OPEN ACCESS

ORIGINAL ARTICLE

Revista Ciencias Técnicas Agropecuarias 34
January-December 2025
ISSN 1010-2760, eISSN 2071-0054
Cu-ID: https://cu-id.com/2177/v34e31

# Proposal for a model for the implementation of circular biofactories for agricultural goods on Cuban farms

## *Propuesta de un modelo para la implementación de biofactorías circulares de biensumos agrícolas en fincas cubanas*

Mayra Arteaga-Barrueta[1*] and José Antonio Pino-Roque[2]

[1]*Universidad Agraria de La Habana "Fructuoso Rodríguez Pérez", Facultad de Agronomía, Departamento de Química y Producción Agrícola, San José de las Lajas, Mayabeque, Cuba.*
[2]*Universidad Agraria de La Habana "Fructuoso Rodríguez Pérez", Facultad de Ciencias Técnicas, Departamento de Matemática Física, San José de las Lajas, Mayabeque, Cuba. E-mail: pino@unah.edu.cu*

[*]Author for correspondence: Mayra Arteaga-Barrueta, e-mail: mayra@unah.edu.cu

**ABSTRACT:** This study proposes a methodological framework for the implementation of economical, circular, and self-sustaining agricultural bioinput biofactories on Cuban family farms. The endogenous conditions of local farms are analyzed and international experiences are reviewed. The current status of farms in the Mayabeque province was identified, and integrated actions for the creation of biofactories under the circular economy model were proposed. It was found that the implementation of biofactories represents a strategic opportunity for the responsible management of natural resources, replacing up to 90% of external inputs. A circular-adaptive model was derived for the implementation of biofactories that contribute to socio-ecological resilience and food sovereignty. Based on the current context identified on the farms, the implementation of agricultural bioinput biofactories was found to provide economic and environmental self-sustainability for the national agricultural landscape.
**Keywords:** Recycling, Waste, Circular Economy, Bioinputs, New Model, Waste Management.

**RESUMEN:** Este estudio propone un marco metodológico para la implementación de biofactorías de bioinsumos agrícolas económicas, circulares y autosostenibles en fincas familiares cubanas. Se analizan las condiciones endógenas de fincas locales y se revisan experiencias internacionales. Se identificó el estado actual de las fincas en la provincia Mayabeque y se propusieron acciones integradas para la creación de biofactorías bajo el modelo de economía circular. Se encontró que la implementación de biofactorías representa una oportunidad estratégica para el manejo responsable de recursos naturales, sustituyendo hasta un 90% de insumos externos. Se derivó un modelo circular-adaptativo para implementar biofactorías que contribuyan a la resiliencia socioecológica y la soberanía alimentaria. De acuerdo al contexto actual identificado en las fincas, se encontró que la implementación de las biofactorías de bioensumos agrícolas, cierre de ciclo de nutrientes y autosostenibilidad económica ambiental para el panorama agrícola Nacional.
**Palabras clave:** reciclaje, residuos, economía circular, bioensumos, nuevo modelo, gestión de residuos.

## INTRODUCTION

The implementation of bio-input biofactories under endogenous waste management systems on farms is a strategy for developing self-sustaining circular agriculture under the current conditions of the global economic crisis and the fight against climate change.

The reuse of natural waste is one of the main challenges for achieving a sustainable world (OCDE-FAO, 2020). To this end, a new paradigm is emerging with the application of circular economy principles through the biofactory model, aimed at small local producers for the valorization of agro-industrial natural waste into low-cost bio-inputs, with more economically and environmentally efficient agroecological practices (Quiroga-Canaviri & Sánchez-Corchero, 2023).

In this way, biofactories become the primary source of inputs for crops, providing autonomy and lower costs for farmers, fostering the harmonious interaction of the physical, chemical, and biological knowledge of researchers with the ancestral knowledge contributed by the wisdom of farmers, which constitutes the basis for sustainable productivity and a healthy environment. They are widespread throughout the world, among the most advanced in Chile, Brazil, Colombia, Mexico, Guatemala, Ecuador, the United States, Spain, and Italy, to fulfill the mission of recycling wastewater, generating biofuels and renewable thermal energy introduced into production processes. Currently, to a lesser extent, they are being established as a paradigm-shifting force

Received: 10/03/2025
Accepted: 01/10/2025
The authors of this work declare no conflict of interests.
**Author contributions: Conceptualization:** M. Arteaga. **Data curation:** M. Arteaga. **Formal Analysis:** M. Arteaga. **Investigation:** M. Arteaga, J. A. Pino. **Methodology:** M. Arteaga. **Supervision:** M. Arteaga, J. A. Pino. **Validation:** M. Arteaga, J. A. Pino. **Writing-original draft:** M. Arteaga, J. A. Pino. **Writing-review & editing:** M. Arteaga, J. A. Pino.
The mention of trademarks of specific equipment, instruments or materials is for identification purposes, there being no promotional commitment in relation to them, neither by the authors nor by the publisher.

in a new alternative for the sustainable management of recycled waste, reduced to zero, for the generation of agricultural inputs (Almulhim, 2024).

Restrepo y Hensel (2013), report that the transition to biofactory models primarily established on farms is a global trend that offers opportunities to improve efficiency, reduce long-term costs, and protect the environment. They also describe that bioprocesses occur in these plants through the use of living cells or biological components to transform natural waste and provide food, healthy remedies to nourish them, and biofuels.

Thus, the production of agricultural inputs is carried out from and for nature to produce liquid and solid products ready for soil and foliar application to increase the productivity of the producers' crops of interest and according to their conditions, without causing harm to the environment Restrepo & Hensel (2013), These authors promote their development on local farms in countries across the Americas (Colombia, Mexico, Brazil, and Chile), sharing their experiences interacting with producers and solving major environmental and sustainability challenges from the perspective of the recyclable biofactory model that strengthens collective work.

In Cuba, the model of comprehensive and sustainable circular biofactories for the generation of agricultural inputs is emerging as an innovative alternative to transform self-sustaining agricultural production systems. For years, Cuba has had a tradition of working with biofactories for the production of vitro plants Noriega (2024), and for wastewater recycling (Díaz et al., 2022). This work is also being carried out in the field of the production of biological control agents such as entomopathogenic fungi, nematodes, and other bioagents for pest control (Parrado *et al.,* 2016). However, with regard to the production of agricultural bioinputs specifically, the situation is characterized by the presence of isolated experiences, pilot projects, encouraging innovative projects with high potential, and local and national initiatives at the level of research centers (INICA, INISAV, INCA) and universities (UNAH, UCV). These initiatives are difficult to scale up industrially, and there are shortages of raw materials that prevent widespread and systematic implementation by producers on farms (Fundora-Sánchez et al. 2024).

This constitutes the main current challenge, as a transition to stable and self-sustaining production for the producer themselves at the level of individual or community local farms, for the production of inputs that guarantee the productive sustainability of healthy crops and contribute to environmental conservation.

Given this background, the objective of this work is to propose a methodological framework for designing and implementing self-sustaining circular economic biofactories for the production of agricultural bioinputs in the context of individual or community family farms in the Cuban agricultural sector. Based on a review of experiences. documented, foundations, conditions and alternatives necessary for the production of agricultural bio-inputs, through the recycling of endogenous waste in local farms with the establishment.

## MATERIALS AND METHODS

The work protocol developed was based on the collection of information through technological and informational surveillance techniques. This was combined with a study conducted on 57 typical local farms in the Mayabeque province by (Fundora-Sánchez et al. 2024). This constituted the basis for identifying and generalizing the farms' endogenous conditions to implement a circular and economical biofactory model for peasant, family, and community agriculture. A proposed methodology was derived for the design and implementation of affordable local biofactories with a circular economy model, adapted to the typical conditions of Cuban farms in the Mayabeque province. The comprehensive assessment of the current state of Cuban farms in terms of their agroecological, logistical, and waste management conditions consisted of a search for information from external sources, strategically collecting, analyzing, and disseminating information from various sources: monitoring specialized databases on specialized agricultural platforms (AGROSAVIA, FAOSTAT, HONTZA UNE 166006: 2011 standard, Scielo search engines, Google Scolar alerts), indexed scientific journals, and patents to identify best practices and technologies available in sustainable soil management, biodiversity, and organic waste treatment. In parallel, information from the local and national logistics sectors was analyzed to evaluate transportation, storage, and cost options, according to Martínez (2014) and San Juan & Rodríguez (2016). The studies were also based on learning, analysis, and identification of conditions in the technical guides and manuals of international models for the replication of the implementation of peasant, family, and community biofactories:

I. Guide for the Implementation of Biofactories for Peasant, Family, and Community Agriculture (ACFC), 2024, by the group of authors and with technical assistance from the United Nations (UN), the Italian Agency for Development Cooperation (AICS), the European Union (EU), and the Colombian Horticultural Association (Asohofrucol) (Monje *et al.*, 2025).

II. Technical Guide: BIOFACTORIES. Production of Biological Inputs for Use in Coffee Growing. ANACAFE, Guatemala, 2022. Technical assistance from the Food and Agriculture Organization of the United Nations (Navarro, 2022).

III. MMA-UN. Environment, (2021). Bioinput Manual for Biofactories of the Association of Agroecological Producers of the Maipo Islands (APADIM). Chile (Lima *et al.*, 2025).

IV. BIOFÁBRICAS AGRO-INNOVA Manual (2024). Inter-American Institute for Cooperation on Agriculture (IICA). EU, CATIE, IICA, 2024 (AGRO-INNOVA, 2024).

V. Technical Manual: The Associative BIOFÁBRICA 2024. INCAS. UNIMINUTOS Colombia, 2025 ed. (Monje *et al.*, 2025).

VI. Bioinputs for Family Farming. FAO 2017. Mexico (Agroméxico, 2017).

Appropriate technologies with low budgets, innovative methods, microbial processes, and isolated global and local experiences were identified by combining scientific information with the experiences of producers, suppliers, and experts. In addition to seeking accessible solutions to the endogenous conditions of most small, local Cuban farms in Mayabeque province, as an efficient and sustainable alternative to waste recycling.

As internal sources: an information sweep was conducted through surveys of stakeholders on local and family farms in Mayabeque province, as well as historical economic production records to understand the current status of workflows and actual waste generation, to lay the groundwork for informed and sustainable strategic planning. Information was taken from the updated study of 57 typical farms in Mayabeque province conducted by Fundora-Sánchez et al. (2024). Based on the SWOT analysis, these authors structured the current weaknesses, strengths, opportunities, and threats. This constituted the basis for the diagnosis to design an action plan to improve soil health, optimize transportation routes, and reduce logistics costs. Implement a low-cost composting-fermentation system for the transformation of the identified organic waste. Based on the strategic diagnosis, the design is established and integrated self-sustaining actions are proposed that allow the creation and implementation of an economic biofactory that makes the circular economy model a reality, for economic and environmental benefit under the development of sustainable circular agriculture, collected in a methodology with a methodological, adaptive and cognitive character.

## RESULTS AND DISCUSSION

The review of specialized literature showed that low-cost circular biofactories provide innovative solutions for transforming agricultural production systems in Cuba, where external input limitations and the need for environmental sustainability demand alternative approaches, integrating agricultural production with the use of organic waste to create closed material and energy cycles, based on the principles of the circular economy.

In Mayabeque province, Cuba, 56% of producers have received training in biofertilizers. Despite challenges such as input shortages, circular biofactories could be key for family farming.

### Conditions highlighted for the establishment of circular bioinput biofactories in Cuba, derived from the SWOT analysis of the study on 57 farms in Mayabeque province

The current agricultural production context revealed that 83.6% of producers use organic fertilizers, while 81.8% still rely on mineral fertilizers Fundora-Sánchez *et al.* (2024). This reflects a partial transition toward fully sustainable models. According to these authors, the main limitations identified include: (I) pests and diseases (76% of farms); (II) herbicide shortage (68%). (III) Lack of chemical and organic fertilizers (65%). (IV) Soil fertility problems (59%). Labor limitations (42%). These challenges must be taken into account in the design of circular biofactories as integrated solutions through nutrient cycling and biological pest control. Additionally, knowledge of the potential and utilization of endogenous residues from farms is scarce.

According to references by Casimiro-Rodríguez (2016); Casimiro-Rodríguez y Casimiro-González (2018); Casimiro-Rodríguez et al. (2020); Lezcano-Fleires et al. (2021); Fundora-Sánchez et al. (2024): Cuba has valuable, isolated and generally uncollected experience in production systems involving biogas production from organic waste, the development of biofertilizers, registered products, and small biodiesel plants. These capabilities and experiences can serve as a basis for scaling up to integrated biofactory models.

In the strategic policy framework, Villalpanda (2024) reports that the Cuban state has identified 17 key actions to enhance the principles of the circular economy, including: (I) solar photovoltaic energy; (II) utilization of forest and crop biomass; (III) biogas production; and (IV) introduction of electric vehicles. Within this framework, the development of circular biofactories is favorable as part of a national sustainability strategy.

### Methodological Proposal for the Implementation of Circular Biofactories on Local Cuban Farms

This study examines documented experiences, rationales, conditions, and alternatives found, which are necessary for the production of agricultural bioinputs through the recycling of endogenous waste on local farms, establishing a circular and sustainable biofactory model under the current conditions of Cuban farms, specifically those in the Mayabeque province. Success relies on starting simply, validating the process, and then scaling it up, minimizing the initial investment and maximizing the use of materials available on the farm.

A proposed methodology was derived for the implementation of circular biofactories on local Cuban farms, consisting of five fundamental phases (Figure 1).

Phase 1: Diagnosis and planning is the main stage of the study process for characterizing the farm through an agroecological, logistical, and economic analysis. Participatory Action Research (APR) methodology is applied as part of the information gathering process. The flow of materials and energy is assessed.

The types and volumes of waste generated are evaluated. The needs for external inputs are evaluated. Prior training for producers is provided through participatory workshops, events, interviews, and hands-on experience as a key player in the process.

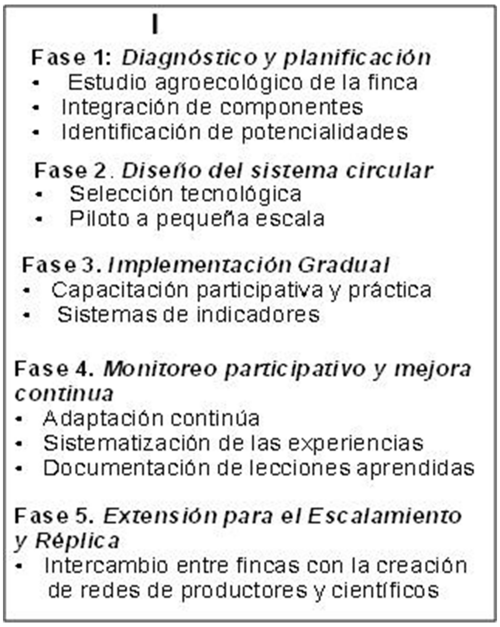


**Figure 1.** Methodological procedure for implementing a biofactory on local farms.

The identification of potential opportunities to determine whether there is sufficient raw material to feed the biofactory includes waste characterization based on an inventory with the identification and cataloging of all organic waste generated on the farm: livestock manure, natural plant residues, pulp, and crop residues. This is quantified by estimating the volume or weight generated (weeks, months, or years).

Waste characterization can have an intuitive basis: (I) as green (nitrogenous) materials, they are moist, decompose quickly, and are poorly stabilized (green grass, fresh manure, and kitchen waste). (II) brown (carbonated), dry, and fibrous materials (straw, dry stubble, sawdust, dry leaves, uninked cardboard).

- To conduct a waste reuse assessment.
- Prioritize appropriate technologies based on: available endogenous and local resources, investment capacity, and existing knowledge.
- Identify needs and markets: (I) internal use on the farm. What does the farm need? Prioritizing what will be used most. (II) Local sale (self-sustainability): Explore whether there is local demand, which is important for generating income and making the project more sustainable.

Phase 2 contemplates the design of a circular system that allows for the closure of the nutrient cycle and the most efficient and viable use through the integration of components with the design of the connected flows:

- Agricultural production - organic waste - processing - bioinputs - agricultural production. - Renewable energy (solar, biogas) - processing - energy application.

In the selection of low-cost technologies, technologies validated in Cuba are prioritized, such as:

I. For solid fertilizers (composts), heap composting by stacking the layers interspersed with green and brown materials in a shaded area. Reducing the need for turning by increasing air intake with interspersed tree branches and increasing the height and width of the pile. Vermicomposting with vermiculture to increase the quality of the humus. Establish niches with boxes or simple beds near the dairy farms, on intermediate routes with the biofactory, and/or near its surroundings. Creation of accelerated composters for plant waste.

II. For liquids and bio-liquids, using an artisanal biodigester (with PVC pipes, tanks, or plastic bags); preparation of bio-liquids (anaerobic fermentation) in airtight tanks with gas valves or even disposable plastic bottles, where manure, plants, molasses, and water are fermented to produce liquid biofertilizers and biopesticides.

III. For microbial inoculants, which are the basis for accelerating composting, enriching soils, and controlling pathogens, where mountain microorganisms (MM) reproduce, capturing native microorganisms from trees and multiplying in rice and molasses in buckets.

For worm farms and the development of MMs, it is necessary to design the flow and space, allocating a specific area, preferably shaded, with access routes to water, protected from animals, and close to the biofactories. The route and work flow design would be from waste reception areas to composting/worm farms to maturation and storage areas to packaging areas.

Phase 3 of gradual implementation begins on a small scale: Small-scale pilot: (I) Start with a core component of building basic infrastructure using local or native, recyclable, and low-cost materials. Examples: composters with plastic tanks, or 1m x 1m x 1m boxes made of pallets or boards, worm farms with old tubs perforated for drainage.

The start-up of the composting process begins with a first pile with the basic ratio: 3 parts brown materials to 1 part green, 60% wet (like a wrung-out sponge), and aerated with turning every 15 days or fixed with central vents, and intermediate vents with tree branches to oxygenate the internal and intermediate parts of the pile. For vermiculture, a bed of semi-composted material is prepared (15 days), alternating with fresh bedding and adding worms.

The temperature can also be monitored and learned empirically by placing your hand in the center of the pile, where it should feel warm. If not, you need to add more green material. For humidity, squeezing a handful of material should drip 1 or 2 drops, and if more drips, it is too wet; dry material is needed. If it doesn't, it is too dry; water is needed. Rotten odors suggest excess nitrogen, making it necessary to add brown material. It could also indicate a lack of oxygen. Turning or adding more branches to the pile can increase air intake.

For bio-liquid, mix 1/3 fresh manure, 1/3 green plant material, and 1/3 water in a 200 L tank, tightly seal with a lid fitted with a hose to release gases. Ferment for 2-3 months. Other elements can be progressively added as the results improve.

It is important to document lessons learned that serve as a basis for correcting work methodology and for participatory and practical training: (I) with programs adapted to existing knowledge levels. (II) experiences (generally, 56% of producers have some training in bioinputs). (IV) approaches to managing circular technologies, bioinput quality control, and impact monitoring. Compliance with these aspects entails maintaining participatory monitoring for continuous improvement of a system of ecological indicators for biodiversity, soil, and water health. Economical in terms of cost reduction and the added value of reusing residual materials. The social factor in job creation and training.

Continuous adaptation is a mechanism for adjusting the system according to changes in production, resource availability, climatic conditions, and the needs of the crops to be grown and the soil where they are grown. A general, adaptive model is proposed, specifically for the case study of Mayabeque province. This model is based on the study and generalization of information on the current status of typical local farms in Mayabeque province, evaluated by Fundora-Sánchez *et al.* (2024), These models comprise the following key components: (I) a biogas unit for processing animal manure; (II) a composting system for animal and plant waste; (III) production of liquid biofertilizers and biostimulants; (IV) integration with existing irrigation systems (85% of farms); (V) training focused on identified gaps (47% without training in bioproducts).

This proposed model predicts benefits in: (I) a cost reduction of approximately up to 40%, depending on the external inputs introduced; (II) an improvement in soil fertility and quality with the application of bioinputs obtained on the farm itself (a problem in approximately 59% of farms). (III) biological pest control using local biopreparations (IV) renewable energy generation for agricultural and domestic operations.

Phase 4 of the extension process for Scaling, Replication, and Sustainability is based on optimization and adaptation, building on what was learned in the pilot phase, such as adjusting mixtures, timing, and designs; it may include replicating processes in large quantities. Quality control is essential, so empirical tests can also be performed first, such as the completion of the composting process. It is cold, crumbly to the touch, with a forest soil odor, and unfermented, with homogeneous composition (the original materials are indistinguishable). Germination tests are then performed (% germination) to assess the impact on seeds such as lettuce and/or radish, which are more sensitive and therefore indicative of the quality of the compost used. If germination is affected, the compost may be immature or too concentrated, making it unsuitable for use.

The creation of an economic circuit for the farm's internal self-consumption, recording changes (improved productivity and quality of plants and soil, reduced costs). Local marketing of surplus produce can be another way to economize and generate profits, offering it at a fair price that covers the costs of labor and external materials (molasses) and its transformation; providing added value as local, organic, and handmade products.

Documentation and replication through the systematization of experiences, documenting internal farm documents and lessons learned, and exchanges between farms, creating networks of producers and scientists to disseminate experiences in technologies. This knowledge is invaluable for improving and training others, replicating the model on neighboring farms.

It is important to consider strengthening support for the development of local, self-sustaining circular biofactories on individual or community farms as a sustainability alternative. It is also important to consider practical training programs, establishing networks for the exchange of experiences between producers and experts, and creating adaptive financing mechanisms. In this methodology, the knowledge acquired at a general level by producers is the most valuable asset. Training farm staff in these techniques turns the bio-input biofactories into replicable and scalable knowledge assets, laying the groundwork for becoming a demonstrative or guiding resource for other farms, and potentially generating income through training.

## CONCLUSIONS

- The proposed adaptive methodology, based on gradual implementation and continuous improvement, offers a viable path for establishing low-cost circular biofactories on Cuban farms, especially in the Mayabeque province. This methodology adapts to the endogenous conditions of each farm and locality.
- They represent a strategic opportunity to promote a transition toward more efficient and self-sustaining cyclical agroecological systems, reducing dependence on external inputs and leveraging available local resources. This eliminates an external cost and generates tangible savings, estimated at between 60 and 90%.
- This alternative can strengthen socio-ecological resilience, create jobs, and create self-sustaining value-added in rural areas. Key to scaling up is the consideration of the endogenous conditions of each locality, along with technical assistance and financial support policies.

## REFERENCES

AGRO-INNOVA: *Manual biofábricas AGRO-INNOVA*, Inst. Instituto Interamericano de Cooperación para la agricultura (IICA). UE, CATIE, IICA, San José, Costa Rica, publisher: San José, Costa Rica, Instituto Interamericano de Cooperación para la agricultura (IICA). UE, CATIE, IICA, 2024.

AGROMEXICO: *Bioinsumos para la agricultura familiar*, *[en línea]*, Inst. FAO, Roma Italia, Roma, Italia, 2017, *Disponible en: http://www.faomexico@fao.org go/agricultura México* .

ALMULHIM, A.I.: "Toward a Greener Future: Applying Circular Economy Principles to Saudi Arabia's Food Sector for Environmental Sustainability", *Sustainability*, 16(2): 786, 2024, ISSN: 2071-1050.

ANAYA, V.A.: "Manual guía de buenas prácticas de economía circular para una cadena alimentaria sostenible en Cuba", En: 2024, DOI: https://doi.org/10.13140/RG2.2.24785.03683 ResearchGate.net/public/.

CASIMIRO RODRÍGUEZ, L.: "Bases metodológicas para la resiliencia socioecológica de fincas familiares en Cuba", 2016.

CASIMIRO RODRÍGUEZ, L.; CASIMIRO GONZÁLEZ, J.A.: "How to make prosperous and sustainable family farming in Cuba a reality", *Elementa: Science of the Anthropocene*, 6, 2018.

CASIMIRO-RODRÍGUEZ, L.; CASIMIRO-GONZÁLEZ, J.A.; SUÁREZ-HERNÁNDEZ, J.; MARTÍN-MARTÍN, G.J.; NAVARRO-BOULANDIER, M.; RODRÍGUEZ-DELGADO, I.: "Evaluación de la resiliencia socioecológica en escenarios de agricultura familiar en cinco provincias de Cuba", *Pastos y Forrajes*, 43(4): 304-314, 2020, ISSN: 0864-0394.

DÍAZ RODRÍGUEZ, Y.; MENDIOLA LAU, L.; GONZÁLEZ SUÁREZ, A.; NAVARRO SOSA, Y.; ACOSTA DÍAZ, S.; CHAO REYES, C.: "Biofiltración de efluentes líquidos de la industria petrolera con materiales naturales", *Ingeniería Hidráulica y Ambiental*, 43(1): 12-24, 2022, ISSN: 1680-0338.

FUNDORA-SÁNCHEZ, L.R.; MARTÍN-ALONSO, G.M.; MIRANDA-MORA, I.; RIVERA-ESPINOSA, R.A.; DUQUE, Y.R.: "Caracterización agroproductiva de fincas de la provincia Mayabeque, Cuba", *Pastos y Forrajes*, 47, 2024, ISSN: 0864-0394.

LEZCANO-FLEIRES, J.C.; MIRANDA-TORTOLÓ, T.; OROPESA-CASANOVA, K.; ALONSO-AMARO, O.; MENDOZA-BERETERVIDE, I.; LEÓN-HIDALGO, R.: "Caracterización de la situación agroproductiva de una finca campesina en Matanzas, Cuba", *Pastos y Forrajes*, 44, 2021, ISSN: 0864-0394.

LIMA, G.L.C.; DA SILVA LUZ, R.; DOS SANTOS VIEIRA, W.C.; DE SOUSA, M.P.; DOS SANTOS QUADROS, H.; DOS SANTOS, S.G.: "Bioinsumos: uma percepção a partir dos agricultores familiares", *Cuadernos de Educación y Desarrollo*, 17(3): e7769-e7769, 2025, ISSN: 1989-4155.

MARTÍNEZ, J.A.: "Desarrollo de una metodología de Vigilancia Tecnológica para la toma de decisiones: aplicación a las tecnologías multimedia", Publisher: ETSIS_Telecomunicacion, plataforma especializada HONTZA norma UNE 166006: 2011, 2014.

MMA-ONU: *Manual de bioensumos para biofábricas de la Asociación de productores agroecológicos de las Islas de Maipo-APADIM*, *[en línea]*, Inst. Ministerio del Medio ambiente-ONU, Santiago de Chile, Financiado en el marco proyecto GEFSEC ID 5135, Santiago de Chile, Chile, 35 p., Encargada a: Ecodaya consultores, 2021, *Disponible en: htpps://gefmontana.mma.gob.cl* .

MONJE, J.; JARAMILLO, K.; CABRERA, C.: *Manual técnico: La BIOFÁBRICA Asociativa 2024*, Inst. INCAS. UNIMINUTOS Colombia, Colombia, 79 p., 2025.

NAVARRO, Y.: "Guía Técnica: BIOFÁBRICAS. Producción de insumos biológicos para su uso en la caficultura", *CEDICAFE ANACAFE Guatemala*, 2022, ISSN: 2421-3700, Disponible en: htpps://www.anacafe.org.

NORIEGA, A.: *Biofábricas: La experiencia cubana*, *[en línea]*, Avance Agroindustrial 43-2 EEAOC ed., 44-46 p., 2024, ISBN: 0326-1131, *Disponible en:* https://www.eeaoc.gob.ar.

OCDE-FAO.: *OCDE-FAO Perspectivas Agrícolas 2020-2029*, Ed. OCDE Publications Centre, 2020.

QUIROGA-CANAVIRI, J.L.; SÁNCHEZ-CORCHERO, M.: "La Bioeconomía en armonía con la Naturaleza", *Revista Iberoamericana de Bioeconomía y Cambio Climático*, 9(18): 2289-2317, 2023.

PARRADO, A., GONZÁLVEZ, J., GONZÁLEZ, E., CASANUEVA, K: "Análisis de la utilización de agentes de control biológico en los sistemas de cultivo protegido en Cuba". *Fitosanidad* 20(1) 45-61, 2016, ISSN: 1362-300.

RESTREPO, J.; HENSEL, J.: "El ABC de la agricultura orgánica", *Fosfitos y Panes de Piedra*, 2013.

SAN JUAN, Y.I.; RODRÍGUEZ, F.I.R.: "Modelos y herramientas para la vigilancia tecnológica", *Ciencias de la Información*, 47(2): 11-18, 2016, ISSN: 0864-4659.