Joint French-South-East Asia Research and Training initiative

DYNAMIC OF LAND USE CHANGES AND SOIL ECOSYSTEM SERVICES (LUSES)

Internal Call for small proposal

Year 2013

Project responsible	Dr Wanpen Wiriyakitnateekul

Title
Characterization of the microbial communities in the soil of a rubber tree plantation in North-Eastern Thailand and impact of increasing biochar doses application.

LMI partners (French)	Dr Didier Lesueur, CIRAD - UMR Eco&Sols

LMI partners (Asian)	Dr Wanpen Wiriyakitnateekul, Land Development Department
	Dr Saowanuch Tawornpruek and Dr Pechrada Pinjai, Kasetsart University + Master student

Others Partners	
Western Countries	Dr Lambert Brau and Laetitia Herrmann, Deakin University
Asian Countries	

Type of support	**Amount (€)**
Deadline (15 th of February)	
Student support	
Student research expenses (Master and PhD)	3,000
Students missions	800
Support to project building	
Collective training expenses	
Mission (exploratory, support)	
Field support	1,200
Exploratory project	
Beside project support (link to a bigger one)	
Equipment	
Others	

Asian Countries involved (put an x)

Thailand	Vietnam	Laos	Others
X			

Working package involved (put an x)

WP1 Soil fertility and the dynamics of mineral nutrients	**WP 2 Soil and water functional biodiversity**	**WP 3 Carbon storage in plant biomass and soil**	**WP4 Regulation of water flow and erosion** s
X	X		

General context of the proposal

The rubber tree (*Hevea brasilensis* Muell. Arg.) is a crop of major importance in Southern Asia and particularly for smallholders in Thailand. It is a fast-growing upright tropical crop mainly cultivated for its production of latex. Rubber is the major industrial product derived from latex collected from trees belonging to the *Hevea* genus. Thailand is the world leading producer and exporter of rubber with a production capacity of about 3.2 millions ton per year, with about 90 percent of the total production capacity exported to foreign markets. In contrast to Malaysia where rubber trees are mainly grown on large estates, 90% of rubber made in Thailand comes from family-owned smallholdings of less than eight hectares in size, with an average area of plantation of only two hectares. A substantial potential for increased production could lie in the establishment of rubber tree plantations in new areas, especially in North and Central Thailand, where the rubber trees currently cover 0.6 million hectares (Saengruksawong et al 2012).

In Thailand, rubber tree can be grown in many areas which are unsuitable for other commonly cultivated cash crops (sandy soils, low fertility, subject to erosion and leaching of applied fertilizers). Rubber trees usually only require a modest level of soil nutrients when compared to coffee, tea, coconut or oil palm,however fertilizer applications are advantageous and are mostly needed to replace nutrients loss (RFD 2000). Cheng et al (2007) showed in China that soil fertility (soil organic matter, total N, available P and available K) decreased with time. Similar results were obtained in Nigeria (Akpan et al, 2007; Njar et al, 2011; Orimoloye et al, 2010). According to Cheng et al (2007), without additional fertilizer applications, levels of P, N, K and Mg will eventually be in deficit. In spite of the major importance of the soil biotic component on soil fertility, the topic has been generally poorly investigated and no or few results are available on the roles of soil microbial communities in South East Asia rubber trees plantations. A better understanding of their functions and impacts on soil fertility mechanisms would be a great advantage to develop a sustainable management of rubber trees plantations.

Biochar is a charred by-product of biomass pyrolysis, which consists in heating plant-derived material in absence of oxygen in order to capture combustible gases (Sohi et al, 2009). Biochar is distinguished from charcoal by its use as a soil amendment and has been described as a possible way to improve soil fertility, as well as other ecosystem services and to sequester carbon (C) to mitigate climate change (Lehmann, 2011). The observed effects on soil fertility have been mainly explained by a pH increase in acid soils (Van Zwieten et al., 2010a and b) or by an improved nutrient retention through cation adsorption (Liang et al., 2006). However, biochar has also been shown to affect soil biological communities composition and abundance (Kim et al., 2007; O'Neill et al., 2009; Liang et al., 2010; Grossman et al., 2010; Jin, 2010) and that may have an effect on nutrient cycles (Steiner et al., 2008a and b) or soil structure (Rillig and Mummey, 2006). Thereby, it is likely to indirectly affect plant growth (Warnock et al., 2007), and microbial communities such as rhizospheric bacteria and fungi, which also affect plant growth (Schwartz et al., 2006; Compant et al., 2010).

Akpan, A.U., Edem S.O. and Ndaeyo N.U. 2007. Latex yield of rubber (*Hevea brasiliensis* Muell Argo) as influenced by clone planted and locations with varying fertility status. Journal of Agriculture and Social Sciences. Vol. 3, No. 1: 27-30

Cheng C., Wang Ru. and Jiang J. 2007. Variation of soil fertility and carbon sequestration by planting *Hevea brasiliensis* in Hainan Island, China. Journal of Environmental Sciences 19: 348–352.

Compant, S., Clément, S. and Sessitsch, A. 2010. Plant growth-promoting bacteria in the rhizo- and endosphere of plants: their role, colonization, mechanisms involved and prospects for utilization. Soil Biology and Biochemistry 42: 669-678

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Jin, H., 2010. Characterization of microbial life colonizing biochar and biochar amended soils.

PhD Dissertation, Cornell University, Ithaca, NY.

Kim, J.-S., Sparovek, S., Longo, R.M., De Melo, W.J. and Crowley, D. 2007. Bacterial diversity of *terra preta* and pristine forest soil from the Western Amazon. Soil Biology and Biochemistry 39: 648-690.

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Njar, G.N., Iwara, A.I., Ekukinam U.E., Deekor, T.N. and Amiolemen, S.O. 2011. Organic carbon and total nitrogen status on soils under rubber plantation of various ages, south-southern Nigeria. Journal of Environmental Sciences and Resource Management, 3: 1-13.

O'Neill, B., Grossman, J., Tsai, M.T., Gomes, J.E., Lehmann, J., Peterson, J., Neves, E. and Thies, J.E. 2009. Bacterial community composition in Brazilian Anthrosols and adjacent soils characterized using culturing and molecular identification. Microbial Ecology 58: 23-35

Orimoloye, J.R., Ugwa, I.K. and Idoko, S.O. 2010. Soil management strategies for rubber cultivation in an undulating topography of Northern Cross River State Journal of Soil Science and Environmental Management. 1(2): 34-39

RFD (Royal Forest Department). 2000. Status of Rubberwood Utilization and Marketing in Thailand. Technical Report. Executing Agency, Forest Research Office, Royal Forest Department. 90 p

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Saengruksawong, C., Soontorn K., Niwat A. and Jitti P. 2012. Growths and Carbon Stocks of Para Rubber Plantations on Phonpisai Soil Series in Northeastern Thailand. Rubber Thai Journal 1:1-18.

Schwartz, M.W., Hoeksema, J.D., Gehring, C.A., Johnson, N.C., Klironomos, J.N., Abbott, L.K. and Pringle, A. 2006. The promise and the potential consequences of the global transport of mycorrhizal fungal inoculum. Ecological Letters 9: 501-515.

Sohi, S., Krull, E., Lopez-Capel, E. and Bol, R., 2010. A review of biochar and its use and function in soil. Advances in Agronomy 105: 47-82.

Steiner, C., Das, K.C., Garcia, M., Förster, B. and Zech, W. 2008a. Charcoal and smoke extract stimulate the soil microbial community in a highly weathered xanthic ferralsol. Pedobiologia-International Journal of Soil Biology 51: 359-366.

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Van Zwieten, L., Kimber, S., Morris, S., Chan, K.Y., Downie, A., Rust, J., Joseph, S. and Cowie, A., 2010a. Effects of biochar from slow pyrolysis of paper mill waste on agronomic performance and soil fertility. Plant and Soil 327: 235-246.

Van Zwieten, L., Kimber, S., Morris, S., Downie, A., Berger, E., Rust, J. and Scheer, C. 2010b. Influence of biochars on "flux of N2O and CO2 from Ferrosol. Australian Journal of Soil Research 48: 555-568.

Warnock, D.D., Lehmann, J., Kuyper, T.W. and Rillig, M.C. 2007. Mycorrhizal responses to biochar in soil: concepts and mechanisms. Plant and Soil 300: 9-20.

Objective of the proposal

The present proposal aims to expand the current knowledge of the effects of biochar on soil fertility in relation to the soil microbial component within a 13-years old rubber tree plantation. As mentioned above, connections between biochar and soil biota are like to exist, and the objective is to gather a full set of data on this from one experimental field site located in Khon Kaen Province. Through the study of the impact of biochar applications on soil fertility (in relation to the microbial components), the project will generate complementary results to establish a link between functional diversity and soil fertility management. To date, the driving components of the biogeochemical processes aren't clearly identified and a systematic examination of the roles played by the different microbial populations is still lacking. The present proposal aims to obtain such results in a rubber tree plantation in North East Thailand where soils are mainly sandy and poorly fertile.

Link with the LMI project (regional aspect, partnership, working package)

Rubber tree is the plant specie selected by LMI for research activities in Thailand.

The topic and the different activities proposed within this proposal strongly fit with the objectives of the WP2 "Soil and water functional biodiversity" and partially with those of the WP1 "Soil fertility and the dynamics of mineral nutrients".

Project description (one page maximum)

The present proposal is part of a broader PhD program that Ms Laetitia Herrmann (Deakin University, Melbourne) will carry out at LDD under the supervision of Dr Wanpen Wiriyakitnateekul, Dr Lambert Brau and Dr Didier Lesueur. This program entitled «The role of the soil microbial communities in sustainable rubber tree cultivation in North-Eastern Thailand» aims to determine recommended practices for sustainable and increased rubber-tree yields, by obtaining of more information about native microbial communities and a better understanding of their relation in regards to soil fertility

The objective of the present proposal is to characterize the soil of a rubber tree plantation before biochar application (prior to the beginning of the rainy season, early March 2013). This will provide a baseline which will be used as a reference to evaluate the biochar impact. The characterization will include the determination of the soil characteristics (both physical and chemical properties) and the soil microbial communities. Both the diversity and the structure of total bacterial and fungal communities will be analysed, as well as particular functional groups such as diazotrophs, P-solubilizing bacteria, arbuscular mycorrhizal fungi. These analyses will be repeated after biochar applications, during the rainy season. Different rates of biochar will be considered.

The identified site is a plantation of approximately 10 ha owned by Mr Apichai Kansuwan and located in Ban Non Tun, in the Khon Kean Province (N 16' 19.614; E 102' 44.923'; altitude of 177 meters above sea level). The plantation was set up in 2004. Before rubber trees were planted, cassava had been grown for 10 years, followed with 10 years of fallow. The lay out of the plantation is as follow: distance between the trees is 3 meters and between the rows 7 meters.

The design is a Randomized Complete Block Design (RCBD) and includes 4 treatments and 4 blocks as described in the NRCT project No 2556 that Dr Wanpen Wiriyakitnateekul is leading. The biochar application rates are as follows: 0, 5, 10 and 20 t/ha (recommended rate in North East Thailand is 10 t/ha).

Analysis will be peformed on top-soil samples collected across the blocks (12 trees located at the centre of the each plot will be samples. For each tree, we will collect one soil sample and it will be analysed individually). Soils subsamples (100 g) will be immediately sieved and kept in a cold box for transport, and then stored in a freezer (-80℃) for further molecular analysis. The rest of the soil samples will be air dried for physical and chemical analysis.

In the frame of her PhD program, Ms Herrmann will undertake the following activities:

- The study of the total microbial communities (bacterial and fungal) living in the rhizosphere of the Hevea trees;
- The isolation and the characterization of the microorganisms with a high potential of P-solubilization (under laboratory conditions);
- The evaluation of the AMF root colonization of the trees;

A Master student of Kasetsart University will carry out the following activities:

- The characterization of the diazotrophic communities
- The enumeration of diazotroph populations;
- The isolation of the diazotrophs (free living N-fixing bacteria) (under laboratory conditions)
- The molecular identification of the isolated strains;

Budget description:

The LMI proposal's budget aims to cover:

- Laboratory analysis for both Master and PhD student;
- Field work and soil samplings (setting up the device, apply the biochar, management of the trial, 2 soil samplings per year).

Co-funding:

- Laetitia PhD fellowship will be provided by Deakin University (approximately € 20,000 for one year as well as $AUD 2200 for project expenses)
- NRCT project leaded by Dr Wanpen (€ 3,500)
- Contribution of Eco&Sols to the laboratory molecular analysis (€ 5,000)

As the project will over a period of 1 year, it will not cover for the registration fees of the Master student. The selected student will start partially with his/her classes at the university but most of her/his time, she/he will be available to start the research work.