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The utilization of leguminous *Gliricidia sepium* as natural fertilizers to improve soil fertility

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Abstract Soil degradation is one of the most important problem to be solved for sustainable agriculture. To improve soil from repetitive land use, the leguminous plant *Gliricidia sepium* was evaluated as natural fertilizer supplementation. The experiment was carried out in pot trial. Green leaf manure and intercropping gave positive effects on the growth of sweet corn. The pH, organic matter content as well as nitrogen, potassium, phosphorous and calcium content of the soil amended with the leaves of *G. sepium* increased. Green leaf manure at 5 and 10 percent supplementation gave the highest plant growth at 4 weeks after transplantation. However, 10 and 20 percent supplementation ratio gave the highest plant development at 8 weeks after transplantation. The chemical properties and nutritional status of the soil increased when mixed with green manure or intercropped with *G. sepium*.

Keywords: *Gliricidia sepium*, natural fertilizer, soil fertility, soil improvement

Introduction

Soil is a natural resource that is vitally important for supporting food production and foundation for agriculture, as well as the growth of all food-producing plants (FAO. 2015). Currently, soil degradation by erosion affects 1,966 million hectares worldwide (Lal, 2007). Soil degradation is now a serious concern for agricultural and crop production in the context of sustainable agriculture especially in Thailand, where the extensive agricultural crop production greatly causes soil erosion and loss of soil nutrients (Putthacharoen *et al*., 1998; Pansak *et al*., 2008; Tingting *et al*., 2008).

Natural fertilizer is one of the alternative ways to improve soil nutrition. According to remediation of soil nutrients, the use of green manure is being

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used to improve soil fertility, refinement of soil structure, induction of microbial activity and maintenance of moisture content (Preston, 2003; Maitra *et al*., 2018).

Gliricidia sepium is one of the leguminous trees that is native plant to Mexico and Central Americas and it was later introduced to other countries including Thailand. This tree can grow in a number of different climates and soil types (Lavin *et al*., 1996). *G. sepium* tree is a fast growing tree after pruning, it possesses nitrogen-fixing ability which improve soil fertility and is being employed as intercrop in cocoa plantations. This plant is also referred to as "Mother of cacao" because of its outstanding advantages in soil improvement (Stewart *et al*., 1996). In some previous studies, *G. sepium* green manure was used as fertilizer to increase nitrogen uptake more effectively in corn than using corn stubble (Abdul and Zaharah, 2006). Moreover, *G. sepium* intercropping was used to improve soil properties and corn yield in South Africa (Beedy *et al*., 2010). The green manure tree, as well as other legumes and forage plants may play a significant role in agricultural management by enhancing the soil properties in intercropping system (Duchene *et al*., 2017).

This study aimed to examine the leguminous plant *G. sepium* as green manure and intercrop and determine its effect on soil quality and plant growth in Thailand.

Materials and Methods

Soil sample and G. sepium fertilizer preparation

Soil sample was taken in an area of Tambon Makam Tao, Wat Sing District, Chai Nat Province Thailand (latitude 15.21456831 and longitude 100.02268497). Soil sampling was done using the method of Carter and Gregorich (2008). The collected soil was dried and crushed into powder. It was kept in dry condition at room temperature until use. *G. sepium* was identified based on its botanical characteristics as described by Stewart *et al*. (1996). Fresh leaves were harvested at Chandrakasem Rajabhat University, Bangkok campus. Cuttings were collected and grown for 3 months and used as intercrop in this study.

Measurement of plant growth as affected by different fertilizer supplementation

The pot trial was designed using completely randomized design (CRD) under greenhouse conditions. The method was modified according the amount of fertilizer which was based on soil organic matter (SOM) intensity (Troeh and

Thompson, 2005). The experiment was composed of 5 treatments: (1) plain soil as control 1 and (5C) soil planted with *G. sepium* cutting alone as a control 2, (2) *G. sepium* green manure at 5 percent, (3) *G. sepium* green manure at 10 percent, (4) *G. sepium* green manure at 20 percent and (5) *G. sepium* cutting intercropped with test plant (Figure 1). Sweet corn (Supersweet corn®, Chua Yong Seng Seed Co., Ltd) was used as test plant to determine the efficiency of fertilizer to induce plant growth and development. Sweet corn at 1 week after emergence was transplanted into each treatment. The plant was evaluated for vegetative growth rate by determination of plant height, stem size, leaf area and leaf number at 4 and 8 weeks after transplantation (Ransom *et al*., 2014; Nleya *et al*., 2016).

Evaluation of fertilizer supplementation for changing soil nutrition

Soil samples from each treatment was collected after 8 weeks. The samples were pooled, dried and grounded into powder at room temperature and indoor conditions. Soil composition of the samples was analysed at the Office of Agricultural Research and Development Region 5, Chainat, Thailand.

Statistical data analysis

The results of the experiment were analysed using one way ANOVA and comparison of means was carried out using Duncan Multiple Range Test (DMRT) at $p<0.05$.

Results

The effect of G. sepium fertilizer supplementation on plant growth

The assessment of the efficacy of *G. sepium* green manure in inducing sweet corn growth and development was made at vegetative stage. The growth of tested plants and growth parameter were shown in Figure 1 and Table 1. The plants that were cultivated in soil supplemented with *G. sepium* green manure have growth and development rate higher than that of the controlled plants (Figure 1). The growth parameters were observed at 4 weeks after transplantation (V8-V9 stage).

It was found that corn grown at 5 percent green manure had significantly higher plant height and leaf number with 23.75±2.06 cm and 7.25±0.96 cm, respectively, compared to all other treatments.

The largest leaf area with 4.88 ± 0.78 m^2 was obtained in treatment with 10 % green manure. In terms of stem size, the use of 20% green manure considerably exhibited larger diameter with 2.60 ± 0.70 cm.

As for the developmental growth rate at 8 weeks after transplantation (V16-V17), the highest plant height and leaf number were obtained in soil supplemented by 10% *G. sepium* green manure. In addition, treatment with 20% green manure supplementation resulted to the highest supplement-induced growth in terms of stem diameter and leaf area.

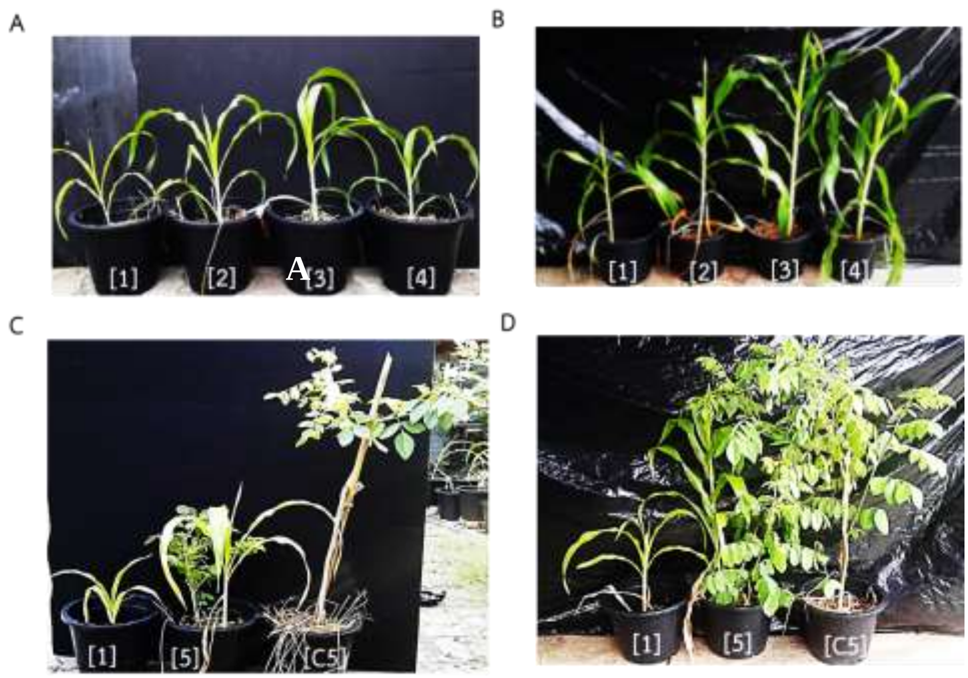

Figure 1. Plant growth in various treatments of *G. sepium* fertilizer: (A) Sweet corn at 4 weeks after transplantation, (B) Sweet corn at 8 weeks after plantation, (C) *G. sepium* intercropping with Sweetcorn 4 weeks after transplantation, (D) *G. sepium* intercropping with Sweetcorn 8 weeks after transplantation: [1]; No used green manure, [2]; Green manure ratio at 5 percent, [3]; Green manure ratio at 10 percent, [4]; Green manure ratio at 20 percent**,** [5]; *G. sepium* intercropping**,** [C5]; Growth of *G. sepium* cutting

Table 1. Growth rate of sweet corn in various treatments of *G. sepium* fertilizer

Treatment	Plant height (cm)	Stem size (cm)	Leaf area (m^2)	Leaf number (leaves/plant)
4 weeks after transplantation				
Control	2.02±16.13[a]	1.80±0.22[a]	1.68±0.29[a]	4.75±0.55[a]
Green manure 5 percent	23.75±2.06[f,g]	2.55±0.19[e]	4.37±0.81[c,d]	7.25±0.96[a]
Green manure 10 percent	19.75±3.52[e]	2.58±0.39[a]	4.88±0.78[c]	7.20±0.45[c]
Green manure 20 percent	18.50±4.36[b]	2.60±0.70[a]	4.50±1.67[d]	6.40±0.55[b]
G. sepium intercropping	18.90±2.75[c]	2.52±0.15[a,b]	2.05±0.51[b]	5.40±0.55[a,b]
8 weeks after transplantation				
Control	33.00±4.42[a]	2.53±0.29[a]	4.64±1.20[a]	7.25±0.65[a]
Green manure 5 percent	57.93±3.32[c]	3.64±0.17[d,e]	9.72±1.08[c]	10.25±0.52[c]
Green manure 10 percent	60.25±5.20[e]	3.63±0.15[e]	12.12±2.56[d]	10.40±0.55[c]
Green manure 20 percent	58.75±4.50[d]	4.43±1.05[e]	12.18±1.25[d]	10.20±0.84[b,c]
G. sepium intercropping	51.70±1.99[b]	2.82±0.40[c]	6.01±1.46[c]	8.60±0.55[b]

The effect of G. sepium fertilizer supplementation on soil composition

To evaluate soil properties from different treatments supplemented with *G. sepium* green manure, a soil sample from each of treatments was collected at 8 weeks after introduction. Soil structure was determined and a loamy sand structure was observed in the control sample, 10% green manure, 20% green manure and intercropping. In addition, pH and electrical conductivity (EC) of soil increased proportionally with higher percentage of the green manure and the adoption of intercropping. Regarding soil chemical contents, there was a significant increase of total nitrogen (N), organic matter (OM), potassium (K), phosphorus (P), and calcium (Ca) when the soil samples were supplemented with *G. sepium* green manure. However, the soil chemical content slightly increased in the *G. sepium* intercropping when compared with the control sample (Table 2).

Table 2. Composition and physical chemistry of soil in various treatments of *G. sepium* fertilizer at 8 weeks after introduction

Treatment	Soil texture	pH	EC (mS/cm)	Total N (%)	OM (%)	K (ppm)	P (ppm)	Ca (ppm)
Control	Loamy sand	5.90	0.04	0.054	1.09	36	30	365
Green manure 5 percent	Sand	6.32	0.06	0.083	1.66	26	81	522
Green manure 10 percent	Loamy sand	6.59	0.10	0.096	1.93	37	139	629
Green manure 20 percent	Loamy sand	6.71	0.13	0.106	2.12	56	119	866
***G. sepium* intercropping**	Loamy sand	6.11	0.04	0.057	1.14	28	43	400

Discussion

Measurment of the efficiency of *G. sepium* green manure supplementation in the soil sample was carried out in this experiment. The vegetative development from V1 to V12, which required considerable amount of macronutrients, especially potassium, nitrogen and phosphorus, of tested plants was determined (Ritchie *et al*., 1997; Bender *et al*., 2013). Results indicated that *G. sepium* fertilizer has a positive effect on both plant growth and soil chemical properties for each of different manure amout contents, as well as the employment of intercropping. Induction of plan growth at 4 weeks after transplantation occurred when the green manure was utilized at the amount of 5% and 10% However, the effective response of Sweet corn to the green manure fertilizer at the amount of 10% and 20% was observed after 8 weeks of transplantation. Furthermore, soil sample test revealed that a high nutrition content was correlated directly to the high concentration of the green manure. The result also showed that *G. sepium* leguminous tree was able to promote soil nutrition that induces plant growth. The result was closely corresponded with previous studies suggesting that the use of green manure could convert soil nitrogen (N) to nitrate, which is the most plant available form of N at 80 days after decaying in soil. Moreover, corn can absorb available nutrients from *G. sepium* green manure in the amount higher than corn stubble (Pandey and Rai, 2007; Abdul *et al*., 2006). Additionally, *G. sepium* leguminous intercropping has been used to enhance corn reproduction, growth and yield in South Africa due to the fact that *G. sepium* leguminous tree can induce soil organic matter (SOM), particular organic matter (POM), as well as increase nitrogen element in corn and *G. sepium* leguminous tree intercropping (Beedy *et al*., 2010). In a previous study, endophytic bacteria residing in the nodules of G. *sepium* can fix atmospheric nitrogen. The study also revealed that *Rhizobium sp*. has a symbiotic relationship with leguminous tree and is able to undertake biological nitrogen fixation activity (Cubillos-Hinojosa *et al*., 2011).

In conclusion, *G. sepium* leguminous tree could be used as a natural biofertilizer, green manure and intercropping plant for improving soil quality, preventing soil degradation and hindering soild structure alteration. The available elements of *G. sepium* fertilizer greatly affect the induction of nutrition uptake during plant growth. This research will be applied to prevent soil degradation and lessen chemical fertilizer ulitization in repetitive agriculture and organic farming areas.

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