National Agency for Science and Engineering Infrastructure (NASENI) Call for Proposals (2025)

Project Title:

Validation and Dissemination of Integrated Technologies for the Management of Field and Store Pests of Cocoa in Nigeria

Lead/Principal Investigator:

Dr. Michael Olusayo Okeniyi
Cocoa Research Institute of Nigeria (CRIN), Ibadan, Oyo State, Nigeria

Email: | Phone: omookeniyi@gmail.com 08059227840

Co-Investigators:

Team of Scientists – Orisajo, S. B., Ogundeji, B., Agbeniyi, S. O., Adedeji, A. R

Duration: 3 years

Thematic Area: Agriculture and Food Manufacturing

August, 2025.

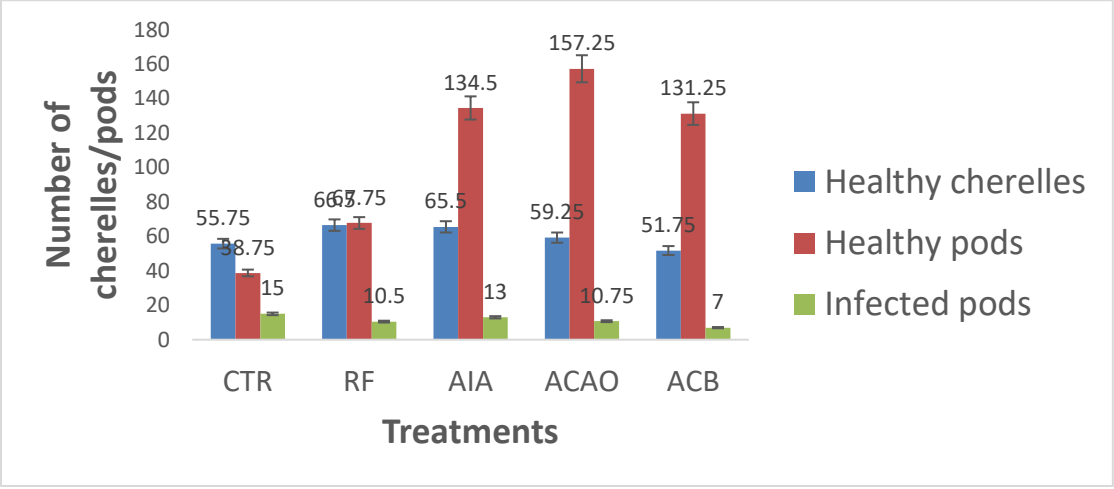
Executive Summary

Cocoa remains one of Nigeria's most valuable export commodities, providing livelihoods for millions of smallholder farmers. However, the sector is increasingly threatened by devastating diseases such as black pod, anthracnose, and cherelle wilt, coupled with the rising incidence of postharvest fungal contamination and mycotoxin accumulation. These challenges cause annual yield losses of up to 80%, undermine bean quality, and limit access to premium international markets. While chemical pesticides remain the dominant control strategy, they are expensive, environmentally unsustainable, and increasingly rejected by international buyers. Against this backdrop, indigenous biopesticide solutions offer a safer, affordable, and locally adaptable alternative. Building on the success of two on-going activities at the Cocoa Research Institute of Nigeria, this proposal seeks to scale up the research innovations into practical, farmer-ready alternative to safe cocoa. The developed technologies have been tried *in-vivo* and postharvest storage systems, and to be further optimize in multi-locational trials, pilot-scale production, and validation across major cocoa-producing states. The outcome will be a climate-smart, cost-effective, and environmentally sustainable disease management strategy that reduces losses, improves bean safety, and enhances Nigeria's competitiveness in the global cocoa market. The outcome will be a single, climate-smart integrated technology for cocoa production and warehousing.

1. Introduction

Nigeria is the 4th largest cocoa producing country globally, contributing significantly to national Gross Domestic Product (GDP), rural employment, and foreign exchange earnings. Despite its economic importance, cocoa productivity is severely constrained by biotic stresses. Black pod disease alone causes up to 90% yield loss annually, while anthracnose, dieback, and cherelle wilt further reduce pod set and tree vitality. Postharvest losses due to fungal contamination and mycotoxin accumulation compound these problems, leading to quality downgrades and export rejections (Agbeniyi *et al.*, 2025; Dormon, 2006). Current reliance on synthetic fungicides poses challenges: high cost, development of resistant pathogen strains, adverse environmental effects, terminal health concerns and tightening international regulations on chemical residues. These factors highlight the urgent need for innovative, eco-friendly, and farmer-accessible cocoa disease management technologies (Deresa and Diriba, 2023).

At the Cocoa Research Institute of Nigeria (CRIN), preliminary studies have identified promising ash botanical blends and indigenous endophytic fungi with strong antifungal and mycotoxin-suppressing activity. Early field trials and storage/laboratory experiments confirm their potentials as low-cost, sustainable alternatives. Some of the botanical ash blends compounded and deployed by CRIN scientists in the year 2024 significantly reduced black pod incidence to as low as 5.06% compared with that of the synthetic fungicide treatment (13.42%), and also clearly enhanced healthy cocoa pod production with wide margins (Figure 1; Okeniyi, *et al.*, 2025). An on-going research activities on use of endophytes to control black pod disease of cocoa at CRIN revealed the ability of indigenous *Trichoderma asperellum* and *Trichoderma harzianum* to reduce the proliferation of cocoa black pod pathogen (*Phytophthora megakarya*) by 83.92 and 75.35% respectively, thus, indicating their potentials as live agents for the control of the disease (Ayanwole, 2025).



Key: CTR – Untreated control; RF – Standard (Synthetic fungicide); AIA – Ash botanical 1; ACAO – Ash botanical 2; ACB – Ash botanical 3

Figure 1. Effects of botanical treatments on cocoa pods and cherelles production at Ajassor substation

The dried fermented cocoa research in the same vein, showed ability of the ash botanical blends to significantly inhibit/prevent growth of toxin producing storage moulds on the stored cocoa beans

varieties, thus indicating a significantly reduced mycotoxin contamination in the commodity (Ogundeji *et al.*, 2025). Hence, the potentials inherent in using the botanical mixes and endophytes as reasonable replacements to the synthetic pesticides widely used by farmers both on the field and at storage. However, these formulations require further refinement, validation, and scale-up before widespread farmer adoption can be achieved.

This project will therefore build on the existing knowledge to develop an integrated biopesticide platform, moving from laboratory optimization through field validation to farmer-centered technology transfer.

2. Problem Statement

Cocoa diseases and postharvest mycotoxin contamination remain major bottlenecks in Nigeria's cocoa value chain. Existing control measures are inadequate, costly, or environmentally unsustainable. If not addressed, these challenges will continue to erode productivity, income, and Nigeria's competitive advantage in the global cocoa trade. There is a pressing need to scale-up indigenous, research and need-driven solutions into practical farmer tools. This requires targeted investment in product development, field validation, quality assurance, and farmer adoption systems. Without such interventions, the nation's cocoa sector risks stagnation, with significant socioeconomic consequences for millions of smallholder farmers. The project aligns with NASENI's mandate to promote indigenous technology, import substitution, and local value addition while targeting food security, industrial linkages, and job creation.

3. Objectives

The overall objectives of this project is to develop, validate, and deploy integrated biopesticide technologies for sustainable management of cocoa diseases and mycotoxins in Nigeria.

Specific Objectives:

1. To optimize formulations of ash/biochar-botanical extracts and indigenous endophytic fungi for effective management of field and store pathogen.

2. To validate the efficacy of the developed technologies in pathogen management through multi-locational field and store evaluations.

4. To set up pilot-scale production, and build capacity of cocoa framers for multiplication and adoption of developed technologies and scaling up.

4. Methodology

The activities will be conducted using four-pronged approach: laboratory optimization, field validation, postharvest application, and farmer adoption/scale-up. Activities will be designed to leverage results from the two major on-going cocoa activities at CRIN and advance them into an integrated solution.

4.1 Laboratory Studies and Formulation Development

Selection of Candidate Biopesticides: Building on previous successes, promising ash/biochar-botanical extracts and indigenous endophytic fungi will be selected for further development.

Formulation Optimization:

i. Ash/biochar botanical formulations that have shown promise in the previous studies, will be blended with diatomaceous earth (carrier) and standardized for active ingredients.
ii. Endophytic fungi with strong antagonistic activity against *Phytophthora* spp. will be co-formulated into bio-inoculants.
iii. Compatibility and Stability Testing: Shelf life, storage conditions, and compatibility between biocontrol agents and carriers will be evaluated.

Mode of Action Studies: Laboratory assays will assess antifungal activity, mycotoxin suppression ability, and plant growth–promoting traits.

4.2 Field Evaluation

Experimental Design:

i. Field validation and capacity building in Oyo, Ondo and Cross River States.
ii. Application methods: Spraying and soil drenching techniques will be compared.
iii. Performance metrics: Disease incidence/severity, yield performance, and cost-effectiveness will be assessed against standard chemical controls.

4.3 Postharvest Disease and Mycotoxin Control

Treatment with Biopesticides: Ash/biochar-botanical blends and fungal inoculants that showed promise will be applied on dried fermented cocoa beans samples and stored to assess mould inhibition and mycotoxin suppression under varied relative humidity. Representative samples of each of the treatments will be processed using standard laboratory procedures and subjected to both metagenomics and mycotoxin analyses before and after the period of storage.

Mycotoxin Quantification: Rapid test kits (developed in ongoing work) will be deployed for aflatoxin B, ochratoxin A, sterigmatocystin, beauvericin, and enniatins detection and quantification, alongside confirmatory HPLC/LC-MS analysis.

The presence and populations of storage insect pests will also be determined in the stored cocoa beans at the end of storage, using standard methods. Treatment(s) that produce best result(s) will be subjected to cytotoxicity testing and sensory evaluation.

4.4 Technology Scale-Up and Farmer Validation

Pilot Production: A semi-processing unit will be set up for small-scale mass production of the integrated formulations using local equipment.

On-Farm Demonstrations: Participatory trials will be conducted with farmer groups in each target state to demonstrate efficacy under real production conditions.

Socioeconomic Studies: Surveys and focus groups will evaluate farmer perception, cost-benefit ratios, and adoption willingness.

Extension and Training: Training-of-trainers workshops will be held for extension officers, cooperatives, and agro-dealers.

4.5 Data Collection, Analysis, and Monitoring

i. Quantitative Data: Disease incidence, yield loss reduction, toxin levels, and economic gains will be recorded and statistically analyzed using ANOVA and regression models.
ii. Monitoring and Evaluation: A structured M&E framework will track project progress against milestones, ensuring accountability and timely reporting to NASENI.

5. Expected Outcomes

i. Optimized, farmer-ready formulations of integrated biopesticides.
ii. Reduced incidence of field pathogens by 50% and postharvest challenges by 30%.
iii. Improved yields, bean quality, and increase competitiveness of Nigeria cocoa in international market.
iv. Strengthened farmer capacity and enhanced adoption of eco-friendly practices.
v. Contribution to Nigeria's self-reliance in agricultural biotechnology through indigenous solutions.
vi. Capacity development of at least 200 farmers, 30 extension workers, and 10 graduate students.
vii. Contribution to food security, foreign exchange earnings, and rural employment.

Team and Institutional Capacity

The project will be anchored at the Cocoa Research Institute of Nigeria (CRIN) with multidisciplinary expertise in Crop Protection (Plant Pathology, Economics and Extension services). Collaborations will be established with farmers groups, input dealers, and other stakeholders to ensure sustainability, scaling, and commercialization of the developed technologies.

6. Budget (Indicative)

1. Personnel Costs:	**N45,000,000 (32.1%)**
Project Management Team	N18,000,000
Project Coordinator:	₦8,000,000
Financial Manager:	₦5,000,000
Monitoring & Evaluation Officer:	₦5,000,000
Research & Technical Team	N20,000,000
Lead Entomologist/Pathologist:	₦8,000,000
Agronomists/Field Technicians:	₦12,000,000 (4)
Dissemination & Training Staff	N7,000,000
Training Coordinators:	₦5,000,000 (2)

Community Mobilizers:	₦2,000,000 (2)

2. Research & Validation Costs: N35,000,000 (25%)

Setting up of Demonstration Plots	N10,000,000
Tagging and mapping out:	₦5,000,000
Farm Labor:	₦5,000,000
Procurement of Inputs & Equipment	N15,000,000
Pesticides (Approved & IPM-Compatible):	₦6,000,000
Formulation of Biopesticide:	₦4,000,000
Pest Traps & Monitoring Tools:	₦2,000,000
Farm Tools & Protective Gear:	₦3,000,000
Data Collection & Analysis	N10,000,000
Field Data Collection Tools (tablets, software):	₦4,000,000
Laboratory Analysis (pest identification, residue tests):	₦6,000,000

3. Dissemination & Training Costs: N25,000,000 (17.8%)

Farmer Training Workshops	N15,000,000
Venue Rental & Logistics:	₦3,000,000
Training Materials (manuals, posters):	₦4,000,000
Refreshments & Stipends for Farmers:	₦8,000,000
Creation of Extension Materials	N5,000,000
Production of training videos & documentaries:	₦3,000,000
Printing of brochures and flyers:	₦2,000,000
Field Days & Community Events	N5,000,000
Logistics & Transportation:	₦2,000,000
Publicity & Awareness Campaigns:	₦3,000,000

4. Travel & Logistics: N15,000,000 (10.7%)

Vehicle Purchase/Lease N8,000,000

Purchase of a reliable 4x4 vehicle: ₦8,000,000

Fuel & Vehicle Maintenance N4,000,000

Fuel allowance for field staff: ₦3,000,000

Vehicle service & repairs: ₦1,000,000

Staff Travel & Per Diem N3,000,000

Accommodation & daily allowances for field trips: ₦3,000,000

5. Project Overhead & Administrative Costs: N20,000,000 (14.3%)

Office Utilities N10,000,000

Electricity, internet & water: ₦2,000,000

Communication N4,000,000

Airtime, data & official phone lines: ₦4,000,000

Office Supplies & Equipment N5,000,000

Laptops, printers, stationery: ₦5,000,000

Contingency Fund N5,000,000

Unexpected costs, fluctuations in prices, etc.: ₦5,000,000

Total Budget Summary

S/N	CATEGORY	BUDGET (N)	PERCENTAGE
1	PERSONNEL COST	45,000,000	32.1%
2.	RESEARCH AND VALIDATION COSTS	35,000,000	25.0%

3.	DISSEMINATION AND TRAINING COSTS	25,000,000	17.8%
4.	TRAVEL AND LOGISTICS	15,000,000	10.7%
5,	PROJECT OVERHEAD AND DMINISTRATIVE COSTS	20,000,000	14.3%
	GRAND TOTAL	140,000,000	100%

7. Project Timeline (24–36 Months)

Year	**Key Activities**
Year 1	Laboratory formulation optimization, greenhouse trials, initial mycotoxin assays.
Year 2	Multi-location field trials, postharvest validation, pilot-scale production setup.
Year 3	On-farm demonstrations, farmer training, socio-economic studies, final reporting.

8. Conclusion

This project directly aligns with NASENI's mandate of driving indigenous technology solutions for national development. By advancing biopesticides from research to farmer-ready technologies, it will provide Nigeria with a sustainable, climate-smart tool for improving cocoa productivity, quality, and export competitiveness.

References

Agbeniyi, S. O., Oladokun, Y. O. M., Agulanna, F. T. and Oluyole, K. (2025). Assessing the economic burden of black pod disease and cherelle wilt on cocoa farmers in Nigeria. African Journal of Agricultural Science and Food Research, 18(1): 112-119.

Ayanwole, S. A., Arotupin, D. J., Ogundeji, B. A., Adeji, A. O., Oladigbolu, Y. O., Orisajo, S. B., Omoleye, M. T. and Laoye, F. T. (2025). Biological control of *Phytophthora* spp. using endophytic fungi isolated from cocoa (*Theobromae cacao* L.) pods. Nigerian Journal of Plant Protection, 39(1): 106-114.

Deresa, E. M. and Diriba, T. F. (2023). Phytochemicals as alternative fungicides for controlling plant diseases: A comprehensive review of their efficacy, commercial representatives, advantages, challenges for adoption, and possible solutions. Heliyon, 9(3) e13810. https://doi.org/10.1016/j.heliyon.2023.e13810

Dormon, E. (2006). From a technology focus to innovation development: The management of cocoa pests and diseases in Ghana. Laboratory of Entomology PhD Thesis, pp. 216, Wageningen University & Research. https://doi.org/10.18174/37758

Ogundeji, B. A., Agbeniyi, S. O., Adedeji, A. R., Orisajo, S. B., Okeniyi, M. O., Oyedokun, A. V., Otuonye, A. H., Olorunmota, R. T., Ayanwole, S., Oladigbolu, Y. O. (2025). Development of eco-friendly and safe approach for preservation of stored cocoa beans. Cocoa Research Institute of Nigeria 2024 Annual Report.

Okeniyi, M. O., Agbeniyi, S. O., Adedeji, A. R., Orisajo, S. B., Otuonye, A. H., Ogundeji, B. A., Ayanwole, S. and Oladigbolu, Y. O. (2025). Development and formulation of biofungicides for the control of black pod disease of cocoa. Cocoa Research Institute of Nigeria 2024 Annual Report.