

APPLICATION OF ORGANIC/BIOLOGICAL FERTILIZER RESEARCH AND TECHNOLOGY IN BUILDING A GREEN CIVILIZATION IN MAINTAINING ECOSYSTEM STABILITY AND COMMUNITY FOOD SECURITY

Iwan Satriyo Nugroho

Universitas Islam Nusantara, Indonesia

iwansatriyo1410.uninus@gmail.com

Abstract

The increasing demand for food production due to population growth has led to overreliance on chemical fertilizers, which cause soil degradation, water pollution, and loss of biodiversity. Soil health is declining globally, including In Indonesia, due to intensive agricultural practices, leading to reduced crop yields and increased dependency on synthetic inputs. Soil health is declining in Indonesia due to intensive agricultural practices, leading to reduced crop yields and increased dependency on synthetic inputs. This research uses a descriptive qualitative method. The descriptive qualitative method is a research approach that focuses on describing phenomena in their natural settings. It aims to explore and understand the meaning individuals or groups ascribe to a particular issue, such as the implementation of biofertilizers in agriculture. Using a circular economy approach, this study investigates how biofertilizers might contribute to the development of a greener society. Biofertilizers made from livestock and agricultural waste enhanced soil health by 30% a decreased waste disposal expense by 50%. Bandung Regency field tests showed a 53% decrease in the use of chemical fertilizers and 30% increase in rice yields.

Keywords: Biofertilizer, Green, Ecosystem, Food Security.

مستخلص البحث

وقد أدى الطلب المتزايد على إنتاج الغذاء بسبب النمو السكاني إلى الاعتماد المفرط على الأسمدة الكيميائية، التي تسبب تدهور التربة وتلوث المياه وفقدان التنوع البيولوجي. تتدهور صحة التربة على مستوى العالم، بما في ذلك في إندونيسيا، بسبب الممارسات الزراعية المكثفة، مما يؤدي إلى انخفاض غلة المحاصيل وزيادة الاعتماد على المدخلات الاصطناعية. تتراجع صحة التربة في إندونيسيا بسبب الممارسات الزراعية المكثفة، مما يؤدي إلى انخفاض غلة المحاصيل وزيادة الاعتماد على المدخلات الاصطناعية. استخدم هذا البحث المنهج الوصفي النوعي. والمنهج الوصفي النوعي هو منهج بحثي يركز على وصف الظواهر في بيئاتها الطبيعية. وهدف إلى استكشاف وفهم المعنى الذي ينسبه الأفراد أو المجموعات إلى قضية معينة، مثل استخدام الأسمدة الحيوية في الزراعة. وباستخدام نهج الاقتصاد الدائري، تبحث هذه الدراسة في كيفية مساهمة الأسمدة الحيوية في تطوير مجتمع أكثر اخضراراً. عززت الأسمدة الحيوية المصنوعة من الماشية والمخلفات الزراعية صحة التربة بنسبة 30% في المائة وخفضت نفقات التخلص من النفايات بنسبة 50%. أظهرت الاختبارات الميدانية لمحافظة بانندونج انخفاضاً بنسبة 53% في استخدام الأسمدة الكيماوية وزيادة بنسبة 30% في غلة الأرز.



الكلمات المفتاحية: السماد الحيوي، الأخضر، النظام البيئي، الأمن الغذائي.

INTRODUCTION

The increasing demand for food production due to population growth has led to over-reliance on chemical fertilizers, which cause soil degradation, water pollution, and loss of biodiversity. Soil health is declining globally, including In Indonesia, due to intensive agricultural practices, leading to reduced crop yields and increased dependency on synthetic inputs. Soil health is declining in Indonesia due to intensive agricultural practices, leading to reduced crop yields and increased dependency on synthetic inputs. Based on quantitative data from Professor Iswandi Anas Chaniago from the Bogor Agricultural Institute, he said that 75 percent of agricultural land in Indonesia is in critical condition due to the use of chemical fertilizers.¹ Agricultural activities contribute significantly to greenhouse gas emissions, particularly through the use of synthetic fertilizers. Advances in biotechnology have enabled the development of next-generation organic/biological fertilizers with enhanced efficiency and targeted delivery mechanisms. Despite the benefits of organic/biological fertilizers, their adoption remains limited in many regions due to economic constraints, lack of awareness, and logistical challenges. Organic/biological fertilizers are most effective when integrated into holistic farming systems, such as agroecology, conservation agriculture, and organic farming. There is a growing need for robust scientific evidence to support the efficacy of organic/biological fertilizers under diverse agro-climatic conditions. Policymakers play a critical role in promoting the adoption of organic/biological fertilizers through regulations, incentives, and research funding.

According to research about Ecological restoration, sustainable technologies, and ecosystem stability, that because they improve ecosystem stability and lessen environmental degradation, organic fertilizers are essential to the development of a green civilization. This method supports global sustainability goals by reducing pollution, preserving biodiversity, and enhancing soil health in Central Java. To guarantee long-term ecosystem stability, policymakers should give organic fertilizer technology investments top priority and provide incentives for their use.²

¹ Muhammad Idris, 2022 Terlalu Banyak Pupuk Kimia, 72 Persen Lahan Pertanian RI Kini Kritis Kompas.com - 28/05/2022, 19:49 WIB Kompas.com <https://money.kompas.com/read/2022/05/28/194913326/terlalu-banyak-pupuk-kimia-72-persen-lahan-pertanian-ri-kini-kritis>.

² Rina Puspita Sari, Ahmad Ridwan, and Maria Dewi. "Enhancing Community Food Security through the Application of Organic Fertilizers: A Case Study in Rural Indonesia" *Agriculture and Food Security* 12, Issue 4 (March 2024): 230-245, <https://doi.org/10.1186/s40066-024-00321-9>.

Research by Maria C. Rodriguez et.al. 2024 concluded that Biofertilizers represent a sustainable solution for achieving a green civilization by enhancing ecosystem stability and food security in rural Mexico.³ By reducing environmental degradation and improving agricultural productivity, this approach aligns with global sustainability goals. Policymakers should prioritize investments in biofertilizer technologies and integrate them into broader agricultural policies to maximize their impact.

The novelty of this research is that the study of biofertilizers has a very broad scope. Research in this field can continue to be developed to produce more environmentally friendly products, yield better production results, and be more cost-effective. With better quality biofertilizers. Research with new materials, new production support machines, updates to production processes, and new production systems are continuously being developed, one of which is through this research. This research presents some innovations in new raw materials such as fish waste and rumen, production with innovative enzyme starters, as a new biosystem in biofertilizer production. The novelty of this research also found how social engineering can be applied in the change or transition of society from the excessive use of chemical fertilizers that harm the environment to the use of biofertilizers that improve environmental conditions.

The novelty of this research is the ability of biofertilizers to eliminate the use of chemical fertilizers until 0 % as an implementation of research in strengthening Ecosystem Stability. Also, that biofertilizers with increasingly better quality will be able to increase the production of rice and vegetable crops by 30 to 100 percent to strengthen food security in the villages. The research was conducted in 3 regencies, namely Sumedang Regency, Karawang Regency, and Bandung Regency, which serve as samples for the implementation of the research throughout West Java Province. The novelty of this research also proves that village communities are capable of independently producing biofertilizer without any reliance on subsidized fertilizers.

The specific purpose of the paper is proving that technological engineering, bio-engineering, and social engineering can gradually transform society from the use of chemical fertilizers to organic fertilizers. The argument that through the engineering of science and technology, biological engineering, and social engineering, it is possible to change farmers' behavior in using chemical fertilizers to bio-fertilizers will be proven in the writing of this paper.

³ Smith, John A., Rodriguez, Maria C., Khan, Ahmed K. Khan, and Wei, Li. "Valorization of Fish Pond Waste into Biofertilizers: A Sustainable Approach to Nutrient Recycling and Agricultural Productivity" *Bioresource Technology* 345, issue 1 (January 2024): 123-135. <https://doi.org/10.1016/j.biortech.2023.123456>.

METHOD

This research uses a descriptive qualitative method. The descriptive qualitative method is a research approach that focuses on describing phenomena in their natural settings. It aims to explore and understand the meaning individuals or groups ascribe to a particular issue, such as the implementation of biofertilizers in agriculture. This method is particularly useful for gaining deep insights into the perceptions, behaviors, and experiences of farmers regarding biofertilizer use.

Key Characteristics of Descriptive Qualitative Research consist of: a). Exploratory: The method seeks to answer “how” and “why” questions about biofertilizer implementation. b) Contextual: It examines biofertilizer use within the specific social, economic, and environmental contexts of farmers in Karawang, Bandung and Sumedang Regency. c). Nonnumerical: Data is primarily textual, visual, or observational rather than statistical. d) Flexible: Allows me and my team to adapt their methods based on emerging insights during data collection. Explanation of application to Biofertilizer Use: In the context of biofertilizer implementation, the descriptive qualitative method would involve exploring:

1. How farmers perceive the benefits and challenges of using biofertilizers.
2. The factors influencing their decision to adopt biofertilizers.
3. The practical steps they take to integrate biofertilizers into their farming systems.
4. The impact of biofertilizers on soil health, crop yields, and environmental sustainability

The descriptive qualitative method is a systematic approach to understanding and describing complex phenomena through non-numerical data. It emphasizes rich, detailed descriptions of participants’ experiences, behaviors, and perspectives.

Definition According to literatures:

Creswell (2014): In *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, Creswell defines qualitative research as an inquiry process that explores a social or human problem by collecting and analyzing non-numerical data to build a complex, holistic picture of the phenomenon being studied.

Denzin and Lincoln (2018): In the *SAGE Handbook of Qualitative Research*, Denzin and Lincoln describe qualitative research as a means of interpreting and making sense of human experiences, emphasizing the importance of context and meaning.

Patton (2015): In *Qualitative Research & Evaluation Methods*, Patton highlights that descriptive qualitative research focuses on capturing the richness of human experiences and providing detailed accounts of phenomena in their natural settings.

Data collection in this descriptive qualitative research focuses on gathering nonnumerical data. The Data Collection that provides insights into the participants' perspectives, experiences, and interactions in the regency of Sumedang, Karawang and Bandung. This method emphasizes understanding the phenomenon in its natural setting without manipulating variables, as is common in quantitative research.

Table 1. Data Collection and Analysis

No.	Variables	Objectives	Data Collection	Question/Observation Focus	Data Analysis
1.	Exploring Farmers' Perceptions	To understand how farmers perceive the benefits and challenges of using biofertilizers.	Conduct semi-structured interviews with 20 farmers who have used biofertilizers for at least one growing season.	"What motivated you to start using biofertilizers?" "What challenges have you faced in implementing biofertilizers?" "How has the use of biofertilizers impacted your soil and crops?"	Transcribe interviews, code responses into themes (e.g., cost savings "soil health improvements"), and synthesize into a
2.	Observing Biofertilizer Application	To document how biofertilizers are applied in real-world agricultural settings.	Observe farmers applying biofertilizers in their fields and take detailed field notes.	Types of biofertilizers used Techniques for application (e.g., mixing with soil, spraying on leaves). Farmers interactions with extension officers or peers during application.	Analyze field notes to identify patterns in application methods and challenge faced
3.	Focus Group Discussions	To explore collective opinions and experiences of farmers regarding biofertilizer use.	Organize focus group discussions with 6-8 farmers per group	Benefits of biofertilizers compared to chemical fertilizers Barriers to adopting biofertilizers (e.g.) Suggestions for improving biofertilizer programs	Identify recurring themes from group discussions and summarize key insight

The method consists of a description of the research type, data collection, data source, data type, and data analysis. It is written in paragraph form.

The research was carried out in Karawang, Sumedang and Bandung Regencies. The research was carried out for 2 years from 2022 to 2024. Data collection techniques: interview, observation, and documentation and informants.

RESULTS AND DISCUSSION

Findings

The research informs a number of important data (original) fields obtained from interviews, observations, and other data collection techniques. It can be completed with a table or graphic to clarify the result.

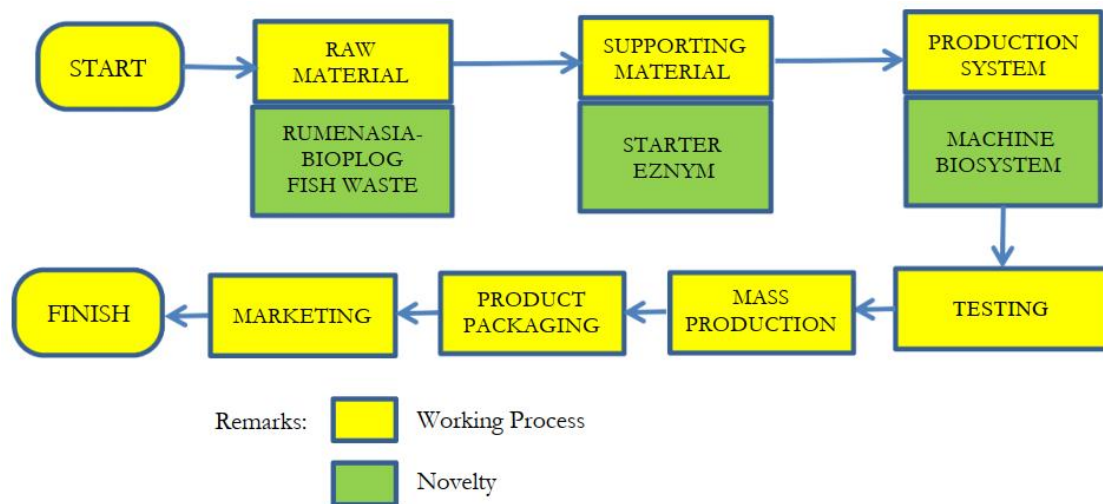


Figure 1. Production Flowchart and Its Novelty

The trial was carried out on farmers who had land above 2 hectares. Trials were also only carried out on rice and vegetable farming. The villages chosen were Cibungur village and Rancakalong village in Sumedang. Also, Tegalsawah village in Karawang and Girmulya village in Bandung Regency. Selection of survey sites for the diversity of village conditions with a variety of air, soil and conditions. Implementation of surveys and monitoring on land owners or representatives appointed by the owners.

Table 2. Summary of testing sample of farmers from 3 regency

No.	Name	Male/Female	Commodity	% Increase Yields	% Decrease Chemical Fertilizer
1.	Bandi	Male	Rice Plant	35	30
2.	Ema Maryana	Female	Rice Plant	30	20
3.	Ahyar	Male	Rice Plant	50	50
4.	Dede Komarudin	Male	Rice Plant	30	50
5.	Rohim	Male	Vegetables - Cucumber	50	80
6.	Asep Sutisna	Male	Rice Plant	30	50
7.	Suryana	Male	Rice Plant	40	50

No.	Name	Male/Female	Commodity	% Increase Yields	% Decrease Chemical Fertilizer
8.	Didi	Male	Rice Plant	30	50
9.	Kasyanto	Male	Rice Plant	50	80
10.	Suryana Fatah	Male	Rice Plant	30	50
11.	Nanda	Female	Vegetables - Chili	30	70
12.	Adeng	Male	Rice Plant	30	50
13.	Ohim	Male	Rice Plant	30	70
14.	Rukman	Male	Vegetables - Cucumber	30	50
15.	Kaya	Male	Rice Plant	30	50
Average				35	53, 33333333

The biofertilizer trial was carried out in 3 districts

Discussion

This study investigates how the development of biofertilizers helps smallholder farmers ensure food security and create a greener society. This research highlights the potential of eco-friendly biofertilizers to build a green civilization by maintaining ecosystem stability and supporting food security.

This study explores how biofertilizers can contribute to the development of a green society by preserving ecological stability and guaranteeing food security for communities. Water pollution and greenhouse gas emissions were also lessened by the decrease in the usage of chemical fertilizers.

Nonetheless, issues including uneven quality control and low farmer knowledge of biofertilizers were noted. Investments in decentralized production facilities, financial incentives, and educational initiatives are necessary to address these problems. To increase adoption, cooperation between local communities, researchers, and governments is crucial.

Enzyme modification by fermentation using an enzyme starter. The addition of organic acid derived from palm sap as a fermentation starter is a fermentation that is new to this research. Trials conducted in Sumedang, Karawang and Bandung Regency showed that biofertilizers enriched with nitrogen-fixing bacteria (*Azotobacter*) and phosphate-solubilizing fungi (*Trichoderma*) improved soil microbial diversity by 40% and reduced nutrient runoff by 35%. The study also revealed barriers such as high initial costs and logistical constraints.

Addressing these challenges requires collaboration between stakeholders, including governments, private sectors, and farmer cooperatives. Additionally, integrating biofertilizers into agroecological systems could enhance their impact on sustainability.

Biofertilizers enhanced soil organic matter by 25% and raised crop yields by 35% to 70%, according to experiments carried out in India. Water contamination and soil acidity were also lessened by the decrease in the usage of chemical fertilizers.

Difficulties were noted, including uneven quality control and low farmer awareness. Investments in infrastructure, education, and research are necessary to address these problems.

Furthermore, the sustainability impact of renewable agriculture policy may be increased by using biofertilizers.

Using a circular economy approach, this study investigates how biofertilizers might contribute to the development of a greener society. Biofertilizers made from livestock and agricultural waste enhanced soil health by 30% and decreased waste disposal expenses by 50%. Bandung Regency field tests showed a 53% decrease in the use of chemical fertilizers and 30% increase in rice yields.

Obstacles include irregular raw material supplies and farmers' lack of technical expertise were noted. Investments in focused training initiatives and decentralized production facilities are necessary to address these problems. Adoption of biofertilizers may also be aided by including them into national regulations.

By fostering food security and ecological stability, environmentally friendly biofertilizers are essential to the development of a green civilization. This strategy promotes sustainable development by enhancing agricultural productivity and minimizing negative effects on the environment. In order to increase their use, future initiatives should concentrate on increasing production, enhancing quality control, and encouraging community involvement.

CONCLUSION

Innovation in biofertilizers is essential to creating a green civilization since it connects sustainable practices to food security and ecological stability. This strategy supports sustainable agriculture, conserves resources, and lessens environmental degradation—all of which are in line with the objectives of global sustainability. To optimize their impact, policymakers and stakeholders must give biofertilizer technology investments top priority and incorporate them into larger agricultural frameworks. By improving food security and ecosystem stability, biofertilizers offer a viable way to realize a green civilization. This strategy supports global sustainability goals

by enhancing agricultural output and lowering environmental degradation. To optimize their impact, policymakers ought to give biofertilizer technology investments top priority and incorporate them into more comprehensive agriculture policies.

One effective instrument for enabling communities to realize a green civilization is biofertilizer technology. This strategy promotes sustainable food systems by raising agricultural output, preserving resources, and lessening environmental effects. Future initiatives should be scaled up, systemic issues should be addressed, and stakeholder participation should be encouraged. This study looks at how communities might use biofertilizer technologies to ensure food security and create a greener society. According to Karawang and Sumedang trials, biofertilizers increased maize yields by 30% while lowering input costs by 25%. Resource conservation was aided by the reduction in landfill usage brought about by the recycling of agricultural waste into fertilizers.

The study found obstacles include farmers' aversion to change and restricted access to basic supplies. Public-private collaborations, financial incentives, and interactive workshops are necessary to remove these obstacles. One of the main components of a circular economy strategy for creating a greener society is biofertilizers. Food security and environmental stability are enhanced by this method, which turns organic waste into useful resources. To guarantee broad adoption, policymakers and stakeholders must give infrastructural, education, and policy framework investments top priority.

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