サブサハラアフリカの稲作における小規模農家の気候変動レジリエンス向上のための水管理イノベーション

エリオット・ロナルド・ドス・ヨボ
気候変動に関する農業専門家
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受賞評価のポイント

受賞者は、気候変動に対する小規模農家の強靭性を高めるための水管理に関する研究を行った。緻密な栽培管理により生産性を向上させる実用的で現場に根ざした研究であり、普及活動等の研究成果の発信力が高い点、水管理や不耕起稲わら管理当の技術開発によりアフリカ水稲栽培に大きな貢献の可能性がある将来性などが評価された。

主な業績

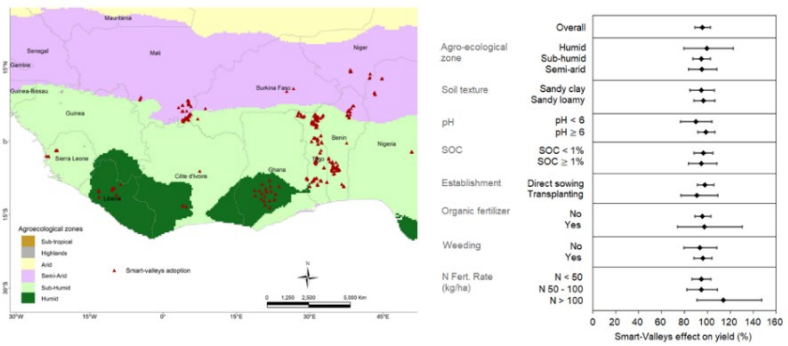
気候変動によって悪化する水関連ストレスは、サブサハラアフリカ（SSA）の作物収量に大きな影響を与え、食料・栄養不安を引き起こしている。我々の研究チームは、鉄毒性、水利用効率、気候適応などの問題に取り組み、この地域の持続可能な米生産を大きく前進させた。

コートジボワールでの研究では、中間期の排水によって鉄毒性が 43%減少し、水使用量が 11%削減され、水生産性が 18%向上した。土壌有機炭素の含有量が高く、適切なタイミングで施肥された圃場では、連続湛水の圃場と比較して収量が向上した。

研究チームは、間断灌漑（AWD）技術を探求し、コートジボワール、ブルキナファソ、マリの灌漑低地では収量を損なうことなく水使用量を 23%削減できることを示した。AWD の成功は、土壌の pH、肥料管理、稲の品種などの要因に影響された。ブルキナファソでは、AWD 実施の重要な要因として土壌の浸透性を特定し、この方法で水使用量を削減しながら稲作地域を拡大できる可能性を示した。

現地に適応した水管理法であるスマートバレー・アプローチの導入と普及により、米の収量が 2 倍になり、収量の安定性が 65%向上した。このアプローチは 10 のアフリカ諸国、600 以上の内陸谷で実施され、5 万人以上の農家の収量、収入、気候変動への耐性を向上させた。

さらに、干ばつの発生マッピングや不耕起栽培・マルチングによる土壌炭素改善に関する研究は、持続可能な農業集約化に貢献し、SSA における米の自給自足、気候変動への耐性、環境の持続可能性を支援している。



サブサハラアフリカにおけるスマートバレー導入地域と稲作収量への影響：農業生態学的地域、土壌特性、農家の管理方法の観点から

主要論文：

(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.

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

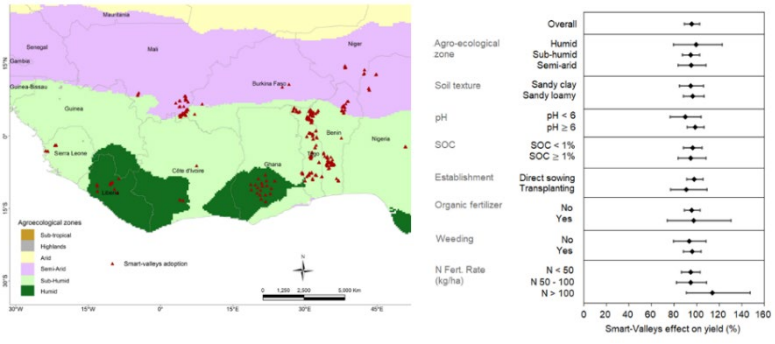
Water-related stresses exacerbated by climate change have a significant impact on crop yields and contribute to food and nutrition insecurity in sub-Saharan Africa (SSA). Dr. Elliott Dossou-Yovo and his team have made substantial progress in advancing sustainable rice production in the region by addressing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

コロンビアの周縁地域発展に向けた インゲンマメの在来遺伝資源を活用した分子育種研究

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研究員
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受賞評価のポイント

受賞者は、温暖化に適応した新しい豆の品種開発のため現地の在来遺伝資源を活用した分子育種と、参加型育種を通じた地域に適応した豆品種の遺伝子選抜の研究を行った。気候変動に対応した品種開発が期待される分子と栽培特性の両方の観点からアプローチした精力的な研究であること、僻地農村コミュニティへの持続的経済成長への貢献が期待できる将来性等が評価された。

主な業績

コロンビアのカリブ海沿岸地域に適応した新しい豆の品種を開発するため、一般的な豆（コモンビーン）とテパリー豆の種間交雑系統を用いた先進的な研究パネルを活用した。この地域では通常、コモンビーンは極端な熱波に適応出来ないことが知られている。本研究の独創性は、コモンビーンの非生物的ストレス耐性に関して、ゲノム予測とハイブリッド育種を初めて実施した点にある。具体的には、以下の成果が得られた。(1) コロンビアのカリブ海沿岸 4 地域における種間交雑豆の収量とバイオマス関連形質の遺伝率と予測能力を推定、(2) ゲノム予測の精度を比較分析により評価、(3) テパリー豆の遺伝的背景を持つ豆パネルにおいて、ゲノム育種価（GEBVs）を用いて優良な遺伝子型を特定。これにより、コロンビアの沿岸部のような極端な気候に適した豆品種の直接選抜や速育種のための貴重な基礎集団が得られた。

さらに、本研究の第 2 の成果として、参加型育種を通じて地域に適応したコモンビーン品種「Liborino」の遺伝子型を選抜し、農家に高品質な種子を配布した。2022 年には、選抜された豆の遺伝子型の均一で安定した種子 253.5kg が 39 人の農家に配布された。

（写真：アンティオキア州リボリーナ 2022/02/26）

主要論文:

(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

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

革新的な細菌叢解析技術による飼料からのフードチェーンおよび農産加工品の安全性と栄養の向上

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カセサート大学食品製品開発研究所

受賞評価のポイント

受賞者は、16S rRNA 遺伝子シーケンシングを活用した細菌叢解析による食品安全確保の研究を行い、食用豚の臓器や死骸取扱者の手指感染との関係性に関する初の細菌叢データベースを開発した。安全な飼料が豚の腸内健康に与える影響を、マルチオミクスアプローチを通じて解析し、豚の感染症が人にいたるまでの伝搬経路について、基礎研究からフードチェーンの追跡まで幅広い観点での研究であり、食品安全の確保にとって重要かつ実用的な研究である点が評価された。

主な業績

16S rRNA 遺伝子シーケンシングによる細菌叢解析は、食品の安全性と品質における真の「画期的イノベーション」である。この技術はフードチェーン全体にわたる細菌叢の動態を識別・分類することを可能とし、食品の安全性と品質の分野において重要な役割を担う。受賞者は、SCOPUS データベースにおいて卓越した国際的な出版実績があり、当該研究分野における顕著なリーダーシップと学術的影響力を示している。

本研究では、安全な飼料が豚の腸内の健康状態に与える影響を網羅的に解析し、豚の糞便や臓器に由来する腸内病原細菌がフードチェーンに侵入する可能性について幅広く検討した。その結果、豚の食用臓器の細菌叢と食肉処理場作業員の手指汚染との関係性に関するデータベースを新たに開発した。

現在進行中の食品の品質と微生物叢に関する研究プロジェクトでは、食品の保存期間との関連性をより深く理解するため、様々な食品原材料における細菌叢の動態を調査している。食と健康のつながりの視点からは、ハーブや藻類に由来する植物機能性成分が腸内細菌叢に与える影響を、健康効果の検証を目的としてヒト腸内モデルにより検証している。以上の取り組みは、細菌叢研究の進展を通じて人間、動物の健康、および食品の安全性と機能性を統合したワンヘルスアプローチを実現し、フードシステムの持続性向上に資する。

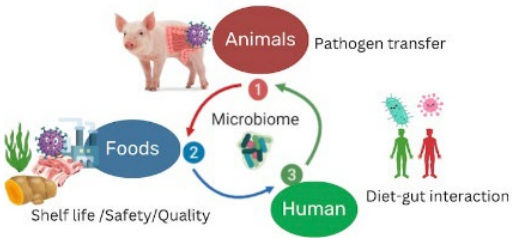

図 1. 研究の対象領域

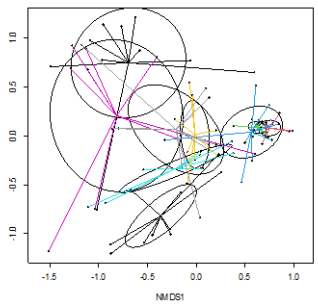

図 2. 豚臓器の細菌叢解析

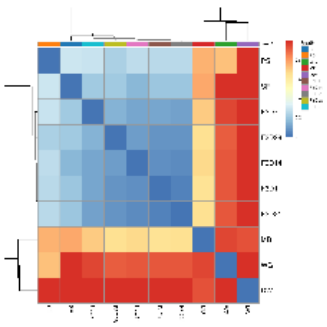

図 3. 植物性代替肉の細菌叢ヒートマップ

主要論文:

(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

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.

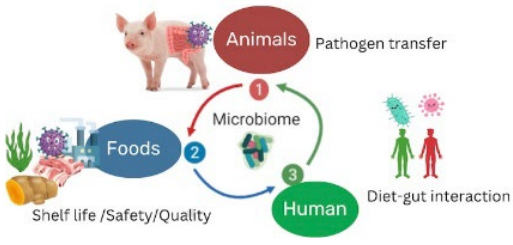

Fig 1. Scope of the research

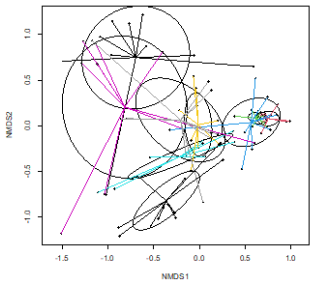

Fig 2. Microbiome analysis in pig organs

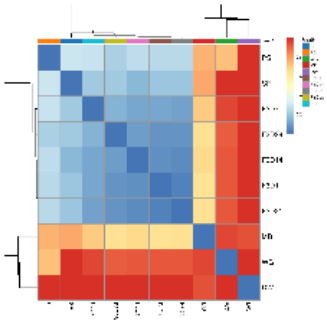

Fig 3. Heatmap on plant-based meat analog

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