CHAPTER 2

LITERATURE REVIEW

2.1 Role of legumes in Asia

2.1.1 Food legumes

Food legumes represent a vital component of the diet in Asian countries. They provide a concentrated source of high quality protein (protein content varied from 20 to 35%) and are a valuable supplement to the cereal based diets, especially in the areas where animal protein (meal, meat and fish) is less available (McWilliam and Dillon,1987). One obvious advantage of grain legumes, easily appreciated by farmers is grain that may be consumed or sold for cash. Many grain legumes have also been part of the traditional cropping systems on highland in Thailand (Rerkasem and Rerkasem, 1989). A major concern to subsistence farmers and other small land holders is the impacts of legumes on food crops. It was reported that improvement of protein content of legumes for animal feed is the premium asset (Donald and Plucnet, 1990).

Mungbean, *Vigna radiata* (L.) Wilczek, has been grown in India since ancient times. It is still widely grown in South-East Asia, Africa, South America and Australia. Mungbean are widely grown for use as a human food (as dry beans or fresh sprouts), but it can be used as a green manure crop and as forage for livestock. Mungbean seeds are sprouted for fresh use or canned for shipment to restaurants. Sprouts are high in protein (21% - 28%), calcium, phosphorus and certain vitamins. If the mungbean seed does not meet sprouting standards it can be used as a livestock food with about 1.5 tons of mungbean being equivalent to 1.0 ton of soybean meal for protein content (Oplinger *et al.*, 1990).

2.1.2 Soil fertility improvement and disease control

Legumes are viewed as an alternative to expensive and largely unavailable nitrogen fertilizers in conditions of low fertility. Their importance to small land holders is their nitrogen fixing and often erosion-halting capacities, at low cost and risk (Donald and Plucnet, 1990). Legumes were also reported to be used as animal feed (essential by-products), soil nutrient through biological nitrogen fixation, and disease control in cereal/legume rotations (McWilliam and Dillon, 1987). Legumes, by virtue of their ability to fix atmospheric nitrogen in association with their nodule bacteria, are often thought of as a low input technology that might help to restore soil fertility in a shorter time than that normally required under forest fallow (Rerkasem and Rerkasem, 1989)

Similarly, the capacity of food legumes for symbiotic nitrogen fixation may reduce the requirements for nitrogen fertilizer, but there seem to be considerable variation in the nitrogen contribution from this source (McWilliam and Dillon, 1987). According to Rerkasem and Rerkasem, (1989) the potential for a legume to improve soil fertility is related to its ability to fix nitrogen from the atmosphere. When some plant parts are removed from the field in the harvest (i.e. in the grain), a crop will leave the soil with more nitrogen than before it was planted only if more nitrogen is fixed than that was removed. It was found that peanut, soybean and black gram possibly leave negative balances of nitrogen in the soil because of usually involving removal of whole plants from the field. Whereas, mungbean, green gram give positive balance of nitrogen in the soil (Rerkasem and Rerkasem, 1989). They also estimated that from the crop with seed yield of 1 t/ha green gram left 1.6 t/ha of stover and its total nitrogen uptake was 68.5 kg N/ha. This estimation was 38% in the stover and 62% in the grains (Claimon, 1988). Thus we might postulate that if mungbean is not to leave the soil with a negative balance of nitrogen they would have to depend on symbiotic nitrogen fixation for more than 60% of their nitrogen. In the field this is likely be the case only with green gram, which is harvested by picking of the mature pods by hand (Rerkasem and Rerkasem, 1989)

Other advantages of growing legumes are to break the cycle of cereal cropping and reduce the incidence of soil-borne diseases, and use their residues after harvest as a valuable source of animal feed (McWilliam and Dillon,1987).

2.1.3 Diversified roles in cropping systems

Food legumes also play a valuable additional role in the rice-based farming system of the Asian region. They are cultivated over a wide range of environments from semi-arid to humid tropics-mostly as rainfed crops on a small scale by small holder farmers and are grown in rotation with rice, usually following the rice crop (McWilliam and Dillon, 1987).

A detail report by Rerkasem and Rerkasem, (1989) revealed many advances of legume roles in cropping systems such as cash, consumption, soil fertility, cover against soil erosion, pasture and forage legumes for animals as well as water conservation. For these purposes, those legumes with low harvest index such as traditional climbing indeterminate cowpea, lablab and rice-bean may leave behind more organic matter than the improved legumes such as soybean and mungbean. Many pasture legume species with potential were identified, but their use and hence benefits towards soil and water conservation depend on their integration into the local farming systems. Cover, tree and shrub legumes with their usefulness were also mentioned in the report (Rerkasem and Rerkasem, 1989).

2.2 The limitations

Acid soil are common throughout the tropics. All legumes suffer when the soil pH is low (<4.5) or high (>7.5). Both conditions effect nodulation and other nutrient availability. At low pH, Al^{3+} and Fe^{3+} toxicity and Mo and Mg deficiencies are common, whereas at high pH, Fe, Mn and Zn deficiencies may occur (Wood and Myer,1987).

There are few evidences which revealed that the mineral limitation are major cause of the low yields of food legumes in the fields of many Asian countries. Most area of food legumes production in Asia have deficiencies of N, P, Ca which are essential factors to contribute high yield of food legumes in Asia (Craswell *et al.*, 1987).

However, having limited resources to apply, usage of proper fertilizer for legume is of great concerns to the farmers, particularly when there is a risk involved. Under rainfed conditions in which crop responses to fertilizer are quite variable due to environmental factors, farmers are generally reluctant to use fertilizer. Other management limitations are the unavailability of the recommended fertilizer formulae in the local market and the lack of knowledge of the differences among different fertilizers. The consequence led to the misuse of fertilizers and thus potential responses are not recognized (Patonothai and Ong, 1987).

2.3 Mungbean production

2.3.1 Mungbean production in South and South-East Asia

The positive trend of mungbean production in Asia was clearly illustrated by Singh, (1988). In South and South - East Asia, an increases in mungbean production occurred through annual increases of both yield and area at 2.1% and 2.5%, respectively. The current average yield of mungbean is rather low, ranging from 405 kg/ha in India to 800 kg/ha in Indonesia. However experimental plot yields showed that of 2,500 kg/ha and farmer's field demonstration provided yield of 1,500 to 2,000 kg/ha are common. This points out that there is a serious gap in the transfer of technology. The average farmer is generally not inclined to invest in inputs for mungbean or pulses* in general. Furthermore, extension and development support are generally inadequate in transferring the existing package of management practices which are known to give improve respectable yield in adaptive demonstration trials (Singh, 1988).

Annually average growth rate of mungbean production is 4.5% against a growth rate of only 0.5% for total pulses* in South and South-East Asia (1961-1986). While the production, yield and area of pulses* as a whole stagnated during the Post-Green revolution era. In general, the performance of mungbean showed a significant positive trend. Major pulses* like chickpea and dried peas were replaced in the cropping systems by high yield varieties (HYVs) of wheat and rice and relegated to mostly rainfed and marginal areas. But, in the cases of mungbean and black gram were developed and fixed in the new situation of HYVs of wheat and rice in which mungbean was considered as rotation crop with HYVs of rice and wheat, and as inter-crops with sugarcane, maize, cassava (Singh, 1988).

2.3.2 Mungbean production in Vietnam and Thua Thien Hue province

In Vietnam, it is difficult to determine exactly the total mungbean planted area because of the variation of mungbean role in cropping patterns in which mungbean, as a component is included in the systems. Furthermore, when statistical data on mungbean are gathered, they are combined under the general category of pulses in which its total growing areas of Vietnam were 182,100 and 190,400 hectare in 1993 and 1994 respectively (General Statistic yearbook, 1995). Nevertheless, the pulse development over years shown up positive trend. A similar trend was recorded with 1,313 , 2,023 , and 2,141 hectare in 1991, 1995, and 1996, respectively in Thua Thien Hue province (Hue Statistical Office, 1997). Whereas cassava, and sweet potato planted areas in Thua Thien Hue province, in which they used to be mainly hills, shown a strong negative trend with about 15,000 , 12,500 , 12,000 hectare in the same period (Hue Statistical Office, 1997). These indicate that hilly farmers intended to incorporate multiple crops to plant in the same area and that crops which perform poorly economic effects, i.e. cassava and sweet potato, are gradually substituted by others, such as mungbean and peanut.

However, mungbean average yield of both the country and the province are quite low. Average national yield of mungbean was about 0.6-0.8 ton/ha (Quyen, 1988) in which it was higher than average yield in Thua Thien Hue which was 0.3-0.5 ton/ha (Hue Statistical Office, 1997). The gap between them is often referred to soil and seed problems (Quyen, 1988).

2.4 Response of legumes to phosphorous fertilizer application

2.4.1 Soil and its limitation

The capacity of supplying phosphorous by soil to plant is relates to the soil acidity. In general, soil phosphorous availability is depressed at high acidity. In acid soil, increasing soil pH generally causes mineralization of phosphates, thereby increasing phosphorous availability to plant, because in acid soil they are dissoluable. Aluminum and iron phosphates are believed to be the most abundant organic phosphorous compounds (Borkert and Sfredo, 1994). Therefore, phosphorous often is present in soil but in a relatively non-absorbable form to plant (Donald and Plucnet, 1990).

Phosphorous requirement by crops varies not only among crops but also among cultivars of the same crops (Sahrawat and Islam, 1988). Besides, results from mungbean fertilizer trials shown that potential yields and yields response to fertilizer application varied from region to region (Claimon, 1988). Reasons of variable phosphorous effect on plants over soil types might be phosphorous adsorption by soils in which phosphorous adsorption of soil is a process mainly responsible for rendering solute phosphate in soil solution becoming unavailable to plants. Many soil properties influence phosphorous adsorption by soil (Sanyal and de Datta, 1991).

Soil in Vietnam with three fourth area located in mountains and hills. They are mainly classified as Acrisols, Ferrasols, and Alisols. In the strongly weathering conditions, soils are often low in available phosphorous. Phosphorous deficit for plants, therefore, is popular (Siem and Khai, 1996; Dinh *et al.*, 1993; Dinh, 1996). Similarly, almost arable land in the hilly zone in Thua Thien Hue is Yellow-Red Ferralitic Soils on Clay Shale (Acrisols) which represent 70 % of provincial total area

(Department of Provincial Land Management, 1991). It is low in pH and fertility (Gon, 1991., Chieu,1992; Chieu *et al.*, 1996; Siem and Khai, 1996). Further findings revealed that especially, phosphorous availability of soil is 2-4 ppm (Cong *et al.*, 1992). This amount is low as compared with 8 ppm which is critical value for mungbean growth (Claimon, 1988). Aluminum and iron in acid soils in the hilly zone are the most abundant minerals and react with phosphorous to form relatively dissolute aluminum and iron phosphates (Gon, 1991., Siem and Khai, 1996).

2.4.2 Role of phosphorous in plant growth

Phosphorous is essential for plants because of its role in vital life processes. It also has a significant role in sustaining and building up soil fertility. Unlike nitrogen, which can recycled to the soil by fixation from air, phosphorous once removed from the soil by crops or by erosion, runoff, or leaching cannot be replenished except from external sources (Sanyal and de Data, 1991). As a major nutrient in soil, phosphorous (P) play an important role for plant growth. P is essential for energy transfers within the plant. It is also the integral part of the plant genetic material, RNA and DNA. Under conditions of phosphorous deficiency, cell and leaf expansion are more retarded than chlorophyll formation. The chlorophyll content per unit leaf area therefore being higher (Hecht and Buchholz, 1967 cited by Marschner, 1986).

2.4.3 Response of legumes to phosphorous fertilizer application

It was found that leguminous crops responded to phosphate fertilization in many areas. Of the three major nutrients, N-P-K, phosphorous is considered to be the most important limiting factor for leguminous crops (Tiaranan *et al.*, 1985). In ICARDA's predominantly nitrogen and phosphorous experiments, even in harsh environments, fertilizer can improve water-use efficiency and farmers' profits can increase (Donald and Plucnet, 1990). Experimental results shown positive responses of grain legumes to P on many soil types in different countries. The magnitude of responses is discussed in relation to liming, use of other nutrients, and sources and placement of P in the soil (Pandy and Mc Intosh, 1988).

Paddy soil in Asia are generally low in phosphorous (Kawaguchi and Kyuma, 1977; cited by Wood and Myer, 1987) but because phosphorous availability increases following submergence, traditional paddy rice varieties do not require additional P fertilizer (Brady, 1982; cited by Wood and Myer, 1987). However, widespread responses to P by rice and legumes grown on upland soils have been demonstrated (Sudjadi *et al.*, 1984; cited by Wood and Myer, 1987). Response to P by food legumes grown on drained paddy fields could also be expected (Wood and Myer,1987). On marginal land with low pasture productivity, phosphorus fertilizer experiments by ICARDA scientists showed significant improvement in total herbage yield (legumes and grass). Legumes seed yield on marginal land increased 27 percent and 61 percent in response to 25 kg and 60 kg of phosphorous, respectively (Donald and Plucnet, 1990).

Almost of Vietnam soil types are high acidity, low total and available phosphorous (P) low cation exchangeable capacity*** (CEC) and basic saturation** (BS). Fused magnesium phosphate (FMP)[a] application to the soil gave improvement on soil properties. So, crop yields were increased and gave high economic effect. Combined application of FMP and superphosphate gave higher yield and better effect as compared with separated usage of each phosphate (Dinh, 1996). In Thua Thien

Hue, the application for peanut at 90, 120 P_2O_5/ha gave increase 64,8%, 26% of yield respectively as compared with control (Cu *et al.*, 1996).

2.4.4 Response of mungbean to phosphorous fertilizer

Experiments on fertilizer use and soil amendment management on acid soils of Thailand are reviewed and discussed. Phosphate fertilizer including rock phosphate, has a potential to increase mungbean yield especially when grown on native low-fertility soils. The liming of acid soils improves crop performance and increases grain yield (Claimon, 1988).

Mungbean has phosphorous, potassium, calcium, magnesium and sulfur requirements similar to other legumes which must be met by additions if the soil is deficient in these elements (Oplinger *et al.*, 1990). However, results from mungbean fertilizer trials showed that potential yields and yield response to fertilizer application varied from region to region (Claimon, 1988). Moreover, phosphorous requirement by crops varied not only among cultivars of the same crop (Sahrawat and Isram, 1988). Causes of different phosphorous effects on plants over soil types might be phosphorous adsorption by soil. This is a process mainly responsible for rendering solute phosphate in soil solution becoming unavailable to plants. Many soil properties influence phosphorous adsorption by soil (Sanyal and de Datta, 1991).

According to Rochaiyati *et al.*, (1987) the magnitude of response of crops to phosphorous application are different and it is determined largely by soil conditions. Similarly, a preliminary yield response assessment of previous mungbean fertilizer trials in relation to soil properties revealed that mungbean response to fertilizer application varied with soil texture and environment. On loamy soils mungbean responded to P and N more than to potassium, whereas on light texture soils P and K play an important role in yield increase (Claimon, 1988; Claimon and Chaiwanakupt,1991).

*= Pulses include all grain legumes which are harvested for dry grain only and are used for or food or for feed and include dry beans, chick pea, pigeonpea, dry broad beans, dry peas, lentils, cowpea and vetch. Dry beans incluse mungbean (*Vigna radiata*), black gram (*Vigna mungo*), adzuki bean (*Vigna angularis*), rice bean (*Vigna umbellata*), horse gram (*Macrotyloma uniflorum*) lackey and khesary (*Lathyrus sativus*) (Singh., 1988).

***= cation exchangeable capacity (CEC) is the amount of exchangeable cations per unit weight of dry soil. It is measuerd in centimols (+) of cations per kilogram of soil [cmol(+)/kg] or meq/ 100g (1 meq/100g = 1cmol/kg of soil) (Miller and Donahue, 1990)

**= Basic saturation (BS.) or Basic cation saturation percentage (BCSP): The cations commonly adsorbed on exchange sites of soil colloids can be divided into acid-forming cations – alumium and hydrogen – and basic (base-forming) cations – Calcium, Magnesium, potassium, and sodium (and some others). The proportion of basic cations, in percentage, to the total cations on the cations exchange complex is the basic cation saturation percentage. The more acidic a soil is, the lower the percentage of basic cation saturation (Miller and Donahue, 1990)

a= Fused magnesium phosphate (FMP) is a kind of phosphorous fertilizer which is processed by heating rock phosphate at high temperature. During processing, it is mixed with some basic chemmical substrates i.e. Magnesium, Calcium or Sodium. Therefore, it is often characterized by basic property instead of acidic property as Supper Phosphate fertilizer (Kha and Dinh, 1996).