Development of Nanofertilizer using Flexible Nanoparticle Catalysis Technology

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Malaysian Agricultural Research and Development Institute (MARDI)

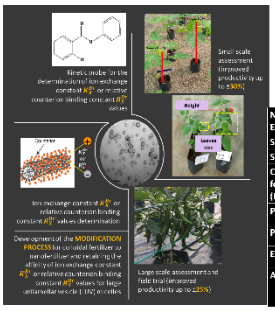
Reason for the Award

The awardee made it possible to produce nanofertilizers inexpensively by using flexible nanoparticle catalysis technology, which can reduce the size of colloidal aggregates of conventional fertilizers to nano-size. The developed nanofertilizer has features that can enhance the characteristics of foliar application fertilizer, improve crop productivity, and reduce the amount of fertilizer applied. This technology has already been commercialized and popularized, and the research has been evaluated for its potential for future development in the context of the need for effective utilization of resources.

Outline of Research Achievement

Fertilizer prices are the number one issue on farmers' minds as they begin to set up purchases for the growing season. Thus, a low-cost, simple, specific and eco-friendly nanofertilizer production process called flexible nanoparticle catalysis technology has been developed to nourish the agriculture, food, and commodity industries. In the present research, the flexible nanoparticle catalysis technology is used to develop the targeted delivery fertilizer for sustainable agriculture. The nano-dimensional adsorbent carrier of surfactant molecules, namely a flexible nanoparticle or a micelle that binds to the nutrients, attaches to the plant system through foliar applications and releases nutrients through targeted delivery to the plant system.

The present innovation has been protected under patent granted (MY-188725-A) and trade secret (TS 2019/ 35/ 079) and was also commercialized by KPG Sdn. Bhd. The technology also won the Gold Medal at the International Trade Fair of Ideas, Inventions and New Products (iENA 2022) in Nuremberg, Germany.



FERTILIZER PRODUCTION PROCESSES COMPARISON

	Natural fertilizer (compost, gypsum)	Synthetic fertilizer (urea, potash)	Mixed fertilizer (paste fertilizer)	FlexNanoCat
Need Expensive Equipment	NO	YES	YES	NO
Simplicity of Process	YES	NO	NO	YES
Skilled Operator	NO	YES	YES	NO
Cost of Production for 1 Liter (EURO)	Low (€5-6)	High (€12-14)	Medium (€8-10)	Low (€5-6)
Production period	Long	Long	Long	Short
Process Safety Risk	Low	High	Medium	Low
Environmental Issue	Low	High	Medium	Low
Absorptivity by plant	Slow	Medium	Medium	Optimized (controlled-release)

Main Publications:

(1) **Khalisanni Khalid**, Muhammad Azri Mohd Noh, Sharifuddin Md. Zain & M. Niyaz Khan (2016) Correlation of kinetic and rheological data for flexible nanoparticle catalysis in the reaction of piperidine with PS-. *Catalysis Letters* 146, 960–967
(2) **Khalisanni Khalid**, Muhammad Azri Mohd Noh, Sharifuddin Md. Zain & M. Niyaz Khan (2017) Determination of relative counterion binding constant to cationic micelles. *Topics in Current Chemistry*, 375(45), 1-18
(3) **Khalisanni Khalid**, Muhammad Azri Mohd Noh, Ibrahim Isah Fagge, Sharifuddin Md. Zain & M. Niyaz Khan (2016) Effects of cationic nanoparticles (CNP) on counterion binding constant(R_X^{Br}) and catalytic constant (*k*cat) in micellar system. *Journal of Molecular Catalysis A*: Chemical 423, 365–370

Development and Evaluation of Ecofriendly Soil Health Management Strategies for Semi-arid and Sub-humid Region of India

Dr. Avijit GHOSH
Scientist
ICAR-Indian Grassland and Fodder Research Institute (IGFRI)

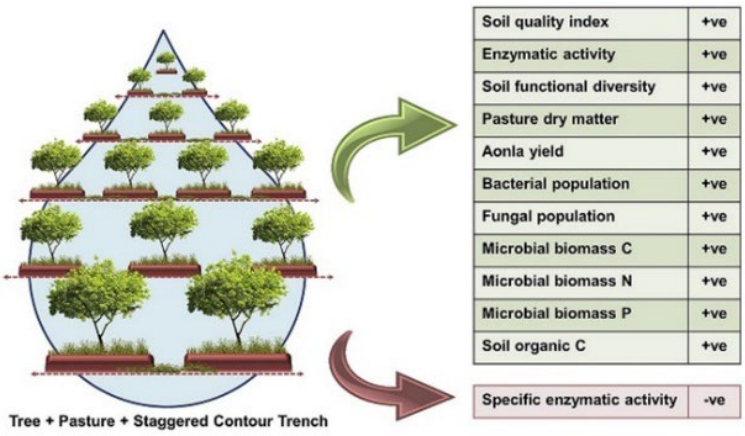
Reason for the Award

The awardee examined the impact of climate change on soil carbon storage by analyzing the thermal and hydrothermal sensitivity of soil organic carbon decomposition in India, and estimating the carbon sequestration capacity of deep soils. In addition, efforts were made to contribute to the coexistence of agricultural production and environmental conservation, such as using rice straw as a natural source of silicon to solubilize native soil phosphorus in order to prevent the incineration of a large amount of rice straw, which is considered to be one of the causes of severe air pollution in India. These research studies have been evaluated for its originality in enabling sustainable land management based on local agricultural methods from a broad perspective.

Outline of Research Achievement

India faces a growing crisis of land degradation. This land degradation is not only whittling away India's gross domestic product but also exacerbating climate change events in the country. Avijit Ghosh and his teammates proved that ecofriendly soil health management strategies have pivotal roles in restoring degraded lands, boosting soil carbon sequestration, and generating income for local people. According to their research, using rice straw as natural silicon source to solubilize recalcitrant soil phosphorus prevented air pollution through incineration.

Climate-resilient alternate land use systems, including soil moisture conservation, conservation agriculture, hortipasture, silvopasture, and silviculture systems suitable for semi-arid and sub-humid India, were developed in the Bundelkhand region. Soil organic carbon accumulation in land eco-restored with *Ficus infectoria*-, *Morus alba*-, *Acacia nilotica*-, and *Leucaena leucocephala*-based silvopastoral systems were approximately 55%, 91%, 77%, and 71% higher than degraded fallow land at surface layers, and the *Leucaena leucocephala*-, *Hardwickia binata*-, and *Acacia nilotica*-based silviculture systems improved the soil functionality by 9.3, 5.3, and 5.1 times over fallow land, respectively. The land restoration models have been disseminated through different national land restoration schemes of the Indian Government.



Main Publications:

(1) **Avijit Ghosh**, Sunil Kumar, M.C. Manna, Amit K. Singh, Poonam Sharma, Abhijit Sarkar, Madhumonti Saha, Ranjan Bhattacharyya, Sukanya Misra, S.S. Biswas, D.R. Biswas, Kamini Gautam, & R.V. Kumar (2019) Long-term *in situ* moisture conservation in horti-pasture system improves biological health of degraded land. *Journal of Environmental Management*, 248, 109339.
(2) **Avijit Ghosh**, R.V. Kumar, M.C. Manna, Amit K. Singh, C.M. Parihar, Sunil Kumar, A.K. Roy & P. Koli (2021) Eco-restoration of degraded lands through trees and grasses improves soil carbon sequestration and biological activity in tropical climates. *Ecological Engineering*, 162, 106176.
(3) Hansa Baradwal, **Avijit Ghosh**, Awanish Kumar, Prashant Deo Singh, Manjanagouda Siddanagouda Sannagoudar, Safik Ahamad, Pramod Jha, Amit Kumar Singh, Ranjan Bhattacharyya, Madhab Chandra Manna, Sunil Kumar & Ram Vinod Kumar (2022) Ecological restoration of degraded lands with alternate land use systems improves soil functionality in semiarid tropical India. *Land Degradation & Development*, 33(7), 1076-1087.

Improving Smallholder Commercialization and Reducing Poverty through the Adoption of Improved Crop Varieties in Africa

Dr. Martin Paul Jr. TABE-OJONG

Associate Research Fellow

International Food Policy Research Institute (IFPRI)

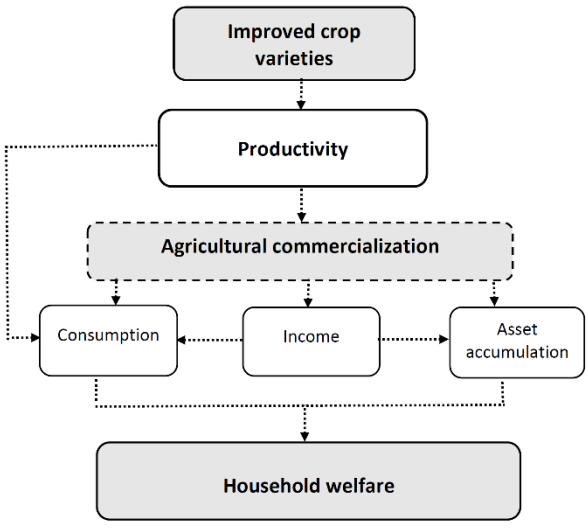
Reason for the Award

The awardee demonstrated that the introduction of drought-tolerant legume varieties with high protein content and potential for soil fertility through nitrogen-fixing functions can improve agricultural production and nutrition for smallholder farmers, as well as their farming activities through commercialization, with the goal of transforming existing grain-based agricultural activities in West Africa. The research has been evaluated as a development economics study that provided a model for agricultural innovation among smallholder farmers in West Africa.

Outline of Research Achievement

Enhancing agricultural productivity through the adoption of improved crop varieties presents a credible pathway to economic development and poverty reduction especially through increased commercialization of production. With insights from the Green Revolution, improved crop varieties are increasingly being developed and disseminated in many developing countries. These improved crop varieties are usually high-yielding and disease-resistant with market-related traits. Given the extended dry seasons common in arid and semi-arid zones, some of these crop varieties are climate-resilient, with the ability to withstand extreme weather events and build climate resilience. These improved crop varieties are a critical part of the climate-smart agriculture (CSA) approach with the potential to offer the triple wins of increasing productivity with ensuing welfare implications, building resilience to climatic shocks and reducing the emission of greenhouse gases.

Martin Paul Jr. Tabe-Ojong and his colleagues have shown the importance and potential of three improved legume crops (groundnuts, beans, and chickpeas) in increasing agricultural production, consumption, and smallholder commercialization with ensuing implications on reducing poverty in various production systems in Cameroon, Ethiopia, Ghana, Mali, Malawi, and Nigeria. Some of this work also looks at the role of genebanks in the development of these improved crop varieties with both production and market-related characteristics. All of this work has been presented at various scientific conferences and policy meetings and have also been published in peer-reviewed journals. Some of this work was earlier awarded the Hans H. Ruthenberg Graduate Award by the Foundation Fiat Panis in 2019.



Adoption of improved crop varieties, commercialization and poverty

Main Publications:

(1) **Tabe-Ojong, M. P.**, Lokossou, J.C., Gebrekidan, B.H. & Affognon, H. (2023) Adoption of climate-resilient groundnut varieties increases agricultural production, consumption and smallholder commercialization in West Africa. *Nature Communication*, 14:5175.

(2) **Tabe-Ojong, M. P.**, Aihounton, B.D.G. & Lokossou, J.C. (2023) Climate-smart Agriculture and Food Security: Cross-country Evidence from West Africa. *Global Environmental Change*, 81(4):102697.

(3) **Tabe-Ojong, M. P.**, Mausch, K., Woldeyohanes, T. & Heckelei, T. (2021) Three hurdles towards commercialization: Integrating subsistence chickpea producers in the market economy. *European Review of Agricultural Economics*, 49(3), 668–695.