JTUS, Vol. 03, No. 10 October 2025
E-ISSN: 2984-7435, P-ISSN: 2984-7427
DOI: https://doi.org/

Journal Transnational Universal Studies

Integrated Agriculture Bioferdom: Promoting Fertilizer Independence Through the Implementation of Biosulphur Fertilizer on Agricultural Land in Banggai Regency

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Abstract
Banggai Regency, Central Sulawesi, has considerable agricultural potential, particularly in Kayowa Village, Batui District, where nearly 70% of the land is farmland. However, farmers face major challenges such as the high cost of chemical fertilizers, uneven distribution, and dependence on these inputs, which threaten soil fertility and the environment. To overcome these issues, PT Pertamina EP Donggi Matindok Field (DMF) initiated the Integrated Agriculture Bioferdom: Promoting Fertilizer Independence Through the Implementation of Biosulphur Fertilizer on Agricultural Land in Banggai Regency program. This initiative uses biosulphur slurry by-products as raw material for organic fertilizers and is carried out collaboratively with village authorities, farmer groups, companies, and the regency government to ensure sustainability and community ownership. Program planning and evaluation followed the Logical Framework Approach (LFA), while research applied a descriptive-qualitative method with active participation. Data were gathered through focus group discussions, interviews, and field observations to identify challenges and design appropriate solutions. Results demonstrate strong outcomes: biosulphur emissions were reduced by 127.6 tons/year, agricultural productivity rose by up to 57%, production costs decreased by IDR 4,080,000/person/season, and the selling value of products increased by IDR 18,144,000/Ha/season. Additionally, 25 farmers were empowered, and reliance on chemical fertilizers was reduced through the adoption of local organic alternatives. The program thus supports Sustainable Development Goals, particularly Goal 1 (No Poverty), Goal 8 (Decent Work & Economic Growth), Goal 13 (Climate Action), and Goal 15 (Life on Land).

Keywords: Bioferdom, biosulphur slurry, sustainable agriculture, community empowerment, SDGs, agricultural productivity.

INTRODUCTION

Banggai Regency, located in Central Sulawesi Province, has abundant natural resources, with agriculture as one of the main pillars of the regional economy. In recent years, this sector has significantly contributed to the Gross Regional Domestic Product (GRDP), influencing both the local economy and community life (Robinson & al., 2024). From 2019 to 2023, the agricultural

sector contributed an average of 1.96% to the GRDP of Banggai Regency (Ali, Rendi Pranata, 2024). Although the agricultural sector dominates local income, resource potential has not been optimally managed, and the economic value generated has yet to be maximized (Suparman et al., 2025).

Kayowa Village, in Batui Subdistrict, Banggai Regency, has sustainable livelihood potential, particularly in agriculture and plantations. Based on regional data, 70% of Kayowa's area consists of agricultural land and forests. The community cultivates rice, corn, coconut, peanuts, cloves, cocoa, sugar palm, coffee, and nutmeg. Farmers, however, face challenges such as high costs of subsidized chemical fertilizers, limited access, and uneven distribution, which hinder timely supply. Heavy reliance on chemical fertilizers increases production costs, depletes long-term soil fertility, and harms the environment, threatening agricultural sustainability (Government, 2023; Kumar et al., 2022; Mitter et al., 2021; Mozumdar et al., 2025; Mustafa et al., 2022).

PT Pertamina EP Donggi Matindok Field (DMF), an upstream oil and gas company in Banggai Regency, produces biosulphur slurry as a by-product of its operations. The BSRU unit generates around 0.843 tons/day (238 tons/year) of non-B3 biosulphur waste, which, if not processed, contributes to Global Warming Potential (GWP) impacts. To address this, biosulphur is utilized as the basis for Bioferdom fertilizer. The Bioferdom program empowers farmers in West Toili and Batui Subdistricts through the application of biosulphur-based fertilizer. Developed via biotechnology, Bioferdom (Biosulphur Fertilizer Donggi Matindok) improves operational efficiency, reduces pollution, and strengthens company-community relations. By offering an affordable, environmentally friendly fertilizer, it enhances yields and supports agricultural sustainability in Banggai Regency (Widiarta & al., 2025).

The program aims to foster community economic independence through integrated, eco-friendly agricultural management, connecting the agriculture, livestock, and organic fertilizer sectors in a sustainable cycle. Previous studies demonstrate potential in sulfur-based fertilizer innovation. Indriani et al. (2024), for example, developed slow-release urea coated with sulfur from BSRU, showing prolonged nitrogen release and favorable economics. Similarly, research on biogas slurry highlights nutrient value but also risks of nitrogen loss through volatilization and leaching (Bonten et al., 2014). However, these studies face limitations, such as narrow field applications, weak methodological consistency, and insufficient integration with farmer needs.

This research therefore extends beyond technical feasibility, aiming to align industrial by-product management with sustainable, locally relevant fertilizer systems. Its goal is to deliver evidence-based recommendations and scalable models to reduce dependency on chemical fertilizers, improve yields, restore soils, and strengthen synergy between communities and companies in Banggai Regency.

RESEARCH METHOD

This study used a qualitative descriptive approach with active community participation to explore problems, design solutions, and evaluate the impact of the Integrated Agriculture Bioferdom program. Data collection was carried out through Focus Group Discussions involving

farmer groups, village governments, companies, and district governments to identify fertilizer problems, map needs, and agree on alternative solutions. In addition, research was conducted using demonstration plots to directly show farmers and related stakeholders the comparison between the growth of corn plants treated with biosulphur and those without biosulphur.

The demonstration plots were established on two experimental plots:

1. Plot without biosulphur
2. Plot with biosulphur

Corn variety: Bisi 18

Planting distance: 65 cm x 35 cm

Number of seeds: 2 seeds/planting hole

Land cultivation system: No-Till Farming (NTF)

RESULTS AND DISCUSSION

The implementation of the Integrated Agriculture Bioferdom Program involves relevant stakeholders from the private sector, government, and community. Parties involved include village governments, companies, farmer groups, and district governments. Through the involvement of relevant stakeholders, it is hoped that the community will feel they have control over the empowerment process. This involvement creates a sense of ownership, which is important for the sustainability of the empowerment program. In addition, the community is the party that best understands the conditions, needs, and potential that exist in their environment. Through the FGDs that were held, the community was able to directly convey the problems they faced and the solutions they considered relevant. In addition, this demoplot activity aimed to directly show farmers and related parties the comparison between the growth of corn plants given biosulphur and those not given biosulphur. Biosulphur is expected to increase the availability of nutrients, particularly sulfur and phosphorus, thereby supporting the vegetative and generative growth of plants. With this activity, it is hoped that the differences can be seen clearly and the benefits of using biosulphur in corn cultivation can be understood.

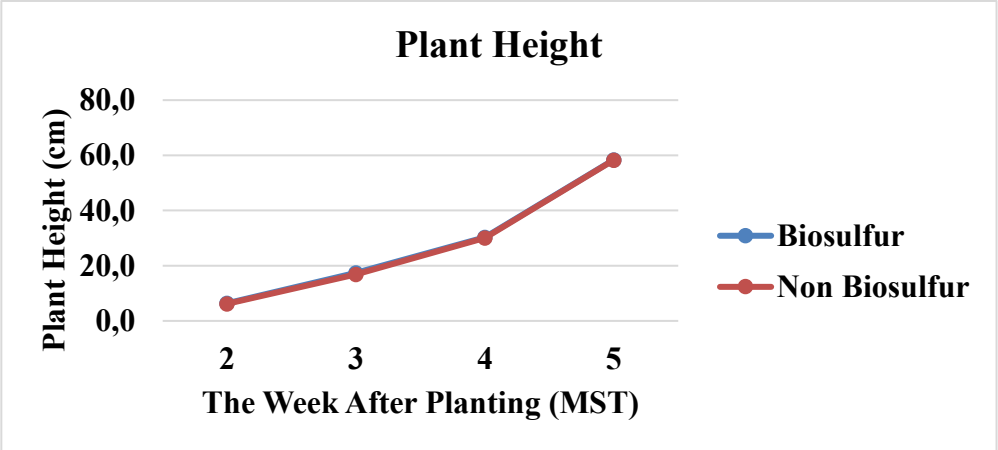

Figure 1. Biosulphur fertilizer graph

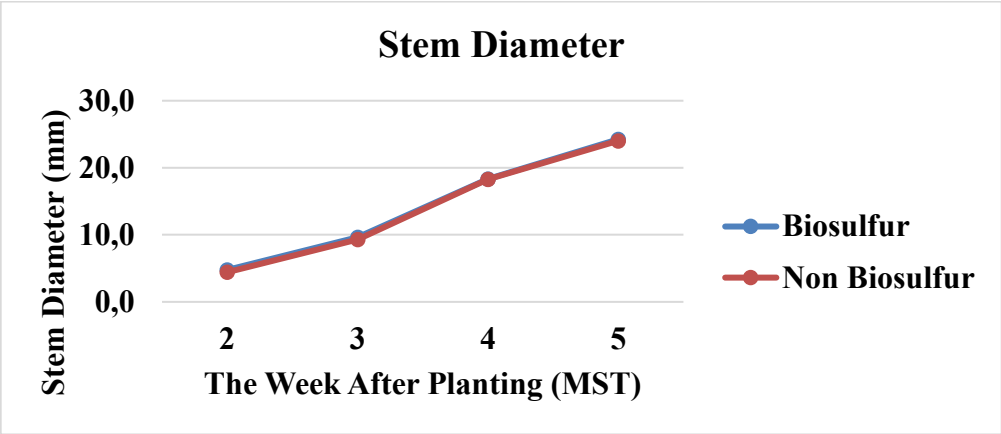

Figure 2. biosulphur fertilizer graph

The biosulphur fertilizer used in the Integrated Agriculture Bioferdom program plays an important role in enhancing the vegetative growth of corn plants, as reflected in increased plant height and stem diameter. Plant height is an indicator of the plant's ability to utilize nutrients to support vegetative growth, particularly the formation of leaves that play a role in the photosynthesis process. The taller the plants and the greater the leaf area formed, the greater the plant's ability to produce photosynthates, which ultimately contributes to seed formation and increased crop yields.

A larger stem diameter indicates strong and healthy tissue growth, which is important for supporting the plant canopy and transporting nutrients from the roots to the leaves and cobs. Biosulphur fertilizer improves the chemical and biological properties of the soil, increasing the availability of macro nutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as improving soil pH. These improvements promote stronger stem growth and a better root system, resulting in more optimal water and nutrient absorption. The combination of maximum plant height and larger stem diameter results in an increase in the number of cobs per plant, the number of rows of seeds per cob, and the weight of 1,000 seeds. This leads to a productivity increase of up to 57%, as achieved in the program implementation.

Figure 3. Processing Cow Manure as a Fertilizer Mixture

Figure 4. Corn Planting

Figure 5. Corn Farmland, Kayowa

Figure 6. Rice Harvesting Activities with Farmer Groups

Amidst the challenges of increasing environmentally friendly agricultural productivity, PT Pertamina EP Donggi Matindok Field presents an innovation through the Tudang Sipulung Field School in the Integrated Agriculture Bioferdom program. This field school collaborates with the Sirkular Center Indonesia Foundation, involving eight groups of Kayowa corn farmers. Tudang Sipulung is a Bugis community tradition of deliberation to reach a consensus in resolving an issue. This activity aims to improve farmers' knowledge and skills so they can manage their farms more effectively and sustainably. Farmers are directly involved in learning, discussing, and practicing integrated agricultural technologies, ranging from the processing of organic bioferdom fertilizer, land management, to marketing strategies for crop yields. This innovation serves as a bridge between local knowledge and modern technology (Chowdhury et al., 2020; (DJKI), 2024; Gerson et al., 2023; Hinckley & al., 2022; Holatko & al., 2023; Indriani et al., 2024).

The Tudang Sipulung tradition creates a sense of togetherness and ensures that knowledge transfer is practical and applicable. By involving beneficiaries in monitoring activities, farmers feel more involved and invested in the program. Active participation in monitoring gives them a

sense of responsibility for the program's success. Farmers who are directly involved have a deeper understanding of the conditions in the field and the challenges they face (Akila et al., 2022; Ali, 2024). By involving them in monitoring activities, the data collected is more accurate and relevant because farmers can provide more detailed information about crop development, problems encountered, and the effectiveness of the solutions implemented. In 2024, the method of producing biosulphur fertilizer from biosulphur waste from natural gas processing was patented by the Directorate General of Intellectual Property (DJKI) on April 3, 2024, with patent number IDS000008299. In addition to the method, the biosulphur fertilizer product from biosulphur waste from natural gas processing also obtained a patent from DJKI on June 13, 2024, with patent number IDS000008321.

CONCLUSION

The Integrated Agriculture Bioferdom program demonstrated substantial benefits across environmental, economic, and social dimensions by reducing biosulphur emissions by 127.6 tons/year in corn and rice farms, improving agricultural productivity by 57%, and enabling cost savings of IDR 4,080,000 per farmer per season alongside an increase in product value of IDR 18,144,000 per hectare per season. Beyond these economic gains, the program empowered 25 farmers in Kayowa Village, strengthened local fertilizer independence, and addressed fertilizer scarcity while promoting agricultural sustainability. Additionally, it contributed to the achievement of multiple Sustainable Development Goals, including No Poverty, Decent Work and Economic Growth, Climate Action, and Life on Land. Future research could further examine the long-term effects of biosulphur-based fertilizers on soil health, crop diversity, and scalability across different regions and farming systems.

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