Dau, et al., 1991).

Food legumes are considered as an important component in cropping systems. The capacity of food legumes for symbiotic nitrogen fixation may reduce the requirement for nitrogen fertilizers of other crops in the systems (McWilliam and Dillon, 1987). According to Myers and Wood (1987), under good conditions, food legumes in the tropics can fix up to 300 kg N/ha in one growing season. Heichel (1987) also showed that in the US, alfalfa followed by a nonlegumes can return 85 pounds/acre of fixed N2 to the soil.

Bruce and Swaify (1987) studied legume effects on soil erosion and productivity and concluded that selected legumes, alone or in combination with nonlegumes, provided protection from soil erosion, increased organic matters in the surface soil, water infiltration and aggregate stability, and improved nutrient status.

2.2 Food legume production in Asia and Vietnam

Asia is a very important zone of legume production in the world. Every year, a large amount of legumes has been produced here, and exported to other countries over the world. This is illustrated in table 1.1 and 1.2.

Table 1.1. Distribution of area and production of food legumes in Asia compared to the world (1982-84 average)

Crops	Area(10^6 ha)		% of Asia	Production (10^6 tons)		% of Asia
	World	Asia		World	Asia	
Drybeans	25.4	12.6	50	14.8	6.7	45
Broadbeans	3.3	1.9	58	4.2	2.5	61
Dry peas	8.0	1.9	24	10.2	2.4	24
Lentils	2.4	1.9	81	1.6	1.3	80
Chickpeas	9.9	9.2	93	6.5	6.0	92
Other pulses	17.3	7.1	40	9.3	3.9	44
Total pulses	66.3	34.6	52	46.6	22.8	49
Soybean	51.0	10.3	20	87.2	12.0	14
Peanut	18.5	11.3	61	19.3	12.7	66
Total	135.8	56.3	41	153.1	47.6	31

Source: FAO (1985, cited by Rao and Oppen, 1987)

Table 1.2. Average yield of food legumes in Asian region and in developing and developed world (1984)

Crops	average yield (kg ha^{-1})		
	Asian	Developing world	Developed World*
Soybean	960	1564	2420
Peanut	1003	1056	3270

Note: * USA.

Source: FAO, 1985 (cited by McWilliam and Dillon, 1987)

According to Rao and Oppen (1987), in Asia, pulses are proportionally more important. They account for 48% of food legume production while groundnuts and soybeans contribute 27 and 25% respectively (table 1). Rao and Oppen also indicated that from 1970 to 1984, the growth rate for production of pulses in Asia was 0.8%, while cereal production grew at 2.9%. From the early 1980s, Asian pulse production has stagnated and declined relative to cereal production, except the important production countries such as Turkey, Burma, and Thailand. By contrast, soybean production in Asia has rapidly expanded. Area under soybean grew at a rate of 3.3% per annum from 1970 to 1984; soybean production grew even faster at 5.9% per annum. Area under groundnuts is slowly increasing, with a growth rate of 0.3%; production is increasing at a faster pace, by 1.4% per annum. McWilliam and Dillon (1987) supposed that reason of stagnation of food legume production, chiefly pulses, in developing world is tendency to underestimate the role of these crops in farming systems.

In Vietnam, especially in Northern mountainous region, food legume production is still limited as well. According to General Statistical Office, (S.R Vietnam 1992), sown area of food legumes are very small as compared with cereal area (3.65% for oil-seed legumes, and 2.4% for pulses). Productivity, in general, is relatively low as compared with other regions of the country and other countries in the Asian region. For example, in Thailand, in 1983, the yield was 1031 kg ha^{-1} for soybean, 1200 kg ha^{-1} for peanuts (Na Lampang, 1985). While, in Northern mountainous region of Vietnam, average yield is about 400 kg ha^{-1} for pulses, 600 kg ha^{-1} for soybean and 700 kg for peanuts (Table 2).

Table 2. Food legume production in Northern mountainous region and Red river delta of Vietnam

Years	Sown area (1000 ha)			Yields (kg/ha)			Total Production (1000 tons)		
	Pul	S	P	Pul	S	P	Pul	S	P
				Northern mountainous region					
1990	21.4	27.9	21.6	470	640	820	10.1	17.8	17.7
1991	22.4	30.8	23.0	440	610	750	9.8	18.8	17.3
1992	22.0	29.5	25.9	400	630	800	8.8	18.6	20.7
				Red river delta					
1991	10.7	12.4	18.3	490	970	1030	5.2	12.6	18.8
1992	8.9	11.8	11.5	510	1090	900	4.4	13.0	15.8

Note: **Pul**- Pulses; **S**- Soybean; **P**- Peanuts

Source: General Statistical Office, S.R. Vietnam 1992-1993

In regard with soybean production, Lai (1994) pointed out that the Vietnamese government for some time has intended to increase acreage under soybean to several mill.

ha. Up to now, however, the cultivated area has not surpassed 200,000 ha, and gross output is still below 120,000 t/year.

2.3. Limitations to food legume production

2.3.1. Socio- economic factors

Sharma and Jodha (1986, cited by McWilliam and Dillon, 1987) supposed that the most important factor that limit food legume production in Asia is the subsidiary status of food legumes. To both farmers and government in Asia, food legumes have generally lacked priority relative to cereal crops. This led to low inputs to food legume production.

The poor prices are also strong economic constraint to food legume production in Asia. In general, government policy in the Asian region favors increasing production of cereal crops by subsidies on inputs, price support and other incentives aimed at increasing cereal production (McWilliam and Dillon, 1987). Cereal growers may have favored access to credit facilities which again fosters cereal production (Byth, *et al.*, 1987).

According to FAO (1985, cited by Rao and Oppen, 1987), average pulse: cereal price ratio in Asia during 1970-1984 was 1.6 (Turky: 3.1, India: 2.1-2.3, Thailand: 1.9), while the current average yields of food legumes in Asia are about one third of that achieved for the major cereal crops grown in the same region. In mountainous region of Northern Vietnam, ratio of food legume and cereal price is 1.5-1.7, while productivity of cereal such as rice and corn is as much twice or more than that of food legumes (General Statistical Office, 1992-1993).

Byth, *et al.* (1987) suggested that the costs of production in Asia are relatively high, and prices of some major food legumes, such as soybean and peanut are relatively low because they are dictated by world supply and demand. Thus, price support and incentive schemes are unlikely to be viable in Asia unless productivity can be increased, and costs of production are reduced, or both.

In Vietnam, especially in mountainous regions, apart from low inputs and poor market, transportation facilities as well as price policy are factors limiting food legume production so far. Lai (1994) carried out the survey on soybean production constraints in Vietnam, and pointed out that lack of cash for input, low price, low productivity, poor soil fertility, as well as low efficiency of biological N fixation, are limiting factors for soybean production in Vietnam now.

2.3.2. Agronomic factors

Average yield of food legumes in Asia is low as compared to yield potential calculated for developing countries. The physical, biological and technical constraints have been identified as limiting factors to the low productivity (Carangal *et al.*, 1987).

Craswell *et al.* (1987) suggested that mineral constraints are a major cause of the low yield of food legumes in many Asian countries, and that almost all major areas of food legume production in Asia have deficiencies of nitrogen, phosphorus, and calcium. The most widespread constraints to soybean production on acid soil (oxisols, utisols, and inceptisols) are deficiency of phosphorus, potassium, calcium and magnesium, and N, P, lime are essential factors to contribute to increasing yields of food legumes in Asia (Rochayati *et al.*, 1987).

Soil acidity factors including low pH, low Ca, high Al and Mn have been regarded as inhibitors of legume nodulation (Munns, 1980). Abruna (1980) also pointed out that acid soils with high concentration of Aluminum and/or manganese and low phosphorus available concentration became limiting factor for growth and development of food legumes, in general, and soybean, in particular, in tropics.

Beck and Roughley (1987) concluded that biological nitrogen fixation of the food legumes is restrained by adverse soil conditions in many production areas. And this is considered as a limitation to food legume production in Asia. Symbiotic nitrogen fixation is commonly limited by soil fertility conditions, especially those associated with the acid soil complex of high aluminum, manganese, low calcium and phosphorus. Some legumes become especially sensitive to these stresses when they are dependent on symbiotic nitrogen fixation.

Borkert and Sfredo (1994) indicated that the predominant soils in tropics are oxisols and utisols, which together comprise 63.9 percent of the area, and high acidity is common in many tropical soils and can be a stress to soybean. The authors also concluded that Acid soil toxicity is not a single factor but a complex of factors that may effect the growth of plants. Generally, the stress may be described as the direct effects of soil acidity and the related indirect effects of soil pH on other factors, especially on availability of essential elements such as Ca, Mg, P, N and Mo. Among the indirect effects of soil acidity, Al toxicity is probably the most important growth limiting factor for plant and Mn toxicity the second. The problem is particularly severe if pH is below 5.0. Soil pH also indirectly affects the kind, number and activities of microorganisms involved in symbiotic N2-fixation and organic-matter transformation. Also, by regulating microbial activities, pH effects the mineralization of organic matter and the subsequent availabilities of N, P, S and micronutrients to the plants (Borkert and Sfredo, 1994).

Besides, water stress, lack of land preparation, poor seed quality, lack of fertilizer input and chemical control of pests and diseases and weeds are also limitations to food legume productivity in rainfed farming systems in Asia (Patanothai, 1987).

In mountainous region of Northern Vietnam, soils in a large part of agricultural land is acidic with low organic matter, and available phosphorus content (Siem and Phien, 1992; Dau *et al.*, 1991).

2.4. Management practices for yield improvement

There are a lot of evidences that mineral constraints are a major cause of the low yields of food legumes in the field of many Asian countries (Craswell et al., 1987). A variety of reports also indicated that a lot of areas of food legume production in Asia have deficiencies of N, P and Ca, and N, P, lime are essential factors to contribute to increasing yields of food legumes in Asia (cited by Craswell *et al.* 1987).

Tiaranan *et al.* (1987) supposed that Among three major nutrients, N, P, K, phosphorus is considered to be the most important limiting factor for legumes in

Northeast, Thailand. And in some large legume growing areas of Thailand where available phosphorus content is as low as 1-5 ppm (BrayII) when fertilizer was applied, soybean yield increased more than twofold. Authors also indicated that the critical level of available phosphorus in the soil is considered to be around 8 ppm. Beyond this level, fertilization is not necessary.

Fox *et al.*(1981, cited by Wild, 1988) as studying on P requirement of various crops indicated that in order to obtain 95 percent of maximum yield, soybean needs phosphorus concentration in soil solution to be 0.20 ppm, and this is considered as external critical level of phosphorus concentration in soil solution for soybean. It is likely to be based on this level to assess phosphorus deficiency in the soil for soybean. And a method of determination of the amount of phosphate which must be added to the soil to raise the phosphate concentration of its solution to a sufficient level has been used for determining applied phosphate rate.

The capacity of supplying phosphorus of the soil to plant relates to soil acidity. In general, soil P availability is depressed at high acidity. In acid soil, increasing the soil pH generally causes mineralization of P phytate, thereby increasing P availability to plant, because in acid soils, the very insoluble Al and Fe phytates are believed to be the most abundant organic P compounds (Borkert and Sfredo, 1994).

Report from the Central Research Institute for Agricultural in Indonesia showed that phosphate applied at the rate of 19.6 kg/ha increased considerably soybean yield (Ismunadji et al., 1987). Borkert and Sfredo (1994) indicated that phosphorus management is critical to the production of soybean, particularly in acid soils with high P-fixation. A lack of this element is doubly serious since it may prevent other nutrients from being absorbed by soybean plants. And the low P availability and the high P-fixation capacity of tropical soils imply a high requirement for P fertilizers.

Dickson et al., (1987) carried out experiments on P fertilizer rates at 27 field sites in Queensland, Australia and showed that soybean yields increased significantly when P fertilizers were applied. And soybean response to applied P depends on soil acidity, soil organic matter level and clay content (Borker and Sfredo, 1994). De Mooy and Pesek (1966, cited by Mengel et al., 1987) reported that phosphorus has a major role in nodule development in soybean, and maximum nodulation required P additions of 400 to 500 mg/kg soil with even higher levels required for maximum activity of the nodule.

As above mentioned, high acidity is common in many tropical soil and can be stress to food legumes, and controlling soil acidity is one of the most important methods for increasing productivity of many legume crops. Mangel et al. (1987) showed that liming acid was and important part of any soybean fertilization program in the USA, and had a number of potential benefits for soybean production as follows: (1) the reduction in the concentration of potentially toxic elements such as H, Al and Mn, (2) the increased availability of plant nutrients such as Ca, Mg, and Mo, (3) improved nodulation and N2 fixation.

Thompson (1957) concluded that in the acid soil, legume growth is encouraged by lime, and a greater amount of nitrogen is fixed by symbiotic bacteria. The response of legumes to lime is most likely due to the increased availability of nitrogen and phosphorus rather than from increased availability of calcium. Soybean and cowpeas made 80% or more of their optimum growth at pH 6.

Significantly increased soybean yields by applying 2t CaCo3/ha with a soil that has an initial pH of 4.5 (Freistas et al., 1960, cited by Abruna, 1980). In other studies, Freitas et al. (1971, cited by Abruna, 1980) showed that soybean responded strongly to liming on Latosols where initial pH values ranged from 4.3 to 5.1. Martini et al. (1974, cited by Abruna, 1980) also pointed out that soybean responded significantly to liming in the soil of oxisols, and liming increased the Ca and reduced the Mn content of the leaves. Mascarenhas et al. (1969, cited by Abruna, 1980) reported an increase of 30% in soybean yield when only 1.6 t/ha of limestone was applied to a red latosols in Brazil with a pH of 5.5.

Abruna (1980) with experiments were conducted on oxisols and utisols of Puerto Rico, indicated that the highest yields of soybean were obtained at pH 5.6, corresponding to 3% Al saturation. Yields decreased 37% when Al saturation increased to 14% and pH dropped to 5.0. The author concluded that soybean responds to liming on both oxisols and utisols, but it responds more strongly on the utisols, and the response seemed to be linked to N and Ca nutrition. Soil acidity factors strongly affected the content of some elements in the soybean leaves, especially Ca and N contents decreased as percent of Al saturation increased, as pH decreased.

Alexander (1961, cited by Borkert and Sfredo, 1994) supposed that liming acid soils enhances carbon volatilization and organic matter decomposition. Borkert and Sfredo (1994) showed that two important microbially induced reactions affecting N availability released from organic matter in soils are ammonification and nitrification. Ammonification can occur over a wide range of pH, but nitrification is markedly reduced at pH values below 6.0 and higher than 8.0. The authors also affirmed that tropical and temperate acid soils should undoubtedly be limed in order to produce high soybean yields.

In India, Kalia *et al* (1984, cited by Borkert and Sfredo, 1994) obtained a significant increase in soybean grain and plant residue yields with liming as compared with those without liming. In Brazil, there are numerous examples of high soybean yield responds to lime (Borker, 1973; Martini et al., 1974; Lobato and Suhet, 1982, cited by Borkert and Sfredo, 1994). Gani et al. (1991) carried out field experiments on acid soils of oxisols and utisols in Indonesia and indicated that applications of dolomitic limestone are successful in overcoming soil acidity problems, and allow quite high yields to be achieved. However, response to lime by peanuts grown in these experiments varied with different cultivars.

In order to determine amount of lime that should be applied to a soil we can use following methods: soil buffer equilibration method, the exchangeable Al method, and method based on the correlation between base saturation and pH (Borkert and Spredo, 1994). The exchangeable Al method was worked out by Kamprath (1970, cited by Sanchez, 1976). Kamprath suggested that lime recommendation be based on the amount of exchangeable aluminum in the topsoil and the lime rates be calculated by multiplying the miliequivalents of aluminum by 1.5 (for CaO) or 1.65 (for $CaCO_3$). Lime rates calculated by this method neutralize 85 to 90% of the exchangeable aluminum in the soil containing 2 to 7% organic matter, and raise the soil pH to about 5.6-6.0.

Borkert and Sfredo (1994) showed that although soybean cultivars differ in their tolerance to acid soils and to high exchangeable Al, yields under acid soil condition will never be as high as those obtained without acidity constraints. However, not all reactions following liming are beneficial to plants. Authors also indicated that under the certain conditions, overliming may be detrimental. In tropicals, optimum pH for soybean is 5.5-6.0 with heavy soil, and 5-5.5 with sandy soils. Overliming may reduce availability of some nutrients and increase base leaching. It may also have an adverse effect on soil structure and on the total complex of soil organisms (Borkert, Sfredo, 1994).

With regard to ability of increasing soybean yields by applying N fertilizers, there still has been a lot of recommendations. In general, food legumes require a large amount of nitrogen for their growth. Cattelan and Hungria (1994) pointed out that in order to yield 2,500 kg of seed, soybean plant has to accumulate about 200 kg of nitrogen, in which 67 to 75% is allocated to seeds. However, the nitrogen required for plant growth can be obtained either from symbiotic fixation of atmospheric nitrogen or from the direct uptake of soil inorganic N.

At present, the researchers in many countries have tried to increase soybean yields through the application of nitrogen fertilizers, however, this consistently reduces nodule number, size and activity, as well as N fixation rates. Many experiments with N fertilization have shown no response or a nonprofitable return in terms of seed yield in comparison with treatments that result in efficient nodulation (Cattelan and Hungria, 1994).

Carmen and Varela (1984, cited by Cattelan and Hungria, 1994) estimated that N_2-fixation provided 132 kg N/ha, representing 57% of the total N absorbed by the soybean plants. And when growth conditions are optimal the amount of fixed N_2 can be higher, and in an irrigated field obtained 244 kg N/ha, representing 67% of total N accumulated in shoot.

However, many other experiments carried out in certain conditions proved the role of N fertilizers in increasing soybean yields. Ham *et al.* (1979, cited by Mengel *et al.*, 1987) reported that N fertilizer increased seed yield, weight per seed, seed protein percentage. Al-Thawi *et al.* (1980, cited by Mengel *et al.*, 1987) concluded that the use of N fertilizer significantly increased soybean yield when the amount of residual NO_3-N in the root zone was low.

Through field experiments in Eastern Nebraska (USA), Sorensen and Penas (1978, cited by Mengel *et al.*, 1987) indicated that response to N fertilizer was highly probable where the soil was acid and the organic matter content was less than 29mg/kg soil.

In regard to effects of nitrogen application on nodulation of soybean, Beard and Hoover (1977, cited by Mengel *et al.*, 1987) reported that the number of nodules per plant was linearly and inversely related to the rate of fertilizer N applied. N rates in excess of 56 kg/ha applied at planting produced fewer nodules, but nodule number was not affected up to 112kg/ha if the fertilizer N was applied at flowering.

Approximately 300kg N is needed to produce 3t/ha of seed soybean. Soybean's demand during the ripening stage, and its low response to basal fertilizer, might best be resolved by applying supplemental N after flowering. This practice could increase carbon assimilation by augmenting photosynthesis. It might also increase nitrogen assimilation to meet N requirements for seed development (Watanabe *et al.*, 1986). From field experiments authors showed that the 60 and 120kgN/ha applied 10 days after flowering increased average yields by 4.8 and 6.7%. Yield increases were mainly due to increases in 100 seed weight. Supplemental nitrogen, in varying amount, was applied at flowering. And yields increased in direct proportion to N application up to a saturation point of 180 kg/ha.

In sum, increasing yield is one of the best ways to enhance food legume production in Asian region. In general, in Asian countries, the soil has low pH, deficiency of P and Ca leading to limited symbiotic N fixation. And in order to increasing yields of food legumes, soil improving measures become very important. At present, the mountainous region of Northern Vietnam is facing two main problems (1) to maintain and improve soil fertility and (2) to increase nutritional quality of human diets. Evaluating the role of food legumes in farming systems as well as identifying facors limiting and measures for improving their productivity are very necessary to increase food legume production in the region.