CHAPTER 2

LITERATURE REVIEW

2.1. Nitrogen Nutrition of Soybean

Soybean derive N from the soil, from fertilizers, and by fixation of atmospheric N through a symbiotic relationship with *Bradyrhizobium japonicum*. However there are strong interactions among these three sources.

2.1.1. Effects of Combined N on N Fixation

As a leguminous crop, soybean has the capacity to fix atmospheric N_2 in symbiosis with rhizobia. Various factors such as soil mineral nutrients as well as environmental condition affect nitrogen fixation in soybean. Mineral nutrient deficiencies can limit nitrogen fixation by the legume-*rhizobium* symbiosis in many agricultural soils and as a result seriously depress potential yields.

Combined nitrogen (soil and fertilizer nitrogen) is another factor, which can affect nitrogen fixation in soybean. This influence can be stimulating or depressing, depending on the level of nitrogen supplied, as shown schematically in Fig. 1.

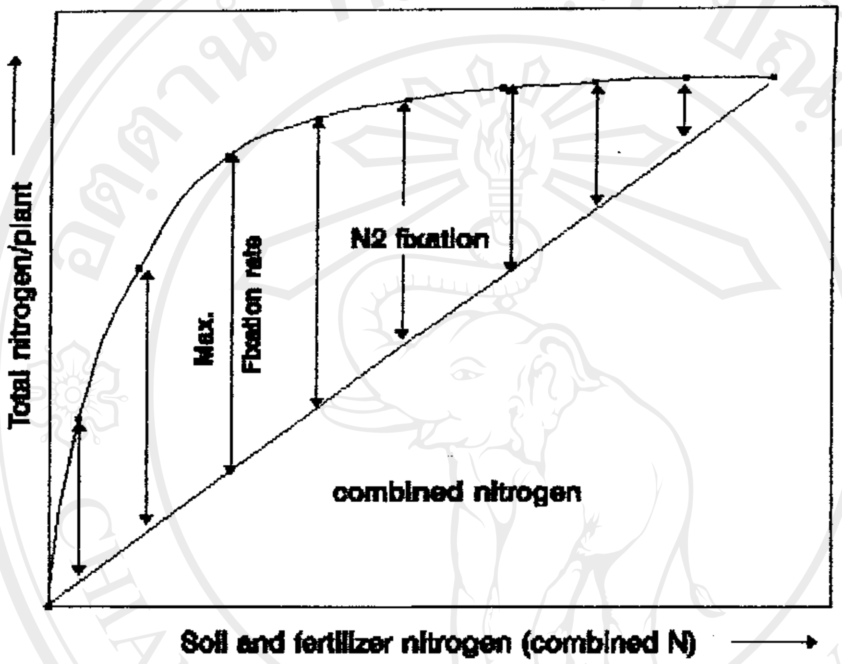

Figure 1. Simplified scheme of the relationship between nitrogen fixation and nitrogen uptake from soil and fertilizer in nodulated legumes (Marschner, 1986)

During the first few weeks of symbiotic development, combined nitrogen is essential for plant growth, which in turn can influence nodule growth. Therefore, in soil with very low levels of combined nitrogen, nitrogen deficiency can depress plant growth and development, and subsequently limit photosynthesis which in turn may limit nodule growth and nitrogen fixation. Thus, from this very low level, nitrogen fixing legumes can respond to increasing levels of mineral nitrogen, to an optimum level, after this level N fixation will be inhibited with further increase in combined nitrogen (Marschner, 1986).

Ying *et al* (1992) found that there was consistent trend of decreased proportion of plant N derived from N fixation with increasing levels of the soil combined N. This relationship was most pronounced during early growth and disappeared at the later stages. He also found that N fixation in soybean was increased by the use of N fertilizer with the preceding rice or soybean. Without N to either crop, soybean fixed 122 kg N/ha. Supply of either starter N at 50 kg N/ha, or the residual effect of 300 kg N/ha to rice increased the amount of N fixed to the level to 140 kg N/ha. Starter N had no effect on N fixation when 100 kg N/ha was supplied to rice, but starter N at 50 kg N/ha significantly decreased N fixation following the application of 300 kg N/ha to rice.

2.1.2. Nitrogen Contribution from Symbiosis

Higher soybean yields with N fertilizer than from N fixation such as reported by DeMooy *et al.* (1973) led to the conclusion that soybeans can use more N than is provided by symbiosis. They estimated that N fixation could account for

25 to 30% of the total N in a soybean crop at that time. Weber (1966) concluded that atmospheric N may provide 40% of the total in favorable seasons or 78 kg/ha for a 2,690 kg/ha seed yield in the midwestern U.S. The contribution from symbiosis N was as low as 13% of the total N in dry seasons and increased to 74% when the soil N was partly immobilized with ground corn cobs. In the Chiang Mai environment, soybean grown for grain has been found to derive 110-225 kg N/ha through atmospheric N fixation and 38 to 85% of its total N requirement (Thongrod, 1991; Wang *et al.*, 1993 and Ying *et al.*, 1992).

2.1.3. Nitrogen Nutrition of Soybean at the Different Growing Stage

2.1.3.1. Vegetative Growth Stages

The period between emergence and the beginning of effective nodule activity is one of the stage found responsive to N application (DeMooy and Sutherland, 1979). Hatfield *et al.* (1974) reported that nodulation was stimulated by adding small amounts of N during 2 weeks after emergence in the greenhouse.

The period of N shortage in the seedling stage may be relatively more important in tropical lowland conditions than in temperate regions because of the extremely low availability of soil N at the critical times, a faster rate of N uptake in the tropics (DeMooy and Sutherland, 1979).

2.1.3.2. Flowering

The period just prior to flowering is frequently named as the critical stage by those contending that the soybean crop needs more N than soil and symbiosis commonly provide. DeMooy *et al.* (1973) reported that soybean yield in outdoor sand cultures was reduced by withholding N during the period 2 to 4 weeks prior to the flowering stage more than any other stage. He also found that withdrawn N fertilizer at 2 week after flowering, did not lead to a large reduction in yield.

It has been known for some time that the number of pods retained by soybeans is conditioned by the N status of the plant (Evans, 1951). High rates of flower and pod abortion in soybean may be partially due to a lack of adequate nitrogen. Brevedan *et al.* (1978) managed to reduce flower abortion from 55 to 45 percent by the application of combined N. Applying the combined N at flowering stage at the rate of 168 kg/ha at the beginning or end of bloom and both, increased yield were 28% and 33%

in the field and greenhouse, respectively. The yield increase was a result of an increased number of seeds per plant and, sometimes, from an increase in the size of seed.

2.1.3.3. Pod Filling Stage

The R4 stage marks the beginning of the important period of plant development in terms of seed yield determination. The period from R4.5 (late pod formation) to about R5.5 is especially critical because flowering becomes complete and can not compensate. Yield reductions at this time result mainly from reductions in total pod numbers per plant, beans per pod with lesser reductions occurring in seed size. Seed size may actually compensate somewhat if growing conditions are favorable after R5.5. However, compensation by seed size is genetically limited. Thus, the plant essentially has no way to compensate for abortion-causing nutrient stress that occur during R4.5 to R5.5 (Iowa State University of Technology, Special Report No. 53, 1982).

2.2. Vegetable Soybean Response to N Application

The marketable yield of vegetable soybeans is defined by 2 and 3 seeded pods without any insect and disease damaged. Studies largely done at AVRDC shown that the marketable yield is more responsive to N fertilizer compared with the total yield. Liang (AVRDC, 1990) found that applying N-fertilizer at 100 kg/ha (half as basal and half as top-dressing at flowering stage) to the vegetable soybean led to higher marketable yield of all five varieties and the average marketable yield increased by 25% while the average total yield increase only 5% compared with N fertilizer control treatment. On the other hand, Maneechote (AVRDC, 1991) reported that both marketable yield and total yield of vegetable soybean responded to the chemical fertilizer applications. She Applied 320 kg/ha of 15-15-15 fertilizer as basal, 320 kg/ha of 15-15-15 fertilizer as the first dressing at the 10 days after the emergency, 320 kg/ha of 13-13-21 fertilizer as the second dressing at the 20 days after the emergency and 320 kg/ha of 46-0-0 as the third dressing 45 days after the emergency could increase marketable yield and total yield up to 44% and 38% respectively compared with no chemical fertilizer. However, it is not clear whether the response was due to N, P or K.

Although a lot of studies have been done on the vegetable soybean responding to nitrogen fertilizer application, there is no report about the relationship of vegetable soybean marketable yield and profits responding to inputs and managements of nitrogen fertilizer.