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CURRENT SITUATION OF NODULATED LEGUMES IN THAILAND

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Abstract

Nodulation and nitrogen fixation status of significant legumes in Thailand are discussed, especially in relation with inoculant needs, soil and other environmental factors.

Many legumes are currently cultivated in Thailand mainly for local consumption as oil, carbohydrate, and protein sources for human and/or animals, with a small surplus for export. Some legumes are grown as cover and forage crops, and little or none for green manuring purposes.

Thailand, as well as other developing countries having limited foreign exchange reserves, is finding it necessary to exploit domestically available resources. One well-known resource derived from making use of the most applicable *Rhizobium*-legume symbiotic nitrogen fixation instead of high-cost inorganic nitrogen fertilizer. In production and establishment of legumes in the country, rhizobial inoculants have been used. In this paper, the situation of nodulated legumes in Thailand is discussed.

Significant Legumes

Currently, the most significant legumes are soybean, mung bean, black matpe bean and peanut. Planted areas, amounts of productions, and yields recorded in 1979[1] are presented in Table 1. Legumes with smaller scale productions include white bean, red bean, black bean, winged bean, and other leguminous vegetables. Winged bean and some other semi-arid legumes, are being potentially considered for future commercial production. *Centrosema pubescens*, *Calapogonium mucunoides*, and *Pueraria phaseoloides* are also regarded as being potentially useful as cover and soil improving legumes, for the large land areas under fruit tree and tree crops (Table 1). Although the land area presently used for grassland is relatively small, certain pasture legumes as Stylo *(Stylosanthes hamata)* and Siratro *(Macroptilium atropurpureum)* are considered as having potential, owing to the Government promotion of beef and dairy cattles production. Green manuring legumes are also being considered, in view of the scarcity and high cost of inorganic nitrogen fertilizer.

TABLE 1. PLANTED AREA, PRODUCTION, AND YIELD OF SOME LEGUME CROPS IN 1979[a]

Crops	Planted area (rai)	Production (tons)	Yield (kg/rai)
Soybean	1,010,401 (161,667 ha)	158,929	157 (981.25 kg/ha)
Mung bean (including black matpe bean)	2,638,082 (422,093 ha)	258,972	98 (612.50 kg/ha)
Peanut	660,333 (105,653 ha)	127,531	193 (1,206.25 kg/ha)
Under fruit tree and tree crops	10,074,959[b] (1,611,993 ha)	–	–
Grassland	323,978[b] (51,836 ha)	–	–

[a]Ref. 1
[b]In 1978

Nodulation and Nitrogen Fixation Status

Information on natural nodulation and nitrogen fixation by *Rhizobium*-legume association is relatively limited. A survey of nodulation by native strains of *Rhizobium* revealed the presence of nodules of 52 legume varieties[2]. Rhizobial strains isolated from the nodules mainly appeared to be ineffective in nitrogen fixation. From the studies on natural nodulation of soybean varieties S.J. 2, Tangtrakul *et al.*[3] found that nodule numbers of soybean observed in non-soybean-cultivated areas were very much lower than those observed in soybean-cultivated areas. They also reported the possibility of the presence of effective rhizobial strains in some soybean-cultivated areas, especially in northern provinces of Chiang Mai and Nakhon Sawan provinces.

Upon inoculation, nodulation and nitrogen fixation appeared to be improved, especially in some North and Northeast areas. Boonkerd *et al.*[4] reported that nodule number, nodule mass, acetylene reduction, and plant nitrogen content were increased from to 103 nodule No./plant, 0.2 to 2.0 g/plant, 3.1 to 13.8 μmole C_2H_4/plant/h, and 1.2 to 2.2%. respectively, when inoculated soybean seeds which were cultivated in Phitsanulok (North) (Table 2). Similar responses were also observed[5] in the Northeast areas, and an example of these responses is shown in Table 2. In comparative studies, Boonkerd *et al.*[6] concluded that seed inoculation with suitable rhizobial strains was able to give soybean yield as high as those obtain nitrogen fertilizer at the rate of 156 kg/ha.

In some soybean-cultivated areas of the North, Central, and East where soybean has been cultivated annually and/or continuously, little or no response of inoculation was observed. There has been two schools of thought on this evidence, putting emphasis on the presence of effective rhizobial strains and the accumulation of nitrogen from other sources, e.g., nitrogen fertilizer applied to previous crops in this multiple cropping system and/or nitrogen fixed by other microbial activities. The economic value of the use of more effective rhizobial strains under these conditions is thus an issue of controversy.

TABLE 2. EFFECTS OF INOCULATION ON NODULATION AND NITROGEN FIXATION OF SOYBEAN (45–50 DAYS AFTER PLANTING)

Location	Treatment	Nodule number (No./plant)	Nodule mass (g./plant)	C_2H_4 formed (μmole/plant/h)	plant nitrogen (%)
Phitsanulok[a] Province (North)	Strain THAI	103.0	2.0	13.8	2.0
	Check	2.0	0.2	3.1	1.2
Kalasin[b] Province (Northeast)	Mixed strains	—	1.6	15.5[c]	2.6
	Check	—	0.1	0.9[c]	2.0

[a]From ref. 4
[b]From ref. 5
[c]μmole/5 plants/h

Inoculant Needs

It has been realized for a certain period of time that seed inoculation with effective *Rhizobium* strains is applicable and necessary for legume production in Thailand. In 1975, a symposium in *Rhizobium* research and facilities[7] was held to provide the necessary inventory of total resources on which development of rhizobial research and legume inoculants can be based. It was after the symposium that the small scale inoculant production has essentially been initiated at the Department of Agricultural Technique and the Thailand Institute for Scientific and Technological Research. The amounts of inoculant produced has been relatively limited, sufficient only for research and development purposes, with small quantities provided to farmers who are interested in using inoculants. Large amounts of inoculant, however, are presently being demanded and the production capacity will have to be expanded. For soybean alone, 750 tons/year of inoculant will be required, according to the national goal to produce 431,200 tons/year of soybean production in approximately 461,537 hectares during 1981 to 1983[8]. Inoculant production has recently become the Government policy, the pilot plant with capacity to produce 150 tons/year of inoculant is now being constructed. The production target, however, is far behind the demand. It is hoped that this activity would soon be equally matched by private manufacture.

Soil and Other Environmental Barriers to Maximum N_2 Input

Most important soil properties which affect N_2 input are nutrient status and soil reaction. Among the nutrients, nitrogen, phosphorus, potassium, molybdenum, and sulphur have been considered to be the most significant factors affecting nodulation and/or nitrogen fixation. Tearanan[9] reported that small quantity of nitrogen was necessary to support initial growth of legume seedlings, but high nitrogen content appeared to retard nodulation and nitrogen fixation. Soil nitrogen content suitable for nodulation and fixation activities was relatively low ranging between 19.5 to 39.0 kgN/ha. Thus, addition of nitrogen to soils planted to inoculated legumes was not necessary, with the exception of soils having nitrogen content lower than 19.5 to 39.5 kg N/ha. Most soils in Thailand contain insufficient phosphorus for nitrogen fixation activity and legume growth, and thus phosphorus fertilizer must be applied[6,10]. Tearanan[9] also suggested that if phosphorus contents (Bray II) of the soils were 8, 5–8, and 5 ppm., the proper quantities of phosphorus to be added should be 0, 37.5, and 56.25 kg. P_2O_5/ha. With regard to potassium, the soil having low potassium contents was found mostly in the Northeast. Therefore, in order to obtain high yield of legume cultivated in these soils, potassium fertiliser must be added. Small areas have been reported to contain insufficient molybdenum, e.g.. some areas in Chiang Mai (North) and Kalasin (Northeast)[11] but not in Nakhon Ratchasima (Northeast)[10], Roi Et (Northeast)[5] and Khon Kaen (Northeast)[12].

Soils which are mainly used for legume cultivation are characterized as acid soils, some having pH as low as 4.5[13]. To improve nodulation, nitrogen fixation, growth, and yield of legumes, liming is nesessary. Boonkerd *et al.*[11] suggested that soils with pH lower than 6.0 should be ameliorated with either lime or marl, the amounts used would essentially be in accordance with lime requirements of the soils.

Other soil properties such as water holding capacity, the presence of ineffective native strains of *Rhizobium*, and accumulation of pesticides would also affect nodulation and N_2 input, For instance, sandy soils with low organic matter content would essentially be low in water holding capacity. Detailed studies on water supplying system and management should be emphasized[14,15]. The presence of ineffective native strains of *Rhizobium* would lead to competition for nodule sites and that studies on this aspect would be most challenging. Effects of pesticides on nodulation and N_2 fixation have been evaluated[16]. Although several pesticides, at recommended rates, showed no effect, some tended to inhibit the microbiological activities. Other environmental factors as toxic substances, gases, soil insect, larvae, viruses, and *Bdellovibrio* may also affect nodulation and/or N_2 input. Studies on these environmtental effects would be of interest.

Agronomic Gaps in Legume Use

The land areas used for agricultural purposes in Thailand can, generally, be devided into two categories: irrigated and non-irrigated areas. In the irrigated areas. mostly in the North and Central, only cash crops such as soybean, mung bean, peanut, cowpea, and other vegetable legumes are cultivated either before or after rice in the multiple cropping systems. Soybean is the most popular crop and commonly planted, after harvesting rice, in the rice stubble without land preparation. Raising of green manure crops in the multiple cropping system are seldom practiced; the farmers are more interested in growing only their main cash crops. In the non-irrigated Northeast and West regions, either rice, maize, cassava, semi-arid legumes, and other economic crops are grown as main crops in rainy season. Multiple cropping systems including crop relation with green manure previously mentioned seem to be impossible under these non-irrigated conditions[17] according to the short period and unpredictability of the rainy season, Until recently, research programs on the development of multiple cropping systems, using early maturing crop varieties, have shown the success of applying several cropping systems in some areas of the Northeast[18] and the West[19]. The examples of these cropping systems include mungbean-rice-mungbean, mungbean-rice-sweet corn, rice bean *(Phaseolus calcaratus)*-rice, cowpea *(Vigna unguiculata* Walp.) -rice and legumes in cassava and sugar cane interplanting. These newly applicable technologies are of interest and are being transferred to farmers.

The use of legume as cover crop under fruit tree and rubber plantations have been realized to enhance vigor and performance of the plants. Either *Centrosema pubescens, Calapogonium mucunoides*, or *Pueraria phaseloides* alone or their mixtures are commonly used, especially in some plantation areas of the Eastwest and the South. Establishment, maintenance, and control of these legumes, however, are difficult due to nutritional requirements, shading effects, and creeping characteristics of such legumes. In term of economic significance, the use of fodder legumes possessing additional value, such as *Stylosanthes* and *Siratro* for these purposes would be more beneficial.

Most Important Problems Associated with Legume Use

The important problems associated with legume use in Thailand are the limitation of appropriate technologies for legume production, reliable supplies of high quality seeds, high cost of fertilizers, and fluctuation of legume prices. Limitation of appropriate technologies, for production of legumes and inoculants, are presumably due to insufficient numbers of scientists working in this line of research. More researchers are urgently needed to contribute joint efforts in the studies associated with selection of rhizobial strains[4], physiology and nutrition of *Rhizobium*[20]. These include some detailed studies concerning adhesive used for inoculation purposes, survival of *Rhizobium*, quality control of rhizobial inoculants and others.

Reliable supplies of high quality legume seeds are presently an important problem of legume use. Seed physiology and post-harvest technology for food, oil, and high protein legumes are being studied at Department of Agricultural Technique and Kasetsart University. Experiments on seed yield and quality of Stylo and Sirato are being caried out by Hill *et al.*[21] and Watkin[22], at Khon Kaen and Kasetsart Universities.

The cost of fertilizers in Thailand is relatively high, leading to low fertilizer consumption. Farmers with low farm incomes do not take their risk to use fertilizer, at optimal rates, to improve legume yields. The use of local resources to produce fertilizers, especially rock phosphate and certain potassium sources, would lower the cost.

The price of legume is also an important problem associated with legume use. In Thailand, the prices of agricultural products are usually low and/or fluctuating, depending upon middlemen who ilegally control the market situations. Definite national program for the control of market situations would lead to the increase in farm incomes and, in turn, higher productions of agricultural products including legumes can be promoted.

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บทคัดย่อ

บทความนี้กล่าวถึงสถานภาพของการสร้างปม และการตรึงไนโตรเจนในถั่วต่าง ๆ ที่สำคัญในประเทศไทย โดยเฉพาะในแง่ที่เกี่ยวกับความต้องการ inoculant และปัจจัยด้านดินและสิ่งแวดล้อมอื่น ๆ