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A REVIEW OF THE FUTURE OF BIOMASS-BASED FERTILIZER IN INDONESIA

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ABSTRACT **DOI No: 10.36713/epra13759** **Article DOI: https://doi.org/10.36713/epra13759**

Biomass-based fertilizers, derived from plant or animal matter, are a sustainable alternative to synthetic fertilizers, derived from renewable sources and encouraging sustainable agricultural practices. Biofertilizers, which contain beneficial microorganisms, increase nutrient absorption and promote plant growth. Biomass-based fertilizers offer numerous advantages over synthetic fertilizers, including organic matter and nutrient enrichment, reliance on renewable sources, soil health and conservation of biodiversity, and reducing agriculture's reliance on chemical inputs. By promoting sustainable agricultural practices and reducing reliance on synthetic fertilizers, Indonesia can achieve its agricultural development goals. However, Indonesia faces challenges in feedstock availability, collection, processing infrastructure, quality control, farmer education, and economic viability. Challenges include improving organic waste management, establishing processing infrastructure, ensuring consistent quality control and standardization, increasing farmer awareness, and addressing economic viability and market development. The future of biomass-based fertilizers in Indonesia holds great potential, with research and development efforts resulting in innovations in production processes, feedstock management, and nutrient formulation. Government support and policy, integration with circular economy practices, and export potential are also key future prospects.

KEYWORDS: ***Biomass; circular economy; fertilizer; sustainability; waste management***

1. INTRODUCTION

National Economic Growth and Swasembada Food Program is a government objective because it is a measure of the achievement of Indonesia's development. Indonesia is an agricultural nation with numerous natural resources and a large labor force, so the government gives the agricultural sector top priority. On the other hand, the perpetually increasing rate of population development results in an increase in food requirements, which must be met by intensifying and expanding the agricultural sector (Rozaki, 2021).

Fertilizer, as one of the supporting components in the agricultural sector, plays a crucial role in boosting farm activity in Indonesia, as producers are aware of its importance to agricultural production (Warr and Yusuf, 2014). As the government effectively implements the agricultural development program through food swaps, notably in terms of intensification efforts, the dependence on fertilizer increases.

The fertilizer industry, which plays a role in the intensification of agricultural output and in its

development, still faces a number of obstacles, according to data from the agricultural department indicating that the demand for fertilizers for agriculture continues to increase by approximately 1 million tons per year, with an average demand growth of 7% per year. The production capacity of the fertilizer plant, which is estimated to be 7,782,000 Tons per year, has not been optimized due to the inefficiency of the old plant's production as well as obstacles in the supply of its raw materials, namely oil and gas, as the agricultural department and the fertilizer producer association in 2015 only produced an average of 6,697,364 tons per year, according to their data (Zulkifli, 2019).

Organic fertilizers derived from plant or animal matter constitute biomass-based fertilizers. These fertilizers are a sustainable alternative to synthetic fertilizers because they are derived from renewable sources and encourage sustainable agricultural practices (Chew et al., 2019). They play a crucial role in enhancing soil fertility and crop yield, thereby providing alternatives to chemical inputs and reducing reliance on them.

Typically, biomass-based fertilizers are derived from diverse organic refuse materials, including agricultural residues, animal manure, food waste, and municipal solid waste (Kurniawan et al., 2023a; Kurniawan et al., 2022). Through decomposition or fermentation, these waste materials are processed and converted into nutrient-rich compost or biofertilizers (Chew et al., 2019; Owodunni et al., 2023).

Biofertilizers are an additional form of biomass-based fertilizer containing beneficial microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and mycorrhizal fungi. These microorganisms establish a symbiotic relationship with plants, which increases nutrient absorption and promotes plant growth (Kumar et al., 2022). Biofertilizers, which can be applied to seedlings, soil, or plant surfaces, offer a natural and sustainable method of nutrient management (Alnawajha et al., 2022).

2. PRODUCTION PROCESS OF BIOMASS-BASED FERTILIZER

The production of biomass-based fertilizer entails a number of critical stages, beginning with the procurement of organic materials and concluding with the packaging of the final product (Chew et al., 2019). Manufacturing procedure of biomass-based fertilizer include:

a) Collecting appropriate organic materials that can be used as fertilizer feedstock is the first stage in the fertilizer production process. This includes crop residues, animal manure, culinary refuse, agricultural detritus, and municipal solid waste. The organic materials should be chosen according to their nutrient content, availability, and composting or fermentation suitability.
b) Classification and pretreatment: Following the collection of organic materials, they may endure classification and pretreatment. This phase involves removing any non-organic substances, such as plastic or metal, from the refuse stream. Additionally, the materials may be pulverized or minced to facilitate the decomposition or fermentation process.
c) Composting or fermentation: Depending on the selected production method, the next stage is either composting or fermentation. If composting is used, organic materials are heaped or placed in windrows, and microorganisms present in the materials or added to the piles begin the decomposition process. Periodically, the mounds are turned to ensure adequate aeration, moisture, and temperature for optimal decomposition. Composting can take anywhere from a few weeks to a few months, depending on variables such as the type of material and environmental conditions.

If fermentation is used instead, the organic materials are placed in an anaerobic environment, such as a digester or bioreactor, where specific microorganisms decompose the materials in the absence of oxygen. This process can generate biogas, which can be utilized as a source of energy (Harirchi et al., 2022).

After the decomposition or fermentation process, the resultant material goes through a phase of maturation or curing. This permits additional decomposition, stabilization, and the maturation of a nutrient-rich product. During this phase, the temperature of the material progressively decreases, and the compost or fermented material is rotated or aerated periodically to ensure uniform decomposition (Mahapatra et al., 2022).

After the compost or fermented material has reached maturity, it is screened to remove any remaining large particles or contaminants and then blended. The inspected material is then mixed to ensure that the final product's nutrient content is uniform (Giagnoni et al., 2020). Blending may involve combining distinct quantities of compost or adding organic amendments to modify the nutrient levels.

The amalgamated substance is subjected to testing to determine its nutrient content, pH levels, and other quality parameters. This phase ensures that the final product satisfies the specified requirements and regulatory requirements. If necessary, adjustments can be made to attain the desired nutrient balance by adding supplements or amendments.

The final stage is packaging the biomass-based fertilizer into suitable containers, such as sacks or bulk

containers, for distribution and sale. Packaging assures the integrity and expiration life of the product. The packaged fertilizer is then distributed to agricultural retailers or applied directly by farmers to their fields.

It is essential to note that the production process can vary depending on the type and quantity of biomass-based fertilizer being manufactured. Large-scale operations may employ specialized equipment and mechanization, whereas smaller-scale operations may rely on manual labor and less sophisticated equipment (Ahmad et al., 2022; Huo et al., 2022). The production of biomass-based fertilizers adheres to the fundamental principles of procuring organic materials, decomposition or fermentation, maturation, testing, and packaging.

3. BENEFIT OF BIOMASS-BASED FERTILIZER

Fertilizers derived from biomass have numerous advantages over synthetic fertilizers and contribute to sustainable agricultural practices (Chew et al., 2019). Some important advantages of fertilizers derived from biomass are:

a) Organic Matter and Nutrient Enrichment: Rich in organic matter, biomass-based fertilizers enhance soil structure, water-holding capacity, and nutrient retention. They enrich the soil with humus, enhancing its fertility and fostering the development of beneficial soil microorganisms. In addition, biomass-based fertilizers contain a variety of essential nutrients, such as nitrogen, phosphorus, potassium, and micronutrients, which are slowly released and provide a balanced nutrient supply to plants.
b) Biomass-based fertilizers are derived from renewable sources, such as crop residues, animal manure, and culinary refuse, thereby decreasing reliance on nonrenewable resources. By diverting organic waste from landfills through recycling, greenhouse gas emissions and the environmental impact of waste disposal are reduced. In addition, fertilizers derived from biomass contribute to carbon sequestration in the soil, which helps mitigate climate change by sequestering carbon dioxide.
c) Soil Health and Conservation of Biodiversity: Utilizing fertilizers derived from biomass improves soil health by enhancing microbial activity, increasing soil organic carbon levels, and enhancing nutrient cycling. This results in enhanced soil fertility, enhanced water infiltration, and decreased soil erosion. In addition to promoting sustainable agricultural practices, biomass-based fertilizers contribute to the conservation of biodiversity by reducing the use of synthetic fertilizers, which can have negative effects on soil organisms, beneficial invertebrates, and other organisms in the ecosystem (Kurniawan et al., 2021a).
d) Biomass-based fertilizers provide an alternative to synthetic fertilizers, thereby reducing agriculture's reliance on chemical inputs. Synthetic fertilizers can cause nutrient imbalances, soil acidification, and runoff-related water contamination. Farmers can reduce their reliance on synthetic fertilizers and mitigate potential negative effects on water quality and aquatic ecosystems by using fertilizers derived from biomass.
e) Long-Term Soil Fertility: Unlike synthetic fertilizers, which provide an immediate nutrient boost but have limited long-term benefits, biomass-based fertilizers contribute to the long-term fertility of the soil. They support sustainable and resilient agricultural systems by enhancing soil structure, organic matter content, and nutrient cycling. Continuous use of biomass-based fertilizers can assist in building and sustaining soil fertility over time, reducing the need for frequent and extensive fertilizer applications.
f) Safe and Sustainable Food Production: Biomass-based fertilizers are generally safer to handle and apply than synthetic fertilizers because they do not contain harmful compounds that could pose dangers to human health and the environment. They contribute to sustainable food production by fostering nutrient-rich soil, increasing crop productivity, and reducing the environmental impacts of conventional agricultural methods.

It is important to note that the efficacy of biomass-based fertilizers can vary contingent on factors such as feedstock quality, processing methods, and application techniques. However, when used appropriately, biomass-based fertilizers can support sustainable agriculture, soil health, and environmental stewardship by providing numerous benefits (Krasilnikov et al., 2022).

4. CHALLENGES AND FUTURE OF BIOMASS-BASED FERTILIZER IN INDONESIA

Indonesia, as a major agricultural country, faces several challenges and holds significant potential for the development and future of biomass-based fertilizers (Yana et al., 2022). Some of the challenges and prospects associated with biomass-based fertilizer in Indonesia are as follows:

a. Feedstock Availability and Collection: One of the primary challenges is the consistent availability and collection of suitable organic feedstock for biomass-based fertilizer production. While Indonesia has abundant agricultural and forestry resources, the collection and management of organic waste materials, such as crop residues and animal manure, need to be improved. Developing efficient collection systems and promoting proper waste management practices are crucial to ensure

a steady supply of feedstock for biomass-based fertilizer production.

b. Processing Infrastructure and Technology: The establishment of processing infrastructure and technology for biomass-based fertilizer production is another challenge. This includes composting facilities, bioreactors, and equipment for large-scale production. Investment in appropriate technologies and the dissemination of knowledge and expertise are essential to enable efficient and cost-effective production processes.

c. Quality Control and Standardization: Ensuring consistent quality and standardization of biomass-based fertilizers is crucial for their acceptance and effectiveness. Establishing quality control measures, testing protocols, and certification systems will help build trust among farmers and consumers. Collaboration between industry stakeholders, research institutions, and government bodies can play a significant role in developing and implementing quality standards for biomass-based fertilizers (Kurniawan et al., 2022b; Kurniawan et al., 2021b).

b) Farmer Education and Adoption: Increasing awareness and providing education to farmers about the benefits and proper use of biomass-based fertilizers is essential for their widespread adoption. Training programs, demonstration plots, and knowledge-sharing platforms can help farmers understand the advantages of organic fertilizers and provide guidance on application techniques. Government support and incentives can encourage farmers to transition from synthetic fertilizers to biomass-based alternatives.

c) Economic Viability and Market Development: Biomass-based fertilizers need to be economically viable and competitive with synthetic fertilizers to attract widespread adoption. This involves addressing cost factors related to feedstock collection, processing, and distribution. Developing a robust market for biomass-based fertilizers and establishing pricing mechanisms that consider their environmental benefits can incentivize farmers to make the switch.

The future of biomass-based fertilizers in Indonesia holds great potential. The country's rich agricultural resources and commitment to sustainable practices create opportunities for the growth of biomass-based fertilizer production (Kurniawan et al., 2021c). Some key future prospects include:

a) Research and Development: Continued research and development efforts can lead to innovations in biomass-based fertilizer production processes, feedstock management, and nutrient formulation. This can result in improved product quality, efficiency, and nutrient availability, making biomass-based fertilizers more attractive to farmers.

b) Government Support and Policy: Supportive policies, such as incentives, subsidies, and regulations promoting the use of biomass-based fertilizers, can stimulate their adoption. Government initiatives that prioritize sustainable agriculture practices, waste management, and environmental protection can provide the necessary framework for the growth of biomass-based fertilizer production.

c) Integration with Circular Economy Practices: Biomass-based fertilizers align with the principles of the circular economy by utilizing organic waste materials as valuable resources. Integrating biomass-based fertilizer production within a larger circular economy framework, including waste management, renewable energy, and resource recovery, can create synergistic benefits and contribute to a more sustainable and efficient agricultural system (Kurniawan et al., 2023b).

d) Export Potential: With the growing global demand for sustainable and organic agricultural products, Indonesia has the potential to become a significant exporter of biomass-based fertilizers. Developing export markets and promoting the country's biomass-based fertilizer industry internationally can drive economic growth and contribute to the country's sustainable development goals.

Addressing the challenges and harnessing the opportunities for biomass-based fertilizer in Indonesia requires collaboration among government, private sector, research institutions, and farmers (Kurniawan et al., 2020). By overcoming these challenges and seizing the opportunities, Indonesia can move towards a more sustainable and environmentally friendly agricultural sector, reducing reliance on synthetic fertilizers and promoting soil health and food security.

5. CONCLUSION

Biomass-based fertilizers, derived from plant or animal matter, offer a sustainable alternative to synthetic fertilizers, promoting sustainable agricultural practices. These fertilizers increase nutrient absorption and promote plant growth, relying on renewable sources, soil health, biodiversity conservation, and reducing chemical inputs. Indonesia faces challenges in feedstock availability, collection, processing infrastructure, quality control, farmer education, and economic viability. Furthermore, research and development efforts can lead to innovations in production processes, feedstock management, and nutrient formulation.

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