Organic matter dynamics in agroecosystems of Madagascar and its effective use for crop production

Dr. Andry ANDRIAMANANJARA
Lecturer
University of Antananarivo

Reason for the Award

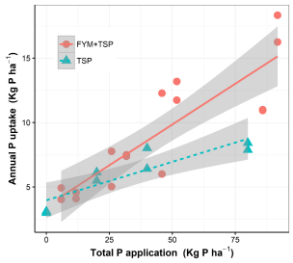
The recipient examined the effectiveness of farmyard manure application to rice in farms in Madagascar, and assessed carbon storage in the country's agroecosystems, as well as identifying the factors affecting carbon storage. The recipient is evaluated highly for his steady efforts in collecting and analyzing soil and plant samples from across the country and in conducting field tests under a range of environmental conditions in cooperation with local farmers. The recipient's work is also evaluated as being of high quality because the data he measured and the results of his assessment were used in the Global Soil Organic Carbon Map (FAO, 2017), contributing to sustainable management of soil organic matter.

Outline of Research Achievements

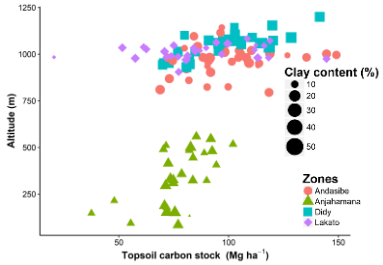
Soil organic carbon (SOC) or organic fertilizer resources play a key role in maintaining soil fertility, increasing crop productivity, and mitigating greenhouse gas emissions particularly in the tropics. Dr. Andriamananjara and his colleagues revealed the role of organic matter application on crop productivity and its interaction with highly weathered and phosphorus (P)-deficient soils in Madagascar. Farmyard manure (FYM) application significantly increased the grain yield of rice and improved P fertilizer use efficiency in the upland ecosystem particularly in fields with low SOC contents and low pH, whereas the effect was not significant in irrigated lowlands where soil P availability was relatively high.

New knowledge about carbon dynamics in plant and soils in various agroecosystems of Madagascar was also obtained. Soil surface has a critical role and is more vulnerable to C storage in various agroecosystems in Madagascar relative to the deep soil layers and aboveground biomass. The topsoil C storage varied with elevation, soil texture, and land cover.

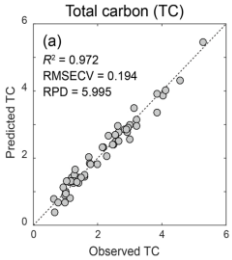
Accurate SOC estimation models were also developed using mid-infrared spectroscopy (for various agroecosystems) or visible and near-infrared (Vis-NIR) diffuse reflectance spectroscopy with partial least squares (PLS) approach (for the upland and lowland rice soils) for a national SOC mapping purpose.



FYM increased the efficiency of TSP in upland rice



Topsoil organic C stock is related to topography and soil properties



Better predictive accuracy of ISE-PLS in soil total C estimation

Main Publications:

(1) **A. Andriamananjara**, T. Rakotoson, O.R. Razanakoto, M.-P. Razafimanantsoa, L. Rabeharisoa, and E. Smolders. Farmyard manure application in weathered upland soils of Madagascar sharply increase phosphate fertilizer use efficiency for upland rice. *Field Crops Research* 222: 94-100 (2018).

(2) K. Kawamura, Y. Tsujimoto, M. Rabenarivo, H. Asai, **A. Andriamananjara**, and T. Rakotoson. Vis-NIR Spectroscopy and Partial Least Squares Regression with Waveband Selection for Estimating the Total C and Total N of Paddy Soils in Madagascar. *Remote Sensing* 9, 1081 (2017).

(3) **A. Andriamananjara**, J. Hewson, H. Razakamanarivo, R. Hary Andrisoa, N. Ranaivoson, N. Ramboatiana, M. Razafindrakoto, N. Ramifehiarivo, M.-P. Razafimanantsoa, L. Rabeharisoa, T. Ramananantoandro, A. Rasolohery, N. Rabetokotany, and T. Razafimbelo. Land cover impacts on aboveground and soil carbon stocks in Malagasy rainforest. *Agriculture, Ecosystems and Environment* 233: 1–15 (2016).

Production of high quality planting materials of popular herbal species in Malaysia, *Labisia pumila*

Dr. Farah Fazwa Md Ariff
Senior Research Officer
Forest Research Institute Malaysia (FRIM)

Reason for the Award

The recipient developed a superior, high-yield variety of the traditional herb *Labisia pumila*, an important crop resource in Malaysia, with a high content of pharmacologically active compounds, as well as a technique for mass production using tissue culture. Furthermore, she conducted on-farm growing trials involving local farmers and worked to disseminate and commercialize the new elite variety, thereby producing practical benefit. These efforts encompass basic as well as applied research and are highly evaluated as an excellent model for community economic development using local products.

Outline of Research Achievements

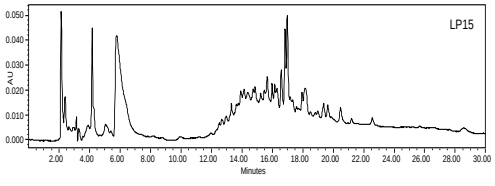
Research in plant breeding in Malaysia, especially in producing good varieties, is only focused on food crops and forest plantation species. No studies had been conducted for herbal species. Dr. Farah Fazwa has pioneered research related to the production of a high-quality variety of the herbal species *Labisia pumila* (Primulaceae). This elite variety has its own uniqueness because it has gone through nine years of R&D and has better traits than the others. It has good morphological characteristics and high biomass, exhibits vigorous growth, and contains high total phenolic compounds. This new variety has also been proven to have high adaptability and survivability under different environments. DNA and chemical fingerprinting of this variety has also been profiled. This elite variety has been registered for Plant Variety Protection (PVP) in 2017 in Malaysia.

In addition, a technique for mass production of the elite variety using tissue culture method through temporary immersion system (TIS) has been developed. This technique is effective for producing mass plantlets in a shorter period and at a lower cost as compared to conventional tissue culture method. The complete R&D package on the production of high quality planting materials of this herbal species is being commercialized to fulfil demand in the industry. The technology developed through this research will also reduce harvesting pressure on raw materials from natural forests.

Elite variety

Mass production

Plantation



High performance liquid chromatography (HPLC) profile of the elite variety of *Labisia pumila* var. *alata*

Main Publications:

(1) **Farah Fazwa, M.A.,** Ab. Rasip, A.G., Maideen, H. and Mohamad, O. Selection Among Two Varieties of *Labisia pumila* that Yield High Phenolic Contents For Establishing Plant Stock and Further Cultivation. *Journal of Tropical Medicinal Plants* 13(1): 17−27 (2012).

(2) **Farah Fazwa, M.A.,** Siti Suhaila, A.R., Syafiqah Nabilah, S.B. Norhayati, S., Norwati, M., Mohd Zaki, A. & Marzalina, M. Rapid mass production of elite clone *Labisia pumila* var. *alata* (KFeFRIM01) for sustainable supply of high quality planting materials. *International Journal of Agriculture, Forestry and Plantation* (IJAFP) 6: 66-72 (2018).

(3) **Farah Fazwa, M.A.** and Aminah, H. The Sustainable Supply of *Labisia pumila* in Malaysia: Production of Planting Materials, Cultivation and Agronomy Practices. *The International Journal of Environmental Sustainability*, 9(4): 17-29 (2014).

Study on diverse micro-organisms responsible for fatal parasitic disease outbreaks in farmed freshwater fish, and development of biology-based preventative measures against the diseases

Dr. Jinyong ZHANG
Associate Professor
Institute of Hydrobiology, Chinese Academy of Sciences

Reason for the Award

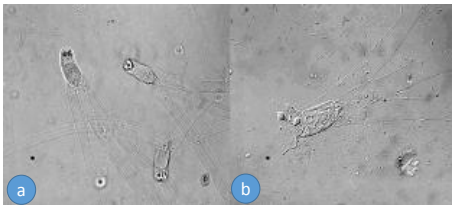
The recipient developed a strategy to control diseases in farmed fish through monitoring the distribution of pathogenic microorganisms in aquaculture by using techniques such as environmental DNA analysis and quantitative polymerase chain reaction (q-PCR). The strategy has been demonstrated to be effective in practice at aquaculture companies. The results of this research, which offer a solution to a major issue faced in freshwater aquaculture, are expected to lead to significant economic benefits, and the recipient is highly evaluated for practical application of the methodology.

Outline of Research Achievements

Parasitosis has increasingly caused huge economic and ecological losses in aquaculture due to increasing drug resistance and vaccine unavailability. This underscores the urgency of developing targeted and eco-friendly control methods to support sustainable development of aquaculture. Taking myxosporidiosis in pond-cultured gibel carp in China as an example, Dr. Zhang and his colleagues have developed an integrative control strategy based on the biology and ecology of the involved etiological agents. It has been applied to production practice, reducing the use of chemical agents by over 60% and decreasing economic losses by over 30%.

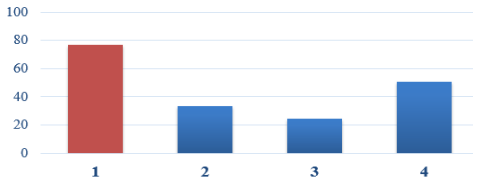
This strategy involves: 1) identifying etiological agents among 30+ gibel carp-infecting myxosporeans, 2) elucidating the life cycles of the 3 main pathogenic myxosporeans, 3) developing molecular detection methods (PCR, LAMP, and QPCR) to qualitatively and quantitatively monitor the pathogens in the culture pond, in combination with eDNA analysis, 4) developing a mode of SPF (specific pathogen free) gibel carp seedling culture, 5) screening chemical agents that are most effective in inactivating the infective actinospores in the water column and blocking its development into mature spores, and determining the usage time-point and period, and 6) fallowing, rotating, and polyculture with grass carp, blunt-snout bream, channel catfish, prawns, and mitten crab based on host specificity, and blocking the life cycle of etiological agents.

Myxosporidiosis in pond-cultured gibel carps



a: intact actinospores with infectivity
b: destroyed actinospores without infectivity

Screening of chemicals to inactivate actinospores



1. Monoculture (Gibel carp); 2. Polyculture with snout bream;
3. Polyculture with common carp;
4. Polyculture with channel catfish

Preventative effects of polyculture on gibel carp myxosporidiosis prevalence

Main Publications:

(1) **Zhang JY**, Yokoyama H, Wang JG, Li AH, Gong XN, Ryu-Hasegawa A, Iwashita M, Ogawa K. Utilization of tissue habitats by *Myxobolus wulii* Landsberg & Lom, 1991 in different carp hosts and disease resistance in allogynogenetic gibel carp: redescription of *M. wulii* from China and Japan. Journal of Fish Diseases, 33:57-68 (2010).

(2) **Zhang JY**, Wang JG, Li AH, Gong XN. Infection of *Myxobolus turpisrotundus* sp. n. in allogynogenetic gibel carp, *Carassius aruratus gibelio* (Bloch), with revision of *Myxobolus rotundus* (s.l.) Nemeczek reported from *C.auratus auratus* (L.). Journal of Fish Diseases, 33: 625-638 (2010).

(3) Liu XH, Batueva MD, Zhao YL, **Zhang JY**, Zhang QQ, Li TT, Li AH. Morphological and molecular characterization of *Myxobolus pronini* n. sp. (Myxozoa: Myxobolidae) from the abdominal cavity and visceral serous membranes of gibel carp, *Carassius auratus gibelio* (Bloch) in Russia and China. Parasite & Vector, 9:562 (2016).