Water management innovations to enhance smallholder farmers' resilience to climate change in rice-based systems in sub-Saharan Africa

Dr. Elliott Ronald DOSSOU-YOVO
Agricultural Specialist for Climate Change
Africa Rice Center

Reason for the Award

The awardee conducted research on water management to enhance the resilience of small-scale farmers against climate change. This research study has been evaluated for its practical and field-based approach that improves productivity through precise cultivation management, its ability to disseminate research results through extension activities, and its future potential to make a significant contribution to rice cultivation in Africa through the development of technologies for water management and no-till rice straw management.

Outline of Research Achievement

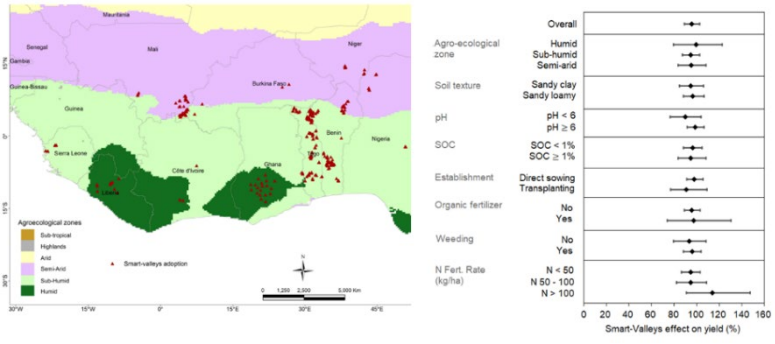
Water-related stresses exacerbated by climate change have a significant impact on crop yields and contribute to food and nutrition insecurity in sub-Saharan Africa (SSA). Dr. Elliott Dossou-Yovo and his team have made substantial progress in advancing sustainable rice production in the region by addressing issues such as iron toxicity, water use efficiency, and climate adaptation.

Their research in Côte d'Ivoire demonstrated that mid-season drainage reduced iron toxicity by 43%, reduced water use by 11%, and improved water productivity by 18%. Fields with high soil organic carbon and well-timed fertilizer applications showed better yields compared to those with continuous flooding.

The team explored alternate wetting and drying (AWD) techniques, which reduced water use by 23% without compromising yields, particularly in irrigated lowlands of Côte d'Ivoire, Burkina Faso, and Mali. Success with AWD was influenced by factors like soil pH, fertilizer management, and rice variety. In Burkina Faso, they identified soil percolation as a key factor for AWD implementation, indicating areas where this method could expand rice cultivation while reducing water use.

Their adaptation and promotion of the Smart-Valleys approach, a locally adapted water control method, resulted in doubled rice yields and a 65% increase in yield stability. Implemented in 10 African countries and over 600 inland valleys, this approach has benefited over 50,000 farmers by improving yields, incomes, and resilience to climate extremes.

Additionally, their work mapping drought occurrences and improving soil carbon through no-tillage and mulching contributes to sustainable agricultural intensification, supporting rice self-sufficiency, climate resilience, and environmental sustainability in SSA.



Smart-Valleys adoption sites and their impact on rice yield across agro-ecological zones, soil properties, and farmer management practices in sub-Saharan Africa

Main Publications:

(1) **Dossou-Yovo Elliott Ronald**, Kouadio Alain, Saito Kazuki. 2023. Effects of mid-season drainage on iron toxicity, rice yield, and water productivity in irrigated systems in the derived savannah agroecological zone of West Africa. *Field Crops Research* 269, 108901.

(2) **Dossou-Yovo Elliott Ronald,** Devkota Krishna, Akpoti Komlavi, Danvi Alexandre Duku Confidence, Zwart Sander. 2022. Thirty years of water management research for rice in sub-Saharan Africa: achievement and perspective. *Field Crops Research* 283, 108548.

(3) **Dossou-Yovo Elliott Ronald,** Saito Kazuki (Africa Rice Center). 2021. Impact of management practices on weed infestation, rice yield, water productivity and grain quality in irrigated systems in Côte d'Ivoire. *Field Crops Research*, 270, 108209.

Research on the use of native genetic resources for the molecular hybrid breeding of common bean as a nature-based solution for the deployment of economic, sustainable and peaceful development in marginal communities across Colombia

Dr. Andrés Javier CORTÉS VERA

Associate Research Scientist

Colombian Agricultural Research Corporation (AGROSAVIA)

Reason for the Award

The awardee conducted research on molecular breeding using local indigenous genetic resources to develop new bean varieties adapted to global warming, and on genetic selection of locally adapted bean varieties through participatory breeding. This study has been evaluated for its energetic approach from both molecular and cultivation characteristics perspectives, which is expected to lead to the development of varieties adapted to climate change, and for its future potential to contribute to sustainable economic growth in remote rural communities.

Outline of Research Achievement

This research achievement used an advanced panel of common bean × Tepary bean inter-specific lines to identify novel sources of adaptation to the Caribbean coast of Colombia, where common bean typically exhibits maladaptation to extreme heat waves. The originality of this work is due to the fact that this is by far the first effort to implement genomic prediction and hybrid breeding in common bean for abiotic stress tolerance.

Specifically, this achievement was able to (1) estimate heritability and prediction ability of yield and biomass variables in inter-specific beans across four localities in the Colombian Caribbean, (2) evaluate via comparative analysis the accuracy of genomic prediction, and (3) identify the top genotypes using the Genomic Estimated Breeding Values (GEBVs) in a bean panel with inter-specific Tepary ancestries. This confers an invaluable base population for direct selection and speed breeding of bean varieties targeting extreme climates, such as those found in coastal Colombia.

The second milestone of this research achievement was to select through participatory breeding locally-adapted common bean var. Liborino genotypes and distribute high-quality seed to farmers. The significance of this second milestone meant that, in 2022, 253.5 kg of uniform and stable seed of the chosen bean genotype were distributed to 39 farmers.

(Photo: Liborina, Antioquia. 2022/02/26)

Main Publications:

(1) F López-Hernández, E Burbano-Erazo, RI León-Pacheco, CC Cordero-Cordero, DF Villanueva-Mejía, AP Tofiño-Rivera, **AJ Cortés**. Multi-environment genome wide association studies of yield traits in common bean (*Phaseolus vulgaris* L.) × Tepary bean (P. acutifolius A. gray) interspecific advanced lines at the humid and dry Colombian Caribbean sub-regions. *Agronomy* 2023 13(5): 1396

(2) D Peláez, PA Aguilar, M Mercado, F López-Hernández, M Guzmán, E Burbano-Erazo, K Denning-James, CI Medina, MW Blair, JJ De **Vega, AJ Cortés**. Genotype selection, and seed uniformity and multiplication to ensure common bean (*Phaseolus vulgaris* L.) var. Liborino. *Agronomy* 2022 12(10): 2285

(3) LF López-Hernández, **AJ Cortés**. Last generation genome – environment associations reveal the genetic basis of heat tolerance in common bean (*Phaseolus vulgaris* L.). *Frontiers in Genetics* 2019 10:954

Enhancement Safety and Nutrition along the Chain of Feeds, Foods, and Agricultural Products by 16S rRNA Gene Sequencing Microbiome Innovation

Dr. Jutamat KLINSODA

Researcher (Professional Level)

Institute of Food Research and Product Development, Kasetsart University

Reason for the Award

The awardee conducted research on food safety assurance through bacterial flora analysis utilizing 16S rRNA gene sequencing and developed the first bacterial flora database on the relationship between hand infection of organs and carcass handlers of food-producing pigs. This study has been evaluated as an important and practical research for ensuring food safety. It analyzes the impact of safe feed on pigs' intestinal health through a multi-omics approach and examines the transmission pathways of pig infections to humans from a broad perspective, ranging from basic research to food chain tracking.

Outline of Research Achievement

16S rRNA gene sequencing is a true “game-changing innovation,” enabling the identification and classification of microbial community dynamics throughout the entire food chain and positioning it at the forefront of food safety and quality research. Dr. Jutamat Klinsoda has led nine projects as the principal investigator and has established a distinguished international publication record in the SCOPUS database.

Dr. Klinsoda and her research team examined the impact of safety feed on pig gut health through multi-omics approaches, exploring how enteric pathogens from pig feces and organs may enter the food chain. She pioneered one of the first microbiome databases focusing on edible pig organs and their relationship to the contamination of slaughterhouse workers’ hands.

In her ongoing projects related to the microbiome and food quality, she is investigating microbial community dynamics across various food sources to better understand the relationship between bacterial communities and the shelf life of food products. For diet-related effects on health, she is investigating how plant-based functional ingredients from herbs and algae affect gut microbiomes utilizing human gut models to validate health claims. Overall, this advancement in microbiome research integrates the One Health approach to create a more sustainable food system.

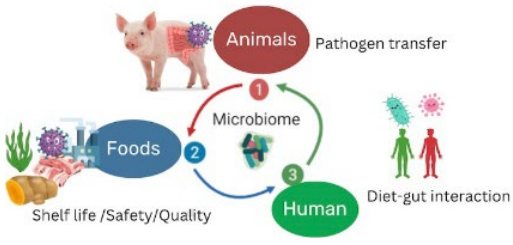


Fig 1. Scope of the research

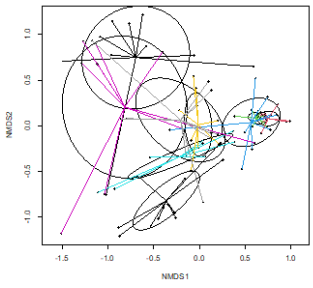


Fig 2. Microbiome analysis in pig organs

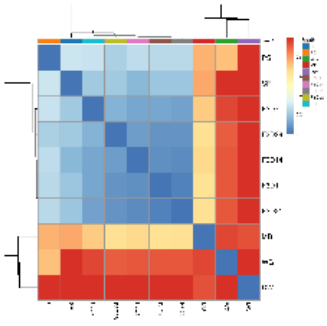


Fig 3. Heatmap on plant-based meat analog

Main Publications:

(1) **Klinsoda J,** Koger, S. Metzler-Zebeli BU. Dietary phytase and lactic acid treated cereals caused greater taxonomic than functional adaptations in the cecal metagenome of growing pigs. *Appl Environ Microbiol*. 2020, 23:02240-20.

(2) **Klinsoda J,** Vötterl J, Zebeli Q, Metzler-Zebeli BU. Alterations of the viable ileal microbiota of gut-mucosa-lymph node axis in pigs fed phytase and lactic acid treated cereals. *Appl Environ Microbiol.* 2020, 86(4):02128-19

(3) **Klinsoda J,** Vötterl J, Zebeli Q, Metzler-Zebeli BU. Lactic Acid Treatment of Cereals and Dietary Phytase Modified Fecal Microbiome Composition Without Affecting Expression of Virulence Factor Genes in Growing Pigs. *Front Microbiol.* 2019, 10:2345