Srisuda Thippayarugs. 2009. **Decomposition and N release from peanut and some tropical legume green manures for late rainy season sugarcane production.** Doctor of Philosophy Thesis in Agronomy, Graduate School, Khon Kaen University.

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ABSTRACT

Northeast Thailand is the main area of sugarcane production but its yield is rather low. Low soil fertility is considered to be one of the yield limiting factors. Continuous monoculture of sugarcane can lead to soil deterioration due to crop removal burning and other processes e.g. leaching, denitrification and volatilization. Approximately 80% of sugarcane planting areas in the Northeast Thailand are in late rainy season (October to November). One crop cycle of sugarcane usually takes at least 2.5 years during which the soil is under continuous sugarcane crop (one plant crop and one ratoon crop). Under this system, there also will be a period of 5-6 months when the soil is left fallow during the rainy season. This will be an opportunity to improve soil fertility of the upland using legumes. Integration of legume green manure into the farming systems can be a cheap alternative in alleviating low soil fertility and erosion problems. Legumes used as green manure are an alternative source of N to sugarcane, and can supplement or replace N fertilization.

Therefore, potential green manure legumes under the Northeast conditions were studied for soil fertility improvement during fallow period as well as their benefits on succeeding sugarcane. This study was conducted at Khon Kaen Field Crops Research Center on a loamy sandy soil (Yasothon series, Oxic Paleustults) from May 2000 to January 2002. Three experiments were conducted in Northeast Thailand. The aims of the experiment I were 1) to evaluate the potential legumes on their biomass production, N content, N_2 fixation, and soil moisture affected by planting legumes on sugarcane emergence, 2) to understand the patterns of

decomposition and N release of the legume residues, 3) to trace N from legume residues contributed to sugarcane cropping system by using ^{15}N labeled residues, and 4) to evaluate the effects of legume residues as N substitute for mineral N fertilizer application on sugarcane production. Experiment II was conducted to study decomposition and N release of 3 legume residues with the aim to understand contribution of N from individual plant parts of legume residues and the combination of the aboveground plant parts under laboratory condition. In the experiment III, the effects of legume residues and rates on sugarcane growth were investigated under pot condition with the aim to understand contribution of N from legume residues to early growth of sugarcane in comparison to mineral fertilizer N.

In experiment I, 6 species of tropical legumes were investigated for planting as potential green manures. Six legume species included a grain legume, peanut (*Arachis hypogaea* L.), three green manuring legumes, pigeonpea (*Cajanus cajan* (L.) Millsp.), jackbean (*Canavalia gladiata* (Jacq.) DC.), sunnhemp (*Crotalaria juncea*) and two local leguminous weeds, *Crotalaria striata* and hairy indigo (*Indigofera hirsuta* Harvey) were evaluated for biomass production, N accumulation, N_2 fixation and soil moisture after planting legumes and during planting sugarcane. The legume were planted in May and harvested in September 2000 using a randomized complete block design with 4 replications. Nitrogen fixation of the legumes was determined using ^{15}N isotope dilution method. Soil moisture determination was conducted after harvesting legume and during early stage of planting sugarcane. To study the effects of legumes residues as N substitute for mineral N fertilizer application at sugarcane planting, the legume residues were incorporated in October 2000, and then sugarcane was planted. Growth of sugarcane was determined at 151 and 285 days after planting (DAP) and yield was harvested in January 2002.

Rates of decomposition and N loss of incorporated residues were also determined using the litter bags buried in the sugarcane field. Remaining weight and N were determined by retrieving bags every 1-2 weeks through out sugarcane planting period. N recovery under field conditions from 4 legume residues (peanut, pigeonpea, jackbean and sunnhemp) was also assessed using high ^{15}N enriched residues. ^{15}N was determined in soil layers, sugarcane and non-decomposed legume residues at 180 DAP.

In experiment II, individual plant parts (stems, leaves, leaf litter and roots) or the combination of aboveground plant part of peanut, pigeonpea and hairy indigo were incubated in 2 liter-pots for 19 weeks using a randomized complete block design with 4 replications. Periodically, remaining plant residues were sieved out (>2 mm), weighed and N content as well as soil mineral N determined.

For experiment III, residues of the 6 legumes with 2 rates of application were investigated using a randomized complete block design with 4 replications for their contribution to soil mineral N dynamics, CO_2 evolution, nutrient contents and early growth of transplanted sugarcane seedlings in a pot (28 litters) experiment. The studied legume residues were peanut, pigeonpea and hairy indigo applied at 6.25 Mg ha^{-1} (low rate) and 12.5 Mg ha^{-1} (high rate) and jackbean, sunnhemp, and *Crotalaria striata* (*C. striata*) applied at low rate only. Sugarcane was harvested at 139 day after seedling transplanting.

The results of experiment I revealed that total aboveground biomass of legumes ranged from 4.2 to 10.7 Mg ha^{-1} and N content ranged from 59 to 150 kg ha^{-1}. Sunnhemp produced the highest biomass and jackbean the lowest. N_2 fixation of all legumes ranged from 61-81% of their total N. Peanut (without P and K fertilizers), jackbean and hairy indigo fixed higher N_2 (80-81% of total N). Soil moisture was affected by growing legumes but did not have significant effect on sugarcane emergence.

The litterbag study showed that jackbean decomposed fastest during 0-49 days after burying bag (DAB) with the rate constant (*kw*) of 0.0180 day^{-1}, leaving residues remaining 32% of initial residue addition whereas pigeonpea decomposition was the slowest with *kw* of 0.0077 day^{-1}, leaving residues remaining 69% of initial residue addition. During the second phase (77-358 DAB) *C. striata* decomposed fastest (*kw* 0.0069 day^{-1}) leaving 5% of dry weight remaining of the initial added whereas pigeonpea decomposed slowest (*kw* 0.0042 day^{-1}) leaving 17% of dry weight remaining of the initial added.

N remaining at 301 DAB was highest in retrieval of pigeonpea residues (26%) with the rate constant (*kn*) of 0.0041 day^{-1} and was lowest in *C. striata* residues (16%) with *kn* of 0.0076 day^{-1}.

Nitrogen at 180 DAP from ^{15}N enriched legume residues was highest with jackbean application which 15% of initially added was in sugarcane biomass and 62% in the soil layers (0-80 cm). Application of peanut residues, ^{15}N recovery was lowest which 5.5% of initially added was in sugarcane biomass and 39% was in soil layers. The total N recovery was highest from jackbean application (87%) and was lowest from peanut application (47%).

The millable cane yield was not significantly different among the applications of legume residues (94-105 Mg ha^{-1}). However, peanut residue applications (with and without P and K fertilizers), jackbean and hairy indigo obtained significantly higher millable cane yields than blank soil treatment and not significantly different with the application of mineral N fertilizer. Millable cane yields from all applications of legume residues were higher than that from the application of weed residues.

Experiment II revealed that above- and below-ground residues of peanut decomposed fastest and showed the largest N release in agreement with their high N concentration and low acid detergent fiber (ADF):N ratio. Hairy indigo was hypothesized to have lower residue quality than pigeonpea because of its high polyphenol content. However, hairy indigo decomposed faster than pigeonpea, largely because of the higher N and lower lignin concentration of its components. Ranking of individual plant components for N mineralization resulted in the following pattern, leaves>leaf litter>roots>stems. In mixtures of stems, leaves and leaf litter, as compared by species, ranking order in fast decomposition was as follows: peanut>hairy indigo>pigeonpea. The amount of N released from the mixture was dominated by stem material that comprised 46-61% of the mixture. The interactions in mixtures were relatively small for peanut (generally high quality components with high N, low lignin and polyphenol) as well as for pigeonpea (low proportion of high quality components, i.e. N rich leaf material). However, a positive interaction occurred during later stages of N mineralization in the mixture of hairy indigo.

The results experiment III showed that legume residues varied in chemical characteristics and could be categorized into three groups using N concentration, C:N ratio, lignin and polyphenol concentrations. The high quality legumes were peanut and sunnhemp, the intermediate quality legumes were jackbean and *C. striata*, and the low quality legumes were pigeonpea and hairy indigo. High quality legume residues resulted in high extractable mineral N, which resulted in higher sugarcane growth at 139 DAT. Peanut residue application resulted in the highest sugarcane biomass and followed by sunnhemp. However, Peanut residue contributed the lowest CO_2 evolution while pigeonpea was the highest. Nutrient uptake in sugarcane biomass at 139 DAT indicated that the uptake of N and K were higher in peanut than other leguminous residues and N fertilizer application. Similarly, sunnhemp and peanut residue treated soils resulted in higher uptake of Mg than those receiving other treatments. In addition, N, P, K and Mg uptake were higher in these treatments than the control treatment. Application of legume residues, especially pigeonpea, resulted in higher soil organic matter when measured after sugarcane harvest at 139 DAT.

It is concluded that all the studied legumes can be used as green manures for sugarcane production. They have different patterns of decomposition and N release depending on the chemical compositions of each plant parts as well as the proportion of each component in the mixed residues. All the legume residues have the potential to substitute N fertilizer applied at sugarcane planting, especially peanut. Information of this study can be used to develop management of legume residues to match N release and sugarcane demand for N.