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Potential of Three Tropical Legumes for Rotation of Corn-Based Cropping System in Thailand

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ABSTRACT

This study was an attempt to search for a means to assimilate tropical legumes into the existing cropping system of corn in order to improve the productivity of the corn crop. The study consisted of three experiments: 1) a study on the growth of three tropical legumes (lablab bean, *Lablab purpureus*; thornless mimosa, *Mimosa invisa* and sesbania, *Sesbania speciosa*); 2) a study on the seed dormancy of the legumes; and 3) a study on the germination behavior of the soil seed bank of a legume (thornless mimosa) in relation to the growing season of corn. The results of the study showed that lablab bean and sesbania were suitable as rotation crops with a corn crop, while thornless mimosa was able to be assimilated into the corn crop in both rotation cropping and intercropping. The results also showed that thornless mimosa had dormant seeds and that a seed bank for this legume could be created in the soil, so there was no need to sow seeds every year, as mimosa would be reseeded from this soil seed bank.

Keywords: tropical legumes, green manure

INTRODUCTION

Deteriorating soil productivity is threatening the competitiveness of field-corn production in Thailand, with low soil organic matter in most cultivated land of the country. Though mineral fertilizer can produce a quick improvement in production, the costs of mineral fertilizer and low organic matter in the soil make it increasingly important to search for biological sources of fertilizer.

The amount of soil organic matter governs both physical and biological properties of the soil, which are key factors in soil productivity and to achieving a better response of plants to the application of chemical fertilizer. Studies have suggested that green manure is a good biological source of fertilizer in corn crops in Thailand (Yamaki, 1981; Sukthumrong *et al*., 1981).

Legumes are a promising source of organic matter, as well as providing nitrogen for the soil. Tropical areas are a rich source of tropical legumes (National Academy of Science, 1979). Trials on a research station have shown a remarkable increase in corn yield by turning legumes into the soil before the corn crop (Phetchawee *et al*., 1985). However, the applicability of tropical legumes to the existing corn cropping system has not been investigated comprehensively.

The aim of this study was to evaluate the growth and suitability of three promising tropical legumes, in order to develop processes to assimilate the legumes into the corn crop.

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MATERIALS AND METHODS

Three experiments were conducted in a Pak Chong soil series at Suwan Farm, Nakhon Ratchasima province. The results of soil analyses before planting were: pH 6.9, organic matter (OM) 2.6%, P level 74 ppm, K level 180 ppm, Ca level 880 ppm and Mg level 110 ppm.

Experiment 1 involved_a study on the growth of three tropical legumes: lablab bean (*Lablab purpureus*), sesbania (*Sesbania speciosa*) and thornless mimosa (*Mimosa invisa*), using a randomized complete block design with three replications. The seed rate of the legumes was: lablab bean, 75.0 kg ha^{-1}; sesbania, 37.5 kg ha^{-1} and thornless mimosa, 37.5 kg ha^{-1}.

Data on the dry weight and plant height of the legumes in an area of 1 m^2 were randomly taken from each trial plot on a weekly basis, throughout the period from the 4^{th} week to the 12^{th} week after planting.

Experiment 2 involved a laboratory study on the seed dormancy of the legumes, using a three factorial completely randomized design with three replications. The first factor was the seed type of two legumes, namely, sesbania *(Sesbania speciosa)* and thornless mimosa *(Mimosa invisa)*. The second factor was three levels of water temperature: ambient (tap water), 60°C and 80 °C. The third factor was the duration for soaking the seeds; 10, 30 and 60 min. The treated seeds were germinated in Petri dishes at room temperature (about 27°C) for 3 d. Then, the germination rate in each Petri dish was recorded.

Experiment 3 involved a study on the germination behavior of the soil seed bank of the legume in relation to the growing season of corn. In 2007, an experimental plot 1 ha in size on the Suwan Farm was planted to mimosa. The mimosa was allowed to grow and bear seeds at the end of the year. In March of the following year (2008), the mimosa plants with their mature seeds were turned over into the soil; therefore, the dormant seeds remained in the soil.

Eight sites in the plot with an area of 1 m^2 were chosen at random in order to determine the reseeding characteristics of mimosa from its dormant seed stored in the soil. Every week from March 27^{th} to November 17^{th}, data on the number of germinating seedlings were taken from the eight sample sites by pulling up and counting the number of seedlings. Then, the amount of the seedlings was determined on a monthly basis.

The amount of rainfall on a monthly basis throughout the study was recorded. The rainy season in Thailand starts from the middle of April and finishes in the middle of October.

RESULTS

Growth and nature of the 3 tropical legumes

The results of Experiment 1 showed that there were noticeable differences in the growth of the three legumes in both magnitude and pattern (Figure 1). In short, the rate of growth of the three legumes ranged from highest to lowest with the lablab bean, sesbania and mimosa respectively; however, at the 12^{th} week, the growth of sesbania caught up with that of lablab bean, while the growth of mimosa was less than half, compared to the growth of the other two. The lablab beans had a high growth rate in the beginning, and slowed down from week 7 onwards, while the growth rate of sesbania was low for the first 6 wk and began to accelerate from week 7 onwards. The growth rate of mimosa was low during the first 8 wk and increased gradually from week 9 onwards.

Height growth was very rapid in the lablab bean, compared to that of sesbania and mimosa (Figure 1). This result also revealed that the lablab bean had the characteristics of a vine (that is, twining around neighboring plants), with the length of its stem ranging from about 1 m at week 4 to 1.6 m at week 12. On the other hand, sesbania had an erect stem with a plant height of about 60 cm at week 4 and about 80 cm at week 12. The mimosa grew in a horizontal direction; it did not have the characteristics of a vine and the length of its stems ranged from about 20 cm at week 4 to about 60 cm at week 12, with the apparent height not more than 80 cm.

Dormant seeds and its germinating characteristic

Sesbania had non-dormant seeds, but mimosa had dormant seeds (Figure 2). The results of Experiment 2 showed that, in the ambient-temperature water (tap water), sesbania had 80% germination, but mimosa had less than 20%. The germination of mimosa increased up to 60% when the seeds were soaked in heated water at 60°C and this increased up to almost 80% when the seeds were soaked in heated water at 80°C. This phenomenon was not apparent with the seeds of sesbania.

In ambient-temperature water, a longer duration of seed soaking resulted in an improvement in germination of the dormant seeds (Figure 2). The study also revealed that, in ambient-temperature water, the germination of mimosa increased considerably when the seeds were soaked for a longer duration. On the other hand, the opposite result occurred in the heated water, especially at 80°C. This adverse effect on germination due to extended hot water soaking was confirmed markedly in the case of sesbania. The study also revealed that the most suitable duration for soaking the seeds in order to break down seed dormancy was 10 min at 80°C.

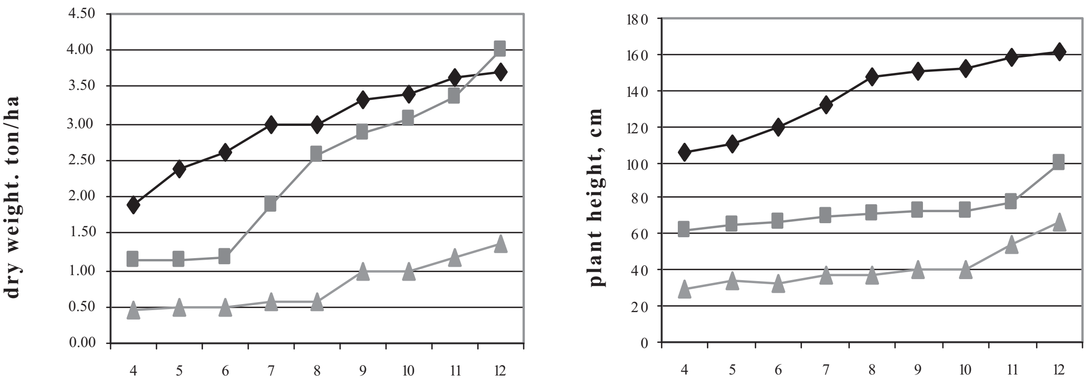

Figure 1 Growth in dry weight (ton/ha) and plant height (cm) from week 4 to week 12 after planting for three legumes: lablab (—♦—), sesbania (—■—) and mimosa (—▲—).

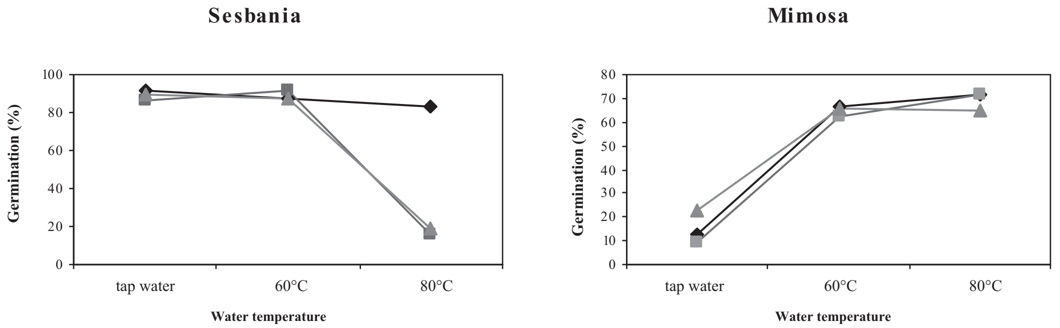

Figure 2 Germination of sesbania and mimosa seeds after soaking at different water temperatures, namely, ambient-temperature water (tap water), 60°C and 80°C, with a duration of 10 (—♦—), 30 (—■—) and 60 (—▲—) min.

Relationship between the legume dormant seeds and the rainfall pattern

By turning over the mimosa plants with their mature seeds into the soil, a seed bank was formed in the soil, which was able to reseed the mimosa, as long as there was rain (Figure 3). In this study, mimosa was reseeded as soon as the first big rain came in March and it continued throughout the rainy season. The phenomenon ceased in November, which was the first month of the dry season.

However, the amount of the reseeded mimosa in the first part of the rainy season was much greater than in the second part. As shown in the Figure 3, more than 60% of the mimosa seedlings germinated from March to the end of May. Then, there was little mimosa germination in June, which was the dry period of the rainy season. Mimosa seedlings germinated again from July to October, and germination ceased from November, which is the beginning of dry season in Thailand.

DISCUSSION

The three tropical legumes as green manure in corn crop

Each of the three legumes required a different period from germination to commence nitrogen fixation. The growth in dry weight of the three legumes revealed that lablab bean started to fix nitrogen from week 4 onwards, with sesbania from week 7 onwards and mimosa from week 9 onwards. This may have been due to the fact that different kind of legumes require different strains of rhizobia to fix nitrogen and not all strains of rhizobia are common in the soil (National Academy of Sciences, 1979). The present study results did not confirm that the slow growth of mimosa was due to a lower amount of suitable rhizobia in the soil. However, reports indicated that remarkable improvements in both the growth of mimosa and soil productivity were recorded from the second year onwards after the introduction of mimosa into a corn crop (Phetchawee *et al*., 1985; Suwanarit *et al*., 1995).

Being short-day plants, the three legumes used all resources (sunlight, rain and time) to produce biomass as organic fertilizer throughout the rainy season, due to the long days. In the current study, the three legumes did not flower during the rainy season; they started to flower just at the end of the rainy season, when the length of the days decreased. The legumes did not cease to produce biomass until they started to flower at the end of the rainy season. In addition, being short-day plants made them tolerable to adverse conditions (diseases and insect pests).

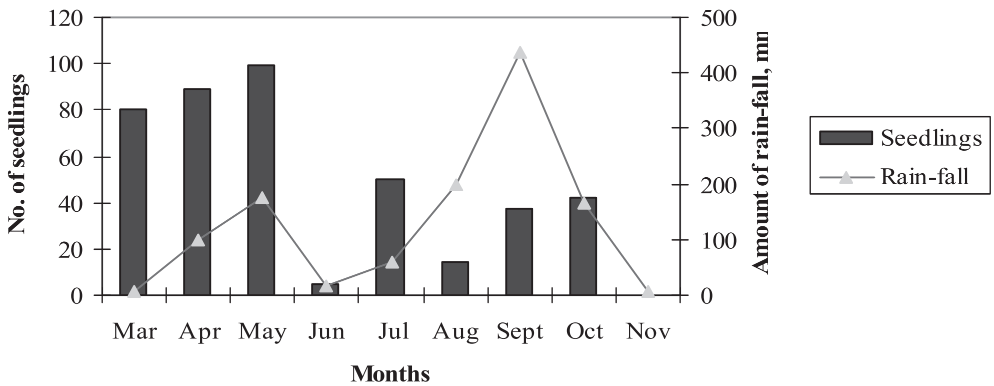

Figure 3 Occurrence of reseeded mimosa seedlings from the seed bank throughout the rainy season.

In the corn growing area of Thailand, the rainy season lasts about six months, starting in April until October. The existing corn crop takes about 110 to 120 d to harvest, or about 4 months. Therefore, Thai farmers have two months extra to grow legumes as green manure before the following corn crop.

The current study revealed that different approaches were needed to grow the three legumes for green manure in the corn crop. Lablab bean and sesbania were suitable for use as a rotation crop with the corn crop because of their vigorous growth. Mimosa appeared to be easier to assimilate as a part of the whole corn crop owing to its longer period of slow growth; moreover, it also had horizontal growth and did not intertwine with neighboring corn plants; this encouraged it to grow underneath the corn plants without reducing the population of the corn crop.

Role of the legume with dormant seeds as a green manure in corn crops

Dormant seeds of the legume in the soil would act like a seed bank that could supply legume plants as green manure. The results of the current study revealed that a seed bank of mimosa was able to be created by plowing under the previous year's crop of mimosa with its mature seeds. The mimosa plants would reseed from these seeds in the soil and would grow to cover the soil during the early part of the rainy season, after which they could be plowed under as green manure for the following corn crop. Furthermore, there was almost no cost associated with growing mimosa and there was more time for growth of the legume to produce organic fertilizer.

Creating a seed bank of mimosa in the soil would make mimosa a potential legume in corn production by improving soil productivity and thus improving corn yield. Mimosa, as green manure in the first part of the rainy season, could be turned over into the soil and a corn crop planted, which would grow healthily. Furthermore, during the corn crop, another batch of mimosa could be grown underneath the corn and stover throughout the corn crop to bear seeds for adding into the seed bank in the soil for next year's crop.

CONCLUSION

There are six months of rain in the corn-planting regions of Thailand, which is more than enough to provide water for a corn crop, whilst allowing the remaining rain to be used to support a crop of legumes to produce green manure before the corn crop is established. The results of the current study have shown that a seed bank of a legume in the soil could be created by plowing in the legume with its mature seeds dormant in the soil. The legume can then act as an organic fertilizer and would be reseeded from these dormant seeds in subsequent years. This provides a practical and economical way to improved soil fertility.

A further goal of this study was to research the use of two kinds of legumes to be grown at the same time and on the same planting area with different plant types in order to maximize the production of the green manure for the following corn crop.

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