Assessing the Quality of Organic Fertilizer Products Made from Cow Dung in Wonogiri Regency, Indonesia

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Abstract

Kebonagung Sub-district, Sidoharjo District, Wonogiri Regency is the Wonoagung Wonogiri Organic Farming Association (PPOWW) location. Mitra is an organization engaged in organic rice and cattle cultivation. The conversion of bovine dung into organic fertilizer, particularly liquid fertilizer containing biological agents, is one of the waste elimination strategies employed to prevent environmental contamination. The nutrient content of organic fertilizer material sources varies. Organic fertilizer of high quality conforms to the Standard for Organic Fertilizers established by the Ministry of Agriculture of the Republic of Indonesia. Only some producers are aware of the standard quality requirements for organic fertilizer. It is necessary to analyze the nutrient content of organic fertilizer products to determine whether the quality of organic fertilizer is excellent. A preliminary survey of partner conditions, preparation of materials (organic fertilizer), and analysis of fertilizer content are among the activities performed. The C/N ratio of organic fertilizer is 8.41, and its pH is 7.6. The analysis results indicate that the Wonoagung Wonogiri Organic Agriculture Association's organic fertilizer products meet the liquid organic fertilizer quality standards. This condition demonstrates that the raw materials used in organic fertilizer production are of high quality and that the appropriate procedures have been followed. Adding biological agents to the production of organic fertilizer can enhance the quality of the finished product.

Keywords: *biological agency, organic matter, quality control, quality of fertilizer*

1. INTRODUCTION

The Wonoagung Wonogiri Organic Farming Association (PPOWW) is located in Kebonagung Hamlet, Kebonagung Village, Sidoharjo District, Wonogiri Regency, where it engages in organic farming and cultivates rice, dragon fruit, pineapple, and pepper. In addition to maintaining a livestock farm, cow dung has not been optimally utilized. Using cow dung residue optimally can lead to environmental pollution (Iwuozor et al., 2022). Creating organic fertilizer from bovine dung is one way to reduce environmental pollution (Tallou et al., 2020). Produced by the PPOWW, sufficient dung can minimize production expenses. The availability of adequate dung will facilitate the cultivation of PPOWW-developed products. Mujiyo et al. (2018) cite efforts to produce organic fertilizer as a component of livestock-plant integration in the context of community empowerment through enterprises in the agricultural sector.

Utilizing cow dung to produce organic fertilizer is a concrete example of implementing waste elimination in cattle farming (Malolan et al., 2021). Using cow dung as a constituent in making organic fertilizer with biological agents will yield organic fertilizer of comparable quality to that obtained from commercial sources (Romadhon et al., 2023). However, Dewi et al. (2023) state that most producers disregard standard guidelines for the quality of organic fertilizer. Analyzing the nutrient content of organic fertilizer products as part of the quality control process (Mujiyo et al., 2022) is necessary to determine whether the quality of organic fertilizer meets industry standards (Dewi et al., 2023). Organic fertilizers containing acceptable biological agents will enhance soil quality and promote soil productivity (Dewi et al., 2022).

The nutrient content of organic fertilizer products can be used to evaluate their quality (Herawati et al., 2021). The nutrient content is determined through laboratory analysis. The analysis procedure refers to Eviati and Sulaeman's (2009) method, include the parameters are water content, total nitrogen (N Total), phosphorus (P), potassium, carbon (C), carbon per nitrogen ratio (C/N ratio), and pH. The results of the organic fertilizer analysis are compared to the organic fertilizer standards established by the Indonesian Ministry of Agriculture (2011). The physical composition of organic fertilizer is related to its water content. Organic (solid) fertilizer with a high water content will solidify the substance (Istiqomah et al., 2023). High water content impacts the availability of soil nutrients and oxygen to the soil (Romadhon and Aziz, 2022). Especially for those beneficial microorganisms in organic fertilizer (Dewi et al., 2023).

Nitrogen, phosphorus, and potassium are essential macroelements that influence soil fertility and plant growth, so their availability must be considered (Sanyal et al., 2015). Concerning the ability to introduce nutrients to the soil, it is crucial to know the C/N ratio. The ratio of carbon to nitrogen in fertilizer affects the rate of decomposition and mineralization of organic matter (Mujiyo et al., 2017). A low C/N ratio indicates that organic fertilizer decomposes into plant-available nutrients more rapidly (Liu et al., 2018). A C/N ratio below 20 will accelerate the decomposition of organic fertilizer (Truong and Marschner, 2018), making nutrients more readily available. The degree of acidity (pH) of the constituents is another crucial factor. The rate at which organic fertilizer decomposes is affected by pH. The degree of acidity (pH) will impact the activity of microorganisms during the decomposition process and the mineralization of nutrient content in organic fertilizer. The pH influences nutrient solubility (Mujiyo et al., 2021).

Organically grown agricultural products typically have higher prices because they are grown without chemical fertilizers and pesticides (Irianto et al., 2023). Standard-compliant bio-based organic fertilizer will increase soil quality, boost soil productivity, and enhance the quality of agricultural products (Kurniawan et al., 2023). Improving quality will also increase the competitiveness of agricultural products on the market, enabling farmers' income (Abate and Yohannes, 2021).

With increasing knowledge, it is anticipated that farmers will be able to independently perform quality control of organic fertilizer products to preserve fertilizer quality, soil quality, and agricultural product quality. This partnership will aid producers in accessing information regarding organic fertilizer quality testing. Through this endeavor, it is anticipated that partners will be able to produce high-quality fertilizer that adheres to industry standards.

Testing the quality of organic fertilizer needs to be carried out to analyze the levels of nutrients in organic fertilizer by the standard organic fertilizer standards of the Indonesian Ministry of Agriculture (2011). With increased knowledge, farmers can independently control the quality of organic fertilizer products to maintain fertilizer, soil, and agricultural product quality (Yu et al., 2023). It is hoped that quality organic fertilizer can improve soil quality to support sustainable agriculture (Brempong and Addo-Danso, 2022). The PPOWW partners' organic fertilizer quality analysis results can be used to evaluate the organic fertilizer produced. Partners can make fertilizer by local standards and land characteristics in the long term. The advantage of PPOWW partners is that they can have their organic fertilizer with high quality and by regional land characteristics so that the results obtained are optimal.

2. MATERIAL AND METHODS

Research activities were carried out in February – September 2023. Organic fertilizer production was done in Kebonagung Sub-district, Sidoharjo District, Wonogiri Regency, the PPOWW location. Organic fertilizer content was analyzed at the Soil Science Study Program Laboratory, Faculty of Agriculture, Universitas Sebelas Maret. This research is a descriptive laboratory research based on assessing the quality of nutrients in fertilizer base on organic materials, which use cow dung. This research was carried out by assisting PPOWW-assisted farmers in processing cow dung into organic fertilizer. This product will be in the form of organic fertilizer, which can meet the minimum technical requirements based on the Decree of the Minister of Agriculture of the Republic of Indonesia (RI) Number 261/KPTS/SR.310/M/4/2019. Details of research activities are listed in Fig 1. The stages of this research consist of: (1) Pre-Survey; (2) Survey; (3) Post Survey. Pre-survey is the initial survey, namely conducting visits to farmer group partners and coordinating cooperation regarding sampling times and

locations. The survey stage is taking fertilizer samples, and the post-survey is carrying out sample preparation and analysis of fertilizer samples in a chemical laboratory.

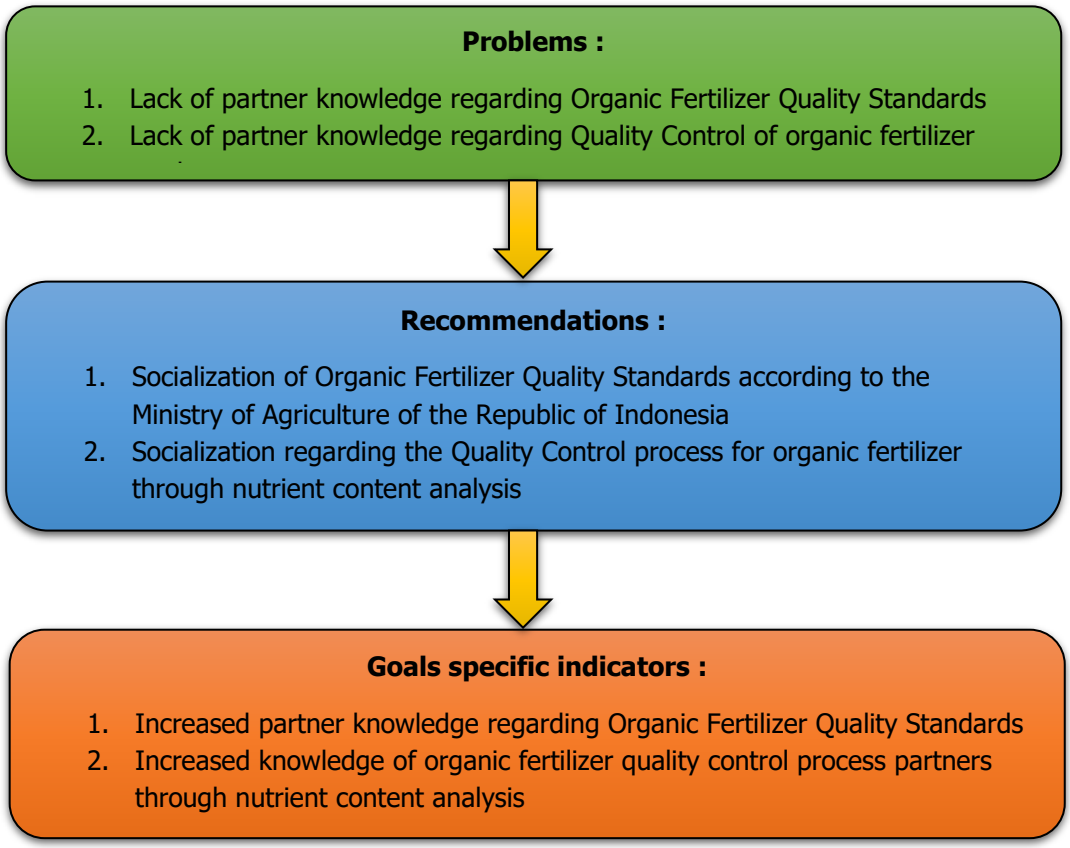

Figure 1. Flowchart of problems faced by partners and recommended solutions

2.1 The Initial Survey

The initial survey was done to determine partner knowledge, environmental conditions, and licensing processes. The initial coordination aims to explain the main objective of the Quality Control of Organic Fertilizer Products service activities. This activity also describes the actions of partners and determines their implementation schedule. PPOWW partners make organic fertilizer using cow manure as the main ingredient mixed with organic materials in the local area, such as banana fronds, coconut fronds, dry leaves, and fruit remains. The percentage of organic materials used needs to be measured precisely and consistently because, so far, they use locally available organic materials.

(a)

(b)

Figure 2. Organic paddy field owned by PPOWW

2.2 Survey Preparation

The materials tested are solid and liquid organic fertilizers produced by partners. Sufficient solid organic fertilizer is taken (sampled) to analyze its nutrient content. The samples taken consisted of 3 replications representing all organic fertilizer products. The sample tested was liquid organic fertilizer produced by partners. Sample collection was carried out at the PPOWW Partner organic fertilizer production house, totaling three samples representing all organic fertilizer products.

Figure 3. PPOWW's cattle farm

2.3 Laboratory Analysis to Determine The Quality of Organic Fertilizer

The analysis procedure refers to the procedure from Eviati and Sulaeman (2009) with analysis parameters of total N, P_2O_5, K_2O, Organic-C, C/N ratio, and pH. The results of the organic fertilizer analysis are then assessed using the standard standards for organic fertilizer by the Indonesian Ministry of Agriculture (2011) and the Decree of the Minister of Agriculture of the Republic of Indonesia (RI) Number 261/KPTS/SR.310/M/4/2019 (Table 1).

Table 1. Standard Standards for Solid and Liquid Organic Fertilizers

Parameters	Methods	Standards	
		Solid	Liquid
N total (%)	Kjeldhal	N total + P2O5 + K2O 4% minimum	N total + P2O5 + K2O 2-6 %
P_2O_5 (%)	Extraction HNO_3 and $HClO_4$	N total + P2O5 + K2O 4% minimum	N total + P2O5 + K2O 2-6 %
K_2O (%)	Extraction HNO_3 and $HClO_4$	N total + P2O5 + K2O 4% minimum	N total + P2O5 + K2O 2-6 %
C-organik (%)	Walkley and Black	15% minimum	6% minimum
C/N ratio	Comparison	15 – 25	-
pH	Electrode glass	4 – 9	4 – 9

Source: Indonesian Ministry of Agriculture (2011) and Indonesian Ministry of Agriculture (2019)

The analysis results of liquid organic fertilizer samples were adjusted to the liquid organic fertilizer standard table based on the Minister of Agriculture's regulations (Table 1). The main elements analyzed are total N, P_2O_5, K_2O, Organic-C, C/N ratio, and pH. Features that meet the standards have a range of values in Table 1. If the laboratory analysis results are still below the average, evaluation, and improvements, need to be carried out to increase compliance with the standards.

3. RESULTS AND DISCUSSION

Organic farming is a potential alternative production system where organic fertilizer guarantees safe agricultural production without harming humans, land, and the environment because of its organic content (Gamage et al., 2023). Organic fertilizer is an essential element in developing organic and sustainable agriculture. Organic fertilizer protects soil health, increases nutrient content, and encourages the activity of soil microorganisms. Organic fertilizer can also improve soil structure and increase soil fertility and water-holding capacity (Yang et al., 2023). Applying organic fertilizer as a soil amendment can restore soil fertility and reduce the use of chemical fertilizers and pesticides to create more efficient agricultural practices (Garbowski et al., 2023).

The PPOWW is a community of several farmer groups engaged in organic farming. The commodities produced consist of organic rice (Fig 2). The supply of organic fertilizer is obtained from cattle farms managed by PPOWW (Fig 3). Mitra has implemented livestock-crop integration through businesses in the agricultural sector. The service activity aims to provide information regarding standard organic fertilizer standards so that the fertilizer quality is maintained to produce better agricultural products.

According to Indonesia Ministry of Agriculture Regulation, number *70/Permentan/SR.140/10/2011* concerning Organic Fertilizers, Biological Fertilizers, and Soil Improvers, organic fertilizers produced and distributed for agricultural activities must meet standard standards. Standard standards or quality standards are the parameters set by the National Standardization Agency in the form of SNI or set by the Indonesian Ministry of Agriculture in the form of Minimum Technical Requirements (Indonesian Ministry of Agriculture, 2011). Standard organic fertilizer standard means the composition and content of organic fertilizer determined by the National Standardization Agency in the form of SNI or the Indonesian Ministry of Agriculture in the form of Minimum Technical Requirements (Indonesian Ministry of Agriculture, 2011).

The PPOWW has partner farmers who manage organic rice fields in several sub-districts in the Wonogiri Regency. Most of these farmers have cattle whose manure has not been utilized optimally. PPOWW and the Research Group are jointly assisting partner farmers in Jatipurno District in processing cow dung into organic fertilizer in both solid and liquid form to meet the minimum technical requirements based on Decree of the Minister of Agriculture of the Republic of Indonesia number *261/KPTS/SR.310/M/4/ 2019* (Indonesian Ministry of Agriculture, 2019). This research activity evaluates the quality of liquid organic fertilizer by analyzing samples in the Soil Science Study Program, Faculty of Agriculture, UNS laboratory. The analysis showed that the organic C content parameters were 22.46%, total N 2.67%, P2O5 1.34%, K2O 1.86%, and pH 7.6. All parameters meet the quality standard requirements for liquid organic fertilizer. The recommendation to ensure that the quality of liquid

organic fertilizer is maintained is by adding fermented solutions of organic materials rich in P and K, such as household waste in the form of leftover vegetables and fruit. Another effort that can be made is by adding an inoculum of P-fixing microbialsuch as bacteria (genus Pseudomonas, Bacillus, and Escherichia) and fungi (genus Aspergillus, Penicillium, and Humicola). Inoculating phosphate solubilizing bacteria as a biological agent into organic fertilizer has been proven to reduce the use of chemical fertilizers and provides the advantages of economic strategies related to agricultural production activities (Bargaz et al., 2021; Zeng et al., 2022). The mechanism of the usefulness of phosphate solubilizing bacteria and their incubation in organic fertilizer was explained in general, as mentioned in Fig 4.

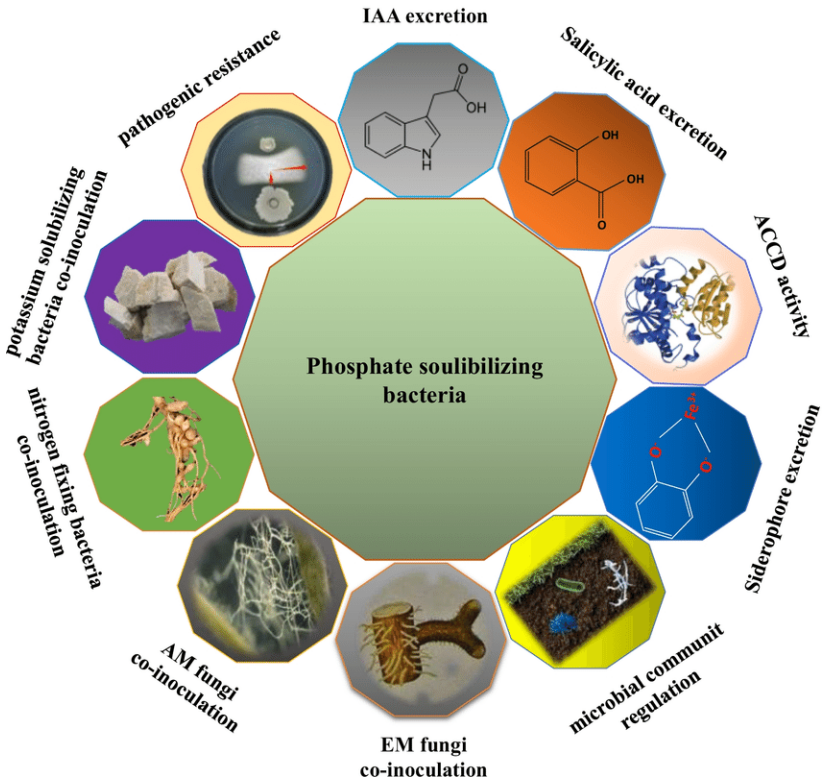

Figure 4. Phosphate solubilizing bacteria and their incubation mechanisms in organic fertilizer (Zeng et al., 2022)

The total N + P2O5 + K2O content of liquid organic fertilizer is 5.87%, which meets the standards. Organic fertilizers from cow dung contain large amounts of nitrogen, phosphorus, and potassium (Chen et al., 2023). Nitrogen, phosphorus, and potassium are essential macronutrients that many plants need. Fertilizers that contain high levels of macronutrients can provide sufficient nutrients for plant growth. The Organic-C content in organic fertilizer is 22.46%, which meets standards. Fertilizer provides carbon and other nutrients for plants. Organic material from manure forms a stable humus fraction through humification and is responsible for the nutrient cycle in the soil (Guo et al., 2022). Animal waste steadily releases macro and micronutrients into the soil during the growing period (Kabasiita et al., 2022). Manure can balance soil organic carbon (Yan et al., 2022). Soil organic carbon can balance nutrient availability, increase soil aeration, increase water infiltration rate, and the soil's ability to store water (Bhattacharyya et al., 2022). Soil organic carbon is essential in improving soil health and sustainability in agriculture (Pambayun et al., 2023).

The C/N ratio in solid organic fertilizer is 8.41, which meets the standards (Table 2). The C/N ratio is related to the decomposition and mineralization process, where the lower the value, the faster the decomposition process of fertilizer into nutrients in the soil. The initial C/N ratio in cow manure is relatively higher, reflecting the cellulose-rich material. The C/N ratio then gradually decreases during composting, indicating a decomposition process (He et al., 2023). A C/N ratio lower than 25 indicates that the compost is mature (Chan et al., 2016). Environmental factors such as C/N ratio, temperature,

humidity, and pH change during the composting process can influence microbes' community and metabolic activity (Wang et al., 2018). C/N ratio and pH also impact microbial community dynamics (Yu et al., 2015, Wang et al., 2015).

Table 2. Liquid organic fertilizer content

Analysis	Result	Annotation
Total N (%)	2.67	Meet the quality aspects of fertilizer
P_2O_5 (%)	1.34	Meet the quality aspects of fertilizer
K_2O (%)	1.86	Meet the quality aspects of fertilizer
Organic C (%)	22.46	Meet the quality aspects of fertilizer
Organic matter (%)	38.72	Meet the quality aspects of fertilizer
C/N ratio	8.41	Meet the quality aspects of fertilizer
pH	7.6	Meet the quality aspects of fertilizer

The pH value of solid organic fertilizer is 7.6, which meets the standards. The pH value will increase during the composting process related to increasing temperature and decomposition of nitrogen-containing organic materials by microorganisms, which produce large amounts of ammonium-nitrogen to raise the pH level (Yang et al., 2019). The final pH value of compost is widely used to evaluate the quality of compost products because it affects soil pH and nutrient bioavailability for plants (Wang et al., 2015). The research results have been conveyed to stakeholders and farmers around the partner areas. Description of the fertilizer quality analysis results is also conveyed directly to organic fertilizer producers as a PPOWW's.

4. CONCLUSIONS

The organic fertilizer products produced by the Wonoagung Wonogiri Organic Agriculture Association meet the standard as well as standards for organic fertilizer by Ministry of Agriculture. The chemical properties of this organic fertilizer derived from cow dung are classified as good, including neutral pH, total N + P2O5 + K2O 5.87 %, C organic is 22.46%, organic matter 38.72%, and C/N ratio 8.41%. The raw materials for cow dung are of good quality, and the manufacturing process is good, creating liquid organic fertilizer products of good quality and meeting standards. The use of biological agents helps to improve the quality of organic fertilizer. The findings of our research have been given to farmer groups and local stakeholder partners so that the production process of organic fertilizer can be evaluated and improved in the future. Farmers and stakeholders embrace this type of collaborative study and hope that it will be sustainable. An assessment of the fertility and quality of soil on land, given organic fertilizer, needs to be carried out to determine the effect of fertilizer on the production of cultivated plants.

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