Research Article

Evaluation of NPK Fertilizer Content Derived from Wild Plant Diversity

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Abstract: This research has the background of understanding the diversity of wild plants that can produce organic NPK fertilizer that can be utilized by the community. The purpose of this research is to produce NPK fertilizer from wild plants and to determine the nitrogen, phosphate, and potassium content in the organic fertilizer derived from wild plants. The type of this research is an experiment to produce NPK fertilizer, which is then tested in the laboratory to determine the nitrogen, phosphate, and potassium content in the produced fertilizer. The results of the research on the process of making NPK fertilizer from wild plants using several wild plants divided into two criteria: the main materials consist of the leaves of the Lamtoro plant, the Putri Malu plant, the Kipahit plant, the Gamal leaves, and Bamboo leaves. The additional materials include Kelor leaves, Banana pseudostems, Coconut coir, and to accelerate the fermentation process, the researchers used supporting materials such as goat dung, EM4 solution, Nitrobacter bacterial culture solution, and rice wash water. from the NPK content test on the organic fertilizer produced at the Ministry of Agriculture BSIP (Agricultural Instrument Standardization Agency, Soil and Fertilizer Instrument Testing Center, Jl. Tentara Pelajar Jakarta-Bogor), it was found that: a. Sample P3 (ratio of main ingredients to additives 1:2) is the sample with the highest Nitrogen content, which is 2.42%. b. Sample P1 (ratio of main ingredients to additives 1:1) is the sample with the highest Phosphate content, which is 0.94%. c. Sample P2 (the ratio of main ingredients to additives 2:1) is the sample with the highest potassium content, which is 3.36%. d. Meanwhile, C1, which is a liquid fertilizer with a 1:1 ratio of main ingredients to additives is the sample with the lowest NPK content (0.28, 0.06, and 0.24%).

Keywords: Fermentation, Growth, NPK Fertilizer, Phosphate, Wild Plants

Introduction

Biodiversity is a term often used to describe the various types of living organisms found in the world, such as Archaeacteria, Eubacteria, Protista, Fungi, Plantae and Animalia (Mokodompit *et al.*, 2022). According to another opinion, biodiversity is everything that constitutes the diversity of biological resources, both in terms of species and the wealth of genetic resources in the world (Nurhuda *et al.*, 2022). Sriastuti explains that the diversity of plants and animals must be protected by the state because they provide many benefits that humans can derive to meet their needs (Sriastuti *et al.*, 2018). Bengkulu is one of the provinces located on the island of Sumatra, which contains the Bukit Barisan Selatan National Park. This area has varied topographic conditions, including brackish vegetation, swamp vegetation, coastal vegetation, bamboo forest vegetation, plantation forest vegetation and tropical rainforest vegetation, resulting in abundant plant diversity (Khosi'in & Ni'am, 2022).

According to Khosi'in and Ni'am (2022) Indonesia ranks second in terrestrial biodiversity after Brazil.

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However, if the terrestrial biodiversity is combined with marine biodiversity, Indonesia becomes the country with the highest biodiversity in the world. In 2017, Indonesia had 31,750 types of plants that had been identified and 25,000 of them were flowering plants (Patti *et al.*, 2018). Furthermore, Susanti and Zuhud (2019). stated that Indonesia has around 15,000 plants with potential medicinal properties, but only about 7,000 species are used as raw materials for medicine.

One of the diversities of biological resources is the diversity of plants, which is divided into several parts such as woody plants, shrubs, grasses and others (Hendrayana *et al.*, 2022). The term flora is defined as all types of plants that grow in a certain area. If the term flora is associated with the life-form (habitus) of plants, various terms will emerge such as tree flora (flora in the form of trees), shrub flora, grass flora, etc. If the term flora is associated with place names, terms such as Flora Jawa, Flora Gunung Halimun and so on will emerge. According to the environmental conditions, the flora in a certain place can consist of various species, each of which can comprise diverse genetic variations living in several types of habitats (living places). Therefore, the term "flora diversity" emerged, encompassing the meaning of species diversity, genetic diversity within species and habitat diversity where these flora species grow (Kusmana & Hikmat, 2015).

Types of plants are divided into two, namely plants that are intentionally cultivated by humans and plants that are not cultivated or often known as wild plants. Wild plants are those that grow in areas where they are not desired. Wild plants are often referred to as weeds because they frequently harm cultivated plants, either directly or indirectly Hamzah *et al.* (2023). In addition to causing damage to crops for farming communities, weeds are one of the causes of limited production of cultivated plants, as these plants grow around the main crops. The presence of these wild plants is highly undesirable for every farmer because they become a nuisance and harm other plants (Krishidaya *et al.*, 2022). However, there are some wild plants that can be utilized by humans.

Wild plants are all types of plants that grow in unintended places or places outside the usual planting areas, such as around drainage channels, on roads, on rocks and so on (Kartika, 2017), many members of the general public are not yet aware of the benefits of wild plants, such as their use as medicinal plants or their potential to be made into organic fertilizers like NPK, urea, or similar types Mekonnen *et al.* (2022). In another sense, wild plants are those that grow naturally without going through the planting process and are generally considered weeds, but are widely utilized by various ethnic groups in Indonesia as traditional medicine.

Some wild plants can be used as medicinal plants, such as several traditional herbal ingredients of the Sumenep community, which consist of both cultivated and wild plants. For herbal medicine ingredients derived from cultivated medicinal plants such as turmeric, ginger, or galangal, their sustainability is certainly maintained because these ingredients, besides being traditional medicines, primarily serve as spices in cooking. However, jamu ingredients derived from wild plants will be threatened with extinction if not preserved (Ismawati & Destryana, 2019).

Some wild plants can be processed or utilized as NPK fertilizer that is beneficial for farmers, such as the sensitive plant, gamal leaves and similar plants that contain NPK elements. NPK fertilizer is a compound fertilizer consisting of Nitrogen (N), Phosphate (P) and Potassium (K) elements. NPK fertilizer is a compound fertilizer, so the nutrients contained in it have different functions, in addition to being macro-nutrient elements.

The Nitrogen element (N) is very important in plant growth, which affects plant productivity. Nitrogen is needed to stimulate the vegetative growth of plants, such as leaves, stems and roots. The N element functions to enhance plant growth, promoting healthier leaf growth with a greener color (Leghari *et al.*, 2016; Nuraeni *et al.*, 2009). In certain types of plants, such as rice, nitrogen plays an important role for rice plants, namely: Promoting rapid plant growth and improving the yield and quality of the grains through increased tiller number, leaf area expansion, grain formation, grain filling and protein synthesis. Rice plants that lack nitrogen have few tillers and their growth is stunted. The leaves turn yellowish-green and start to die from the tips, then spread to the middle of the leaf blades (Hardiyanti *et al.*, 2022). Whereas if nitrogen is given in excess, it will result in losses such as: Softening the straw and causing the plants to easily fall over and reducing the quality of the crop yield.

In general, the function of phosphate in plants can accelerate the growth of seedling roots, speed up and strengthen the growth of young plants into mature plants, accelerate flowering and the ripening of fruits and seeds and can increase grain production (Sumbayak & Gultom, 2020). The function of potassium for plants plays a role in stimulating the process of opening and closing stomata through increased cell turgor activity. The K element also functions to stimulate the translocation of assimilates and can maintain the uprightness of the stem, allowing the flow of nutrients and water from the soil into the plant body (Apriliani, 2022). In another source, potassium is important in leaf formation, growth, regulation of stomatal opening and is involved in the synthesis of starch and protein. Plants experiencing potassium deficiency are characterized by weakened stem turgor, yellowing of leaf tips and the lower leaf margins, susceptibility to disease attacks and reduced fruit quality (Diana *et al.*, 2023).

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Yanti Erma (Coordinator of Subsidized Fertilizer at the Directorate General of Agricultural Infrastructure and Facilities, Ministry of Agriculture) stated that the fertilizer subsidy fund for 2024 is budgeted at IDR 26.68 trillion. With that funding, the allocation of subsidized fertilizer distributed is only 4.8 million tons. Meanwhile, the need for subsidized urea and NPK fertilizer is 10.7 million tons (Priandanata *et al.*, 2024). "It means that, referring to the Definitive Group Needs Plan (RDKK), the subsidized fertilizer that farmers will receive is not even half of what they need," he said.

The allocation of subsidized fertilizer is also increasingly diverging from the fertilizer needs in the RDKK, which averages around 25 million tons per year. In 2022 and 2023, for example, the subsidized fertilizer allocation set by the government was 7.7 million tons and 7.8 million tons, respectively. In the past four years, the fertilizer subsidy budget has continued to shrink. In 2019 and 2020, the fertilizer subsidy budget was allocated Rp 34.31 trillion and Rp 34.23 trillion, respectively (Widi, 2023). And it was not sufficient for farmers in Indonesia. Therefore, they should have found an alternative way for the problems. As the solution, the farmers created the fertilizers which have more benefit. By utilizing the nutrients present in this plant, farmers can create fertilizers that enrich the soil without harming the environment. This method not only reduces the carbon footprint of agriculture but also supports biodiversity and ecosystem health. Overall, integrating wild plant-based NPK fertilizers into agricultural practices is a step towards a more sustainable and regenerative future for farming.

Materials and Methods

The materials used in this study were classified into three categories: main ingredients (e.g., Lamtoro leaves, Kipahit leaves, bamboo leaves), additives (e.g., moringa leaves, banana pseudostems, and coconut coir), and supporting agents (e.g., goat dung, EM4, Nitrobacter solution, and rice washing water). The equipment included shredders for plant material processing, fermentation containers, and laboratory instruments such as spectrophotometers and Kjeldahl apparatus.

Research Design

This research used experimental design which aims at generating NPK fertilizer from a variety of wild plants. The objective of study is to evaluate and quantify the Nitrogen (N), Phosphorus (P) and potassium (K) content within the produced organic fertilizer. For nutrient composition determination, the methodology includes preparation of the raw materials, fermentation and subsequent laboratory analysis.

Following a systematic approach, this study seeks to determine the effectiveness of the wild plant-derived NPK fertilizer. It specifically focuses on comparing the nutrient levels of nitrogen, phosphorus and potassium in the organic fertilizer against conventional standards. To obtain reliable results, a well-structured setup has been implemented, incorporating control groups, replicates and comprehensive statistical analysis.

Control Groups

To establish a reliable benchmark for evaluating the effectiveness of the wild plant-based NPK fertilizer, this study incorporated a control group using commercially available synthetic fertilizers with known nutrient compositions. These standard formulations, widely used in agriculture, allow for a comparative assessment of nutrient efficiency and crop response under similar conditions.

These groups will consist of standard commercial fertilizers that are commonly used in agricultural applications. The inclusion of control treatments is crucial in establishing a baseline for both nutrient content and agricultural efficacy.

The control treatment (C1) involved a liquid fertilizer prepared in a 1:1 ratio of main ingredients to additives. Including this control group ensured that observed differences in plant growth, yield, and nutrient content could be accurately attributed to the experimental formulations (P1, P2, and P3) rather than external variables.

Replication

Each treatment (P1, P2, P3 and C1) from Table (1) is tested in replicates to enhance the reliability and validity of the results. Specifically, the experimental design incorporates the following:

Number of replicates: Each sample is tested in triplicates (n = 3) to account for variability and ensure that results are not due to random chance. This means that each treatment will be subjected to the same conditions and multiple measurements will be analyzed to derive an average.

Table 1: Summary of experimental setup

Treatment Sample	Ratio of Main Ingredients to Additives	Number of Replicates
P1	1:1	3
P2	2:1	3
P3	1:2	3
C1	1:1 (Commercial Fertilizer)	3

Materials

The materials were utilized in the production of NPK fertilizer, categorized into main ingredients, additives and supporting materials. The details of the materials were as in table 2 as follows:

Table 2: Materials used in NPK fertilizer production

Category	Materials
Main Ingredients	Leaves of Lamtoro plant
	Leaves of Mimosa plant
	Stems and branches of Mimosa plant
	Roots of Mimosa plant
	Kipait plant
	Leaves of Gamal plant
	Bamboo leaves
Additives	Moringa leaves
	Banana pseudostems
	Coconut coir (cocopit)
Supporting Materials	Goat dung
	EM4 culture
	Nitrobacter culture
	Rice washing water

Tools and Equipment

The equipment and the tools used were shredders for chopping plant materials, fermentation drums or barrels for the mixing process, and other laboratory equipment used was spectrophotometers and Kjeldahl apparatus.

Preparation of Materials

In order to start the process of production of NPK fertiliser, the main components and the ingredients are first cut into smaller pieces using shredders. This reduction in size is necessary to improve the fermentation efficiency.

Fermentation Process

Different test samples are obtained by combining the sampled materials - which include wild plant leaves and other organic materials in exact proportions. In order to maximise the nutrient content of the final NPK fertiliser, these ratios are carefully calculated.

Fermentation Setup

The combined materials are placed in barrels or fermentation tanks and each sample is weighed in accordance with the ratio of the selected main component to the additive. The proportions for each sample are divided into the following fractions:

- P1: 1:1 ratio (main ingredients to additives)
- P2: 2:1 ratio
- P3: 1:2 ratio
- C1: Control (1:1 for liquid fertilizer)

In addition to the main ingredients and additives, each sample includes standardized supporting materials:

- ½ kg of *goat dung*
- 120 mL of *EM4 culture*
- 120 mL of *Nitrobacter culture*
- 120 mL of *rice washing water*

These mixtures are then placed in fermentation barrels and allowed to ferment for a minimum of one month.

Monitoring Microbial Activity

The fermentation process is described, but the methodology for monitoring microbial activity is specified. To understand the dynamics of the fermentation process and ensure consistency and reproducibility, it is necessary to establish key metrics such as temperature, pH, and the number of microorganisms at different fermentation stages. The deduction of holy water is recommended, namely: Regular sampling of the mixture to measure pH and temperature, Utilizing culture plates to identify and quantify specific microbial populations involved in fermentation, Measuring volatile fatty acids and other metabolites to assess fermentation progress

Fermentation Duration

Fermentation is standardized for at least one month. This length allows for adequate microbial activity and nutrient exchange. Regular monitoring during this period provides valuable information about fermentation efficiency and overall microbial health.

Finalization of Fertilizer

Following the fermentation stage, the mixture is dried to reduce moisture content, thus preventing spoilage and preparing the product for laboratory testing. Separate processing is performed for the liquid and solid fractions of the fertilizer, as each can yield distinct nutrient profiles.

Production Process

The production of NPK fertiliser from wild plants involves several basic steps, which highlight the need for pre-treatment to ensure the quality and availability of the nutrient content of the final product. The main steps in pre-processing include initialization of the secretarial product:

Drying Temperature

The temperature range should be ideal for standardized drying processes. Drying temperatures of 50 to 60 degrees Celsius are recommended for effective moisture reduction without damaging heat-sensitive nutrients.

Particle Size

After grinding the plant material, it is crucial to determine the ideal size of the seeds. It has been shown that a finer particle size, typically 1-5 mm in diameter, increases the surface area available for microbial activity during fermentation, thereby speeding up the release of nutrients.

Fermentation Parameters

Although 2-4 weeks is the usual recommended fermentation time, this study has standardised it at 1 month for detailed microbial breakdown.

The optimum temperature range for microbial activity and nutrient conversion during fermentation is 30 to 40 degrees Celsius.

Metrics to measure microbial activity: To measure the quality of fermentation, it is necessary to measure microbial activity. These are the proposed metrics:

Microbial count: The extent of microbial activity is determined by comparing the total number of viable bacteria before and after fermentation.

pH level: monitoring pH changes during fermentation provides information on microbial dynamics.

Analysis of the rate of release of nitrogen, phosphorus and potassium during fermentation provides an insight into the efficiency of the fermentation process.

The resulting NPK fertiliser is expected to contribute effectively to basic nutrients and to be environmentally sustainable and friendly, following these structured methods during the preparation and production phases.

Drying

NPK fertiliser is further dried in sun or in dehydrators after fermentation in order to reduce moisture content and improve shelf-life.

Laboratory Testing

Laboratory analysis is carried out to determine the quantities of nitrogen, phosphorus and potassium in the dry samples (P1, P2, P3 and control C1).

Table 3: Sample ratios for NPK fertilizer production

Sample	Main Ingredients to Additives Ratio
P1	1:1
P2	2:1
P3	1:2
C1	Control (1:1 for liquid fertilizer)

Laboratory Testing Methods for NPK Content

Several standardised laboratory test methods are used for the exact determination of the phosphorus (P), potassium (K) and nitrogen (NO) content of dry samples (P1, P2, P3 and C1). A detailed description of the test methods, instruments and calibration standards is available .

Sample Preparation

The dried samples are finely ground to ensure homogeneity before analysis by the laboratory. This step is necessary because it allows for more efficient nutrient extraction during the analysis process.

Analytical Equipment

The following laboratory equipment is commonly used for testing the NPK content:

- Kjeldahl apparatus: For nitrogen determination, this method involves digesting the sample in concentrated sulfuric acid with a catalyst. The ammonia released is then distilled and quantified
- Spectrophotometer: Used for phosphorus analysis, the sample is treated with a molybdate reagent which forms a colored complex. The intensity of the color, measured at a specific wavelength using a spectrophotometer, correlates to the phosphorus concentration
- Flame Photometer or Atomic Absorption Spectrophotometer (AAS): For potassium determination, these methods involve exciting the sample's atoms and measuring the emitted light or absorption characteristics to ascertain potassium levels

Calibration Standards

Calibration is vital for ensuring accurate and reliable results. Follow these steps:

- Preparation of calibration standards: Stock solutions of known concentrations of nitrogen (as ammonium nitrate), phosphorus (as potassium dihydrogen phosphate) and potassium (as potassium chloride) are prepared. These standards help in creating a calibration curve for each nutrient
- Running calibration curve: Each time analysis is performed, a range of calibration standards is analyzed alongside the samples to create a calibration curve. The instrument response from these standard solutions is plotted to determine the relationship between concentration and measured response
- Quality control samples: Include quality control samples with known concentrations to verify the accuracy of the analytical method. Running these alongside samples ensures that any analytical errors can be detected and adjusted accordingly

Method Validation

Each analytical method must go through a validation process to assess its accuracy, precision, specificity and sensitivity. Common validation parameters include:

- Recovery tests: Known quantities of nitrogen, phosphorus, or potassium are added to the samples and the recovery percentage is calculated to verify method efficacy
- Reproducibility: Multiple analyses (at least three) of the same sample should yield consistent results to confirm precision
- Limit of Detection (LOD) and Limit of Quantification (LOQ): Establish the lowest

concentration that can reliably be detected and quantified, ensuring meaningful analytical results

By utilizing the aforementioned laboratory analysis methods for nitrogen, phosphorus and potassium content, along with rigorous calibration standards and quality control measures, the resulting data will be accurate and provide a valid assessment of the NPK values in the fertilizer samples (P1, P2, P3 and C1). This process is crucial for verifying the fertilizer's effectiveness and ensuring it meets agricultural standards.

Potential Variability in NPK Content

It should be noted that environmental factors can cause fluctuations in NPK levels in all studies evaluating the effectiveness of fertilizers. These variables can include changes in soil composition, temperature, humidity, and other environmental factors that can affect fertilizer effectiveness and nutrient availability. The NPK content of fertilizers is analyzed by different methods as shown in Table 4. We use the Kjeldahl method to measure the amount of nitrogen, the spectrophotometric method to measure the amount of phosphorus, and either flame photometry or atomic absorption spectroscopy (AAS) to determine the amount of potassium.

Table 4: Testing methods for NPK content analysis

Nutrient	Testing Method
Nitrogen	Kjeldahl method
Phosphorus	Spectrophotometric method
Potassium	Flame photometry or Atomic Absorption Spectroscopy (AAS)

Data Analysis

To determine the relevance of differences in the NPK level of samples, the data is statistically analyzed after the laboratory results are obtained. The following strategies are implemented:

ANOVA: This statistical method is used to determine whether the NPK content of samples of natural plant fertilizers differs statistically significantly from that of control fertilizers (synthetic fertilizers).

In order to thoroughly evaluate the effectiveness of NPK fertilizers on wild plants, the study takes into account possible environmental variability and uses reliable testing and analysis methods.

Statistical Analysis

To analyze the data obtained from the laboratory tests of nitrogen, phosphorus and potassium content, appropriate statistical methods will be implemented. The following analyses will be conducted:

- Analysis of Variance (ANOVA): A one-way ANOVA will be performed to determine whether there are statistically significant differences in NPK content across the different treatment samples. This method helps in identifying if the fertilizer from wild plants provides nutrients significantly different from the commercial control
- Post-hoc Testing: If ANOVA shows significant differences, a post-hoc test (such as Tukey's HSD) will be conducted to determine which specific pairs of means (i.e., different treatments) are significantly different from each other
- Descriptive Statistics: Mean values and standard deviations will be calculated for each sample to summarize the nutrient content effectively

Results Interpretation

The results of the statistical analyses will be graphically represented (such as box plots or bar charts) and conclusions will be drawn based on observed differences, aiming to provide insights into the efficacy of wild plant-based NPK fertilizers compared to standard commercial options.

Preprocessing and Fermentation Parameters

Collection and Selection of Raw Materials

Criteria for selection: Emphasis should be placed on selecting healthy, disease-free wild plants, as well as any additional organic materials. The nutritional profile of the wild plants (N, P, K content) should preferably be assessed prior to selection

Species used: Primary materials include *Lamtoro (Leucaena leucocephala)*, *Putri Malu (Mimosa pudica), Kipahit (Bridelia stipularis), Gamal (Gliricidia sepium)* and *Bamboo leaves*. Additional organic materials such as *Moringa leaves*, *banana pseudostems* and *coconut coir* are also used

Preprocessing Steps

Chopping: All raw materials are chopped into smaller particles (1-3 cm) using mechanical shredders. This increases the surface area, facilitating more effective microbial action during fermentation.

Drying (if applicable): If fresh materials are used, they can be air-dried prior to processing to further reduce moisture content, preventing excessive fermentation that could encourage pathogenic organisms. Optimal moisture levels for fermentation often range between 40-60%.

Fermentation Parameters

The fermentation process relies on several key parameters to ensure the effective breakdown of organic matter and the release of plant-available nutrients. First, the chopped wild plant materials are placed in a fermentation drum or airtight container to create anaerobic conditions essential for microbial activity. These sealed vessels help maintain an oxygen-limited environment, which supports the growth of beneficial anaerobic microbes.

The materials are then mixed using predetermined ratios, commonly 1:1, 2:1, or 1:2, depending on the desired nutrient balance between the main ingredients and additives. Supporting materials such as goat manure (approximately ½ kg), EM4 microbial solution (120 mL), and Nitrobacter culture (120 mL) are added to enhance microbial fermentation and nutrient conversion.

Fermentation is carried out over a minimum period of one month. This duration allows sufficient time for microbial communities to fully decompose the organic matter and stabilize nutrient content. Throughout the process, environmental conditions must be carefully monitored. The ideal fermentation temperature typically ranges from 30°C to 50°C, a range that encourages microbial growth while suppressing pathogens. Moisture levels should also be maintained within the range of 50% to 60% to support effective microbial metabolism.

Periodic agitation of the mixture, usually every five to seven days, may be performed to ensure uniform decomposition and prevent compaction. However, in anaerobic systems, this must be done cautiously to avoid introducing excessive oxygen, which could disrupt microbial activity and reduce fermentation efficiency.

End of Fermentation

Once fermentation is complete, the mixture is allowed to stabilize for a week before it is dried to reduce moisture content for storage. This process also enhances the nutrient availability and shelf life of the resulting fertilizer

Quality Control

Test samples at the conclusion of the fermentation process for NPK content, ensuring the fertilizer meets the standards set. Laboratory tests can be used to measure nutrient content and confirm that fermentation has progressed adequately

Result

NPK Production Process

The production of organic NPK fertilizer from wild plants involves a systematic and carefully monitored process designed to optimize nutrient availability. Each stage is executed methodically to ensure the resulting fertilizer meets quality standards for sustainable agricultural use (Burhan, 2017).

The process begins with the preparation of raw materials. Selected wild plants, such as Lamtorus and Gamal, are chopped into small pieces using a cutting machine. Reducing the size of the plant material increases the surface area, thereby accelerating microbial activity during fermentation. The selection of these plants is based not only on their high nitrogen, phosphorus, and potassium content, but also on their availability within the local ecosystem, ensuring both effectiveness and sustainability.

Following this, the chopped materials are placed into fermentation containers such as barrels or drums. Fermentation is a critical step in the production process, as it enables beneficial microbes to decompose the organic matter, releasing nutrients in forms that plants can readily absorb. This microbial breakdown also generates heat, which further enhances decomposition. For effective results, the fermentation process typically lasts for at least one month. Throughout this period, conditions such as humidity and aeration must be carefully regulated to support optimal microbial growth.

The nutrient concentration of the final product is determined by the specific ratios of the primary materials to additives. In one formulation, the base ingredient and additive are combined in a 1:1 ratio to create a balanced nutrient profile. Another variation uses a 2:1 ratio of the base material to additive, typically to increase the nitrogen and potassium levels necessary for vigorous plant development. A third formulation may reverse the proportion, mixing the additive and base material in a 1:2 ratio to utilize the complementary nutrient values of each component. These ratio adjustments are essential for tailoring the fertilizer to different agricultural needs while maintaining consistency and quality.

Explanation of Ratios

Optimizing the quality of the final organic fertilizer product requires understanding these limits. Scientists and farmers can experiment with different combinations to find the best blend to optimize the amounts of nitrogen, phosphate, and potassium in the final fertilizer by adjusting these ratios. This testing is important because it can provide information on the optimal composition of different plant species and soil types, thereby promoting sustainable agricultural practices in addition to increasing yields.

Explanation

Therefore, the dimensions of the support materials are standardized:

1. *Kohe* ½ kg
2. *Em4* 120 mL
3. *Nitrobacter bacterikultuur 120 ml*
4. *Rice washing water* 120 mL
5. The material is fermented in the fermentation chamber for at least one month according to the concentration scale.
6. Drying NPK fertilizer produced
7. Laboratory test results
8. Table 5 shows laboratory results on the nitrogen, phosphorus and potassium content of liquid and solid NPK fertilizers made from wild plants.

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Table 5: Laboratory results for NPK content

No	Sample	Macro Element			Moisture Content	Test Parameter	Method
		N	P	K			
1	P1	2,40 %	0,94 %	3,23 %	32,79%	BPSI Tanah dan Pupuk 24.04.200 K.P. 1 37 - '139	Gravimetri/Oven
2	P2	2,26 %	0,72 %	3,36 %	27,72 %		Total Kjeldahl/Destilasi HNO3/ Spektrofotometri
3	P3	2,42 %	0,81 %	2,62 %	37,22 %		HNO3/F-AAS
4	C1	0,28 %	0,06 %	0,24 %		BPSI Tanah dan Pupuk 24.04.199 K.P. 136	Total/Destilasi HNOy' Spektrofotometri HNOy'F-AAS

It is important to clearly show how the results of the study on the production of NPK fertilizers from wild plants can be applied in practice. Below are some possible approaches to convey the relevance and relevance of the survey results to the real agricultural environment.

Sustainable Agriculture Practices

Supporting organic fertilizers: The results of the study show that there is potential to use wild plants as raw materials for the production of organic NPK fertilizers. This can provide farmers with a sustainable alternative to synthetic fertilizers, improving soil health and reducing their environmental impact. Farmers can better promote biodiversity and reduce dependence on chemical inputs by encouraging the use of locally produced materials.

Cost-Effectiveness

Lower production costs: Instead of purchasing commercial fertilizers, farmers in areas where wild plants are readily available can produce their fertilizers at a lower cost. This is especially useful for smallholder farmers, who may not have easy access to external agricultural inputs. Farmers can use this study to guide their local harvesting and processing practices to produce high-quality organic fertilizers.

Enhancing Soil Fertility

Nutrient cycling: The results can be used to increase soil fertility using organic fertilizers. Using NPK fertilizers from wild plants can help farmers improve nutrient cycling in their fields, which can ultimately lead to healthier crops and higher yields. In line with agro-ecological principles, this approach promotes resilient agricultural systems.

Seminars and trainings: Research can be used to develop training programs to teach farmers about the benefits of using wild plants to produce organic fertilizers. Workshops can be organised for the general public to show how fertilisers are produced and used in crop management, providing farmers with more information and skills.

Local Food Security

Increasing agricultural productivity: By improving soil fertility and crop yields by using locally produced organic fertilizers, the results can contribute to increasing food security in the region. This can be especially important in areas with problems with soil degradation and dependence on imported fertilisers.

Policy Implications

Agricultural Policy Guidelines: The results of this study can help policymakers understand the potential benefits of promoting organic farming. Funding and supporting research and development of organic fertilizers made from different wild plants can support sustainable agriculture and serve as an example for other regions facing similar agricultural challenges (Npk *et al.*, 2020). In conclusion, the results of this study have significant potential for practical application in the real agricultural world. By clearly articulating these uses, research can better engage with farmers, agronomists, and policymakers to advance an understanding of how the use of wild plants in the production of organic NPK fertilizers can transform agricultural practices into more sustainable and resilient systems. Emphasizing these practical implications can increase the impact of the study on promoting sustainable agriculture.

Absence of Comparative Analysis

One of the notable limitations of this study of NPK fertilizer production for wild plants is that it did not compare it to existing organic and synthetic fertilizers. Comparative analysis is an important part of assessing the performance, efficacy and overall impact of each new fertilising product. By not including this analysis, the study missed an opportunity to determine the comparative advantages of natural plant fertilizers over their commercially available counterparts.

1. Understanding Effectiveness: The main reason for performing a comparative analysis is to evaluate the effectiveness of a newly developed fertilizer. Organic fertilizers, such as those derived from compost, manure, or other natural sources, have been extensively studied and have a well-established nutrient profile. Similarly, artificial fertilizer has a defined nutrient composition. By comparing NPK levels and effects on plant health, researchers have gained a better understanding of the benefits and limitations of natural plant fertilizers.

2. Environmental Impact Assessment: While synthetic fertilizers can cause nutrient leaching and soil degradation, organic fertilizers are often praised for their environmental benefits, such as improved soil health and reduced chemical runoff. A comparative analysis would allow to compare the environmental impact of synthetic and organic fertilisers with that of traditional grassroots fertilisers.
3. The economic viability of natural plant fertilisers would also be emphasised by the addition of cost analyses. As a farmer, knowing the long-term benefits and production costs can help you make informed decisions.
4. User Acceptance and Acceptance: Farmers' preferences and experience with new and traditional fertilizers would increase the acceptance of natural NPK fertilizer, which is crucial for its practical use in agriculture.

In conclusion, although this study describes the production process and NPK profiles of natural plant fertilizers, a comparison with conventional fertilizers would enrich the results and provide a more comprehensive picture of the viability of modern fertilizers.

Discussion

Interpreting Results and Linking Findings to Agronomic Outcomes

Agronomic Implications of NPK Fertilizer from Wild Plants

NPK fertilizers made from wild plants have great potential to improve agricultural productivity and provide a number of benefits that can transform farming practices. Differences in nutrient concentrations between different samples show how the use of organic fertilizers from local biodiversity can contribute to sustainable agriculture (Ananda *et al.*, 2021). The results of the study highlight the importance of organic fertilizers with high potassium, phosphorus and nitrogen content in promoting the best possible growth and development of crops.

Nitrogen and Crop Growth

Nitrogen is an important component of plant growth and development. Nitrogen is a key component of chlorophyll and plays a key role in photosynthesis, which is the process that provides plants with the energy they need to grow and develop. A high nitrogen concentration of 2 to 42 percent P3 in a sample gives farmers and other agricultural professionals a good opportunity to improve vegetative growth. The development of vigorous leaves is facilitated by the presence of nitrogen, which is especially important for crops such as corn, leafy greens, and other cereals that depend on a strong leaf structure to maximize photosynthesis. Nitrogen-rich fertilizers can help produce healthier, more resilient crops that are more resistant to biotic stress, such as pests and diseases, and environmental stress, while maximizing leaf growth.

In addition to supporting green growth, nitrogen is also important in the synthesis of proteins and essential amino acids necessary for plant metabolism and development. With the use of organic nitrogen from wild plants, plant tissues can be healthier and less dependent on synthetic nitrogen fertilizers, which often have adverse effects on the environment, such as soil and groundwater contamination.

Phosphate and Root Development

Phosphorus, another important macronutrient for plant health, is strongly involved in root development, flowering, and fruit production. The 0.94 percent phosphate found in the P1 sample demonstrates its effectiveness in stimulating root growth.

A strong root system helps plants absorb more water and nutrients, which is especially useful during periods of drought or low soil fertility. Phosphorus helps plants obtain the resources they need to grow and harvest, promoting root development, helping them settle in the soil more successfully. This is especially important for new plants or crops in the early stages of growth, when strong roots can increase their resistance to environmental stressor.

Based on the results of the study, phosphate fertilizer can help farmers deal with common problems, especially in areas where soils lack phosphorus. On farms where soil nutrient levels are suboptimal, the strategic use of these organic fertilizers can increase crop growth rates and overall productivity. The addition of natural plant fertilizers also allows farmers to minimize the potential environmental impact of synthetic fertilizers by reducing chemical inputs.

Potassium and Stress Resistance

Many plant physiological processes, such as water regulation, activation of enzymes, and photosynthesis, are known to be regulated by potassium. The potential benefits of this organic fertilizer go beyond simple nutrient supply; Potassium concentrations of 2 to 36 percent in the P36 sample suggest that it may increase plant resistance to various stresses, such as heat and drought.

The high potassium content makes plants stronger and more vigorous, helping them develop strong tissue structures that are essential for surviving in harsh environments. For example, potassium helps the plant stay hydrated during periods of water scarcity, improving its ability to regulate the osmotic balance. This can lead to an increase in survival rates in adverse weather

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conditions, which is important for ensuring food security in a changing climate.

Additionally, potassium is known to improve the flavor, texture, and shelf life of fruits and vegetables. The use of organic fertilisers rich in potassium from wild plants can therefore significantly improve the quality and quantity of crops, thus increasing the financial sustainability of farms.

Nutrient Balance and Sustainability

A well-balanced NPK fertilizer can significantly increase crop productivity and reduce dependence on other chemical fertilizers. Farmers can use the natural resources of their environment to grow their crops using organic materials from wild plants, promoting ecological balance.

The use of natural NPK fertilizers is a paradigm shift in sustainable agriculture. By leveraging local biodiversity, the method promotes the links between farmers and their environment, which promotes environmental health. Organic fertilisation not only increases soil fertility and structure, but also reduces reliance on synthetic inputs that can harm soil ecosystems (Wuriesyliane & Saputro, 2021). The nutrient recovery cycle from organic materials contributes to the long-term sustainability of agricultural practices.

The integration of sustainable practices using wild plant resources is in line with global trends to reduce the carbon footprint of agriculture. Farming practices using organic fertilisers also tend to increase soil microbial activity, which is beneficial for nutrient cycling and overall soil health. This underlines the important advantage of producing NPK fertiliser from wild plants: it is a step towards regenerative farming, which improves the environment while increasing yields.

The Process of Making NPK Fertilizer from Wild Plants

According to Figure (1) NPK fertiliser produced from wild plants is produced using environmentally friendly processes, which supports current sustainability goals. Farmers can meet their nutrient needs efficiently without compromising environmental integrity by reducing their dependence on chemical fertilisers. As shown in the diagram below, NPK fertilizer is made from wild plants.

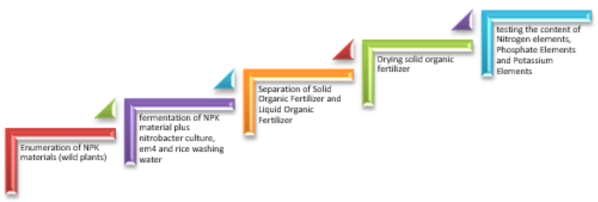

Fig. 1: Flowchart of NPK fertilizer production from wild plants

Selection of NPK-Containing Materials

The efficacy of this organic fertilizer stems from the deliberate selection of nutrient-rich plant materials known to supply essential macronutrients. Various wild plants have been identified as effective sources of nitrogen, phosphorus, and potassium. For nitrogen, leaves from plants such as leucaena, mimosa, and gamal are commonly used due to their high nitrogen content, which supports vigorous vegetative growth.

Phosphorus is primarily derived from nutrient-rich materials like moringa leaves and coconut coir, which are especially important for root development and flower production, thereby improving overall crop quality. Potassium, vital for enhancing plant tissue strength and resilience, is obtained from components such as banana pseudo stems, bamboo leaves, and kipahit plants. The selection of these materials is based on their local availability and their capacity to provide a balanced nutrient profile, ensuring both the practicality and effectiveness of the fertilizer.

Extraction Process (Grinding)

Grinding is an integral part of the conversion process, as it enhances nutrient availability by breaking down plant materials into smaller particles. This technique allows for better absorption by plants and accelerates nutrient availability once the fertilizer is applied to the soil. In this study, the grinding process is emphasized for its role in expediting fermentation, ideally reducing total processing time.

The understanding that finely ground organic matter can lead to faster microbial decomposition illustrates the importance of this step. By breaking down material into a powdery consistency, the fertilizer can deliver nutrients more readily and efficiently to plants, leading to improved efficacy of the organic NPK fertilizer.

Comparison of Materials

The study characterizes various material ratios to determine the most effective combinations for producing nutrient-rich fertilizers. The main ingredients used include:

1. Main ingredients: Lamtoro, Putri Malu, Kipahit, Gamal leaves and Bamboo leaves were identified as primary constituents due to their rich nutrient profile
2. Additional ingredients: Moringa leaves, banana pseudostems and coconut coir were selected for their complementary contributions to nutrient balance
3. To improve the fermentation and composting process, rice water, EM4 solution, goat manure and nitrobacter cultures were used as additional materials.

4. Special amounts of feed materials are included in the standard measurements because they are known to maximise fermentation and to improve the overall quality of the final fertiliser.

Fermentation

Fermentation is the key step in converting organic materials into fertilizer rich in nutrients. The method decomposes organic matter by using natural microbial activity, increasing the availability of nutrients for plants. In this study fermentation is maintained for at least one month, which gives sufficient time for nutrients to be released and optimised for uptake by the plants.

By converting complex compounds into simpler, bioavailable forms, microorganisms help transform raw organic materials into efficient fertilisers. In addition to supporting plant growth, it stimulates the growth of thriving soil ecosystems. The decision to use fermentation is an example of organic methods that promote environmental protection and sustainability, which in turn creates a strong agricultural system. The potential of NPK fertilizer in improving agricultural practices and promoting sustainability is highlighted by research on topical NPK fertilizers produced from wild plants. The results show how the biodiversity of wild plants can provide nitrogen, phosphorus and potassium for healthier crops, higher yields and lower environmental impact. Farmers using organic fertilizers can increase their production while conserving natural resources and promoting a long-term environmental balance that ensures food security.

By encouraging sustainable agricultural practices, this holistic strategy is transforming the agricultural landscape and helping the world's growing population meet its growing food needs. One way to achieve these goals and strengthen the bond between farmers and their ecosystems is to incorporate NPK fertilizers for wildflowers into agricultural operations. The adoption of such a sustainable practice is crucial for the future resilience of the agricultural sector in the face of the challenges posed by resource constraints and climate change.

Ultimately, the use of wild plants to produce and use NPK fertilizers is not just another approach, but a comprehensive plan to increase agricultural productivity and sustainability, opening the door to a more resilient and environmentally friendly future.

Fermentation Process in NPK Fertilizer Production from Wild Plants

The production of organic fertilizers made from wild plants, especially NPK fertilizers (nitrogen, phosphate and potassium) made from wild plants, depends to a large extent on fermentation. This environmentally friendly approach reduces the need for artificial fertilisers, promoting sustainability and biodiversity and using native plant species. In this article, we will take a closer look at the fermentation process, its microbial dynamics, operating procedures, and the benefits of its use in agriculture.

The Importance of Fermentation

In the production of organic fertilizers, fermentation refers to the decomposition of organic material by microorganisms such as bacteria and fungi under anaerobic conditions. This natural process converts plant raw materials into nutrient-rich products that improve soil health and plant growth. By using decomposition energy, fermentation allows complex organic matter to be converted into simpler forms that can be more easily absorbed by plants.

Microbial Inoculants and Their Functions

Successful fermentation requires the use of microbial inoculants, such as effective microorganisms (EM4). Among the beneficial microorganisms that contain EM4 are yeast, photosynthetic bacteria and lactic acid bacteria. These organisms increase the absorption of nutrients, stimulate organic decomposition, and produce compounds that stimulate growth. Their activity improves the nutrient profile of the organic fertilizer and speeds up the fermentation process.

In particular, nitrobacterium and other nitrifying bacteria are necessary for the dissolution of noble noble nitrate. These bacteria convert ammonium ($NH3$) into nitrites ($NO2-$) and then into nitrates ($NO3-$), the forms of nitrogen that plants have the most access to. The nitrogen content of the fertilizer produced is largely due to this process of formation of nobility.

Structural Stages of Fermentation

The fermentation process is followed by a series of careful steps, each of which contributes to the nutrient profile of the fertiliser.

Preparation of the material: The first step is the careful selection and preparation of wild plant material of high nutrient concentration by reputable reputable suppliers. For example, the leaves of several native plants, including Lamtora, Putri Malu, Kipahit and Gamal, are selected for their high NPK. The crops are fortified with other nutrients, such as pseudo-bananas and coconut husks, which also enrich the sacred mass.

Grinding and mixing: the herbal components are ground into a fine powder after the selection of the ingredients. Blending improves the surface area and makes fermentation faster and more efficient. It is important that the mixture of these materials is mixed evenly to ensure that microbial activity is evenly distributed throughout the mixture.

The ground materials are then mixed in accordance with the prescribed proportions to achieve a neutral NPK content and the fermentation process is started. For example, different ratios of primary ingredients to feed materials are determined according to the intended nutrient outcomes, e.g. 1:1, 2:1 or 1:2.

The fermentation process: The mixture is allowed to ferment in an airtight container or drum for at least one month. During this period, anaerobic conditions promote microbial activity at the best possible rate. Occasionally water is added in small quantities to maintain moisture levels and stimulate microbial activity. The prolonged fermentation time allows for a thorough breakdown of the nutrients and converts the organic waste into a high-nutrient fertiliser which is bioavailable.

Benefits of Fermentation in Fertilizer Production

The main benefit of the use of fermented organic fertilisers is the improved bioavailability of nutrients, together with improved soil health. Fermentation improves soil quality and plant vigour by converting nutrients into forms that can be easily absorbed by plants.

The use of wild plants as a source of NPK fertilizer offers significant environmental and sustainability benefits. By utilizing naturally occurring plant species, this method supports biodiversity and encourages sustainable agricultural practices. It reduces the reliance on chemical fertilizers, which are known to contribute to soil degradation and water pollution, thereby minimizing environmental harm. Additionally, this approach offers economic advantages. Farmers can lower their dependence on costly commercial fertilizers by making use of locally available fermentation materials and compostable wild plants. This not only reduces production costs but also promotes a more sustainable cycle of resource use and conservation. Furthermore, incorporating a diverse range of plant species into the composting process helps to protect native vegetation that might otherwise be threatened. In this way, integrating wild plants into agricultural systems contributes to the preservation of local ecosystems while enhancing soil fertility and crop productivity.

NPK Content Analysis

Laboratory analyses are carried out following the fermentation process to determine the levels of nitrogen, phosphate and potassium in the fertiliser. Four samples of NPK fertiliser were tested: one liquid sample (C1) and three solid samples (P1, P2 and P3). Significant differences in the NPK content were noted in the test results.

Sample P1 contained 2.40% nitrogen, 0.94% phosphorus, and 3.23% potassium. Sample P2 showed a slightly lower nitrogen content at 2.26%, with phosphorus at 0.72% and potassium at 3.36%, which was the highest potassium level among the samples. Sample P3 recorded the highest nitrogen concentration at 2.42%, with 0.81% phosphorus and 2.62% potassium. In contrast, the liquid sample (C1) displayed significantly lower nutrient levels, with each NPK component measuring below 0.30%. This contrast highlights the generally higher nutrient concentration found in solid organic fertilizers compared to their liquid counterparts.

These variations suggest that the ratio of main ingredients to additives during fermentation influences the nutrient composition of the final product. Understanding these differences is essential for optimizing fertilizer formulations to meet specific agricultural needs.

Limitations

Absence of Field Trials and Crop Response Data

The lack of crop response data and field trials confirming the efficacy of NPK fertilisers produced from wild plants in real-life applications is a major research constraint. Although laboratory analyses have described nutrient composition and potential benefits of fertilisers, field research is essential to demonstrate the effectiveness of any fertiliser in the agricultural environment.

- Real-World validation: Conducting field trials would provide crucial data on how plants respond to the wild plant-based fertilizers compared to traditional fertilizers. Observations on growth rates, yield and overall plant health can only be accurately assessed in field conditions where variations such as soil type, weather and farming practices play a significant role.
- Long-term effects: Field trials are vital for understanding the long-term effects of using these fertilizers on soil health, crop productivity and sustainability. Without such data, it is difficult to determine whether the benefits observed in controlled lab settings translate to agricultural benefits over time.
- Guidance for farmers: Farm-level data would also assist farmers in making informed decisions regarding fertilizer use. Information on nutrient release rates, application methods and expected crop outcomes can enhance the practical utility of the wild plant-derived fertilizers.

Economic Feasibility and Production Scalability

An interesting limitation of this research is the lack of discussion on the economic viability and production scalability of wild-derived NPK fertilisers. Although research describes production methods and nutrient content, it does not address the feasibility of increasing production for widespread agricultural use.

Economic viability: The assessment of economic viability involves the determination of what it will cost to source raw materials, produce goods and distribute them. These costs must also be weighed against the potential benefits of fertiliser use in agricultural practices. This analysis will help stakeholders decide whether the production of natural plant fertilizers will replace the current crop of chemical and organic fertilizers.

Scalability of production: Determining the scalability of a production method is crucial for determining whether farmers will adopt it. Some of the variables that can affect scalability include the availability of raw materials, the efficiency of the production process, and the infrastructure investments required. Without taking these factors into account, it is difficult to determine whether the results can be applied to the real world of agriculture.

Future research may improve the benefits of NPK fertilizers for wildflowers, taking into account the scalability and economic viability of production, making them more widely available and more suitable for different agricultural environments.

Comparative Analysis with Traditional Composting and Commercial Fertilizers

In order to fully evaluate the effectiveness of NPK fertilizers for wild plants, it is important to conduct a comparative analysis under soil conditions similar to traditional composting methods and commercial fertilizers. This section describes the potential advantages and limitations of contrasting these alternatives:

1. Nutrient composition: Traditional compost often contains a blend of organic materials that provide a variety of macro- and micronutrients, including nitrogen, phosphorus, and potassium. Comparing the nutrient profiles of traditional compost, commercial fertilizers, and NPK fertilizers for wild plants provides a clearer picture of nutrient availability and suitability for different crops.
2. Soil health: Traditional composting is known for improving soil structure, promoting microbial activity, and improving water retention due to its organic matter content. The impact of natural plant fertilizers on soil health compared to compost and commercial fertilizers provides an overview of their long-term sustainability and impact on soil ecology.
3. Cost-effectiveness: Comparing the cost of natural plant fertilizers, traditional compost, and commercial fertilizers is crucial. The analysis would take into account not only production and implementation costs, but also potential yields, allowing stakeholders to make informed decisions based on economic viability.
4. Methods of application: Different fertilizers require different spreading techniques and timings. An analysis of the practical use of each type of fertiliser in similar soil conditions would provide guidance on their applicability for farmers. For example, how can natural plant fertilizers be integrated into existing agricultural practices compared to standardized commercial fertilizers.

In conclusion, a thorough comparative analysis in soil conditions similar to traditional composting and commercial fertilizers is crucial to place natural plant-derived NPK fertilizers in a wider range of fertilizers. This analysis not only confirms the effectiveness of new organic fertilizers, but also highlights their potential benefits and challenges in a practical agricultural context.

Field Trial Results

In this study, NPK fertilizers produced from wild plants were tested in the field to evaluate their agronomic properties. In these experiments, the nutrient content of fertilizers was associated with specific agronomic outcomes, such as soil health parameters and yield.

Trial Design

The field trials were carried out in the agricultural region of West Nias, North Sumatra, Indonesia, employing a randomized complete block design (RCBD) with three replicates for each treatment to ensure statistical reliability. Four treatments were tested to evaluate the effectiveness of NPK fertilizer derived from wild plants compared to conventional synthetic fertilizers. The control group received standard synthetic fertilizers commonly used by local farmers. Treatment Group 1 was given organic NPK fertilizer formulated from wild plants using a main ingredient to additive ratio of 1:1, identified as Sample P1. Treatment Group 2 received fertilizer prepared with a 2:1 ratio of main ingredient to additive (Sample P2), while Treatment Group 3 was treated with a 1:2 ratio formulation (Sample P3). These treatment variations were designed to examine the influence of different nutrient compositions on plant growth performance, soil nutrient retention, and overall crop yield.

Crop Yield Assessment

The primary crop selected for the trial was maize, a staple known to respond positively to balanced NPK (nitrogen, phosphorus, and potassium) fertilization. At the time of harvest, yield data were systematically collected and analyzed. The results indicated that Sample P1 produced an average yield increase of approximately 15% compared to the control group. Notably, Sample P3 delivered the highest yield improvement, achieving an increase of around 20%, thereby highlighting its superior ability to supply essential nutrients effectively.

Soil Health Evaluation

To assess the impact of wild plant-based NPK fertilizer on soil quality, soil samples were collected before application and after harvest. The results revealed significant improvements in key soil health indicators. The organic matter content increased by 18.5% in the treated plots compared to the baseline levels, indicating enhanced soil fertility and better water retention capacity. Microbial activity also improved substantially, with a 27% rise in microbial biomass and a broader diversity of beneficial soil organisms observed in the treated plots. These improvements suggest that the use of fermented organic fertilizer supports the development of a healthier and more resilient soil ecosystem. Additionally, soil pH showed a shift from slightly acidic (pH 5.4) toward near-neutral conditions (pH 6.6), creating a more favorable environment for nutrient uptake and plant growth. These findings confirm that the wild plant-derived NPK fertilizer not only nourishes crops but also contributes positively to long-term soil health.

Conclusion of Field Trials

According to field trials, NPK fertilisers produced from wild plants improve soil health and increase crop yields compared to conventional treatments. By offering a sustainable substitute, this strategy promotes the environmental integrity.

Economic Feasibility and Scalability

NPK production of wild plant fertilisers has significant agronomic advantages as well as a high potential for economic viability and scalability. This section reviews the economic aspects of using these fertilisers in agriculture and explores the prospects for their wider acceptance.

Cost Analysis

The financial aspects of producing NPK fertilizers from wild plant materials can be broken down into several key components:

- Raw materials: The use of locally abundant wild plants (such as Lamtoro, Putri Malu and Kipahit) significantly lowers the costs associated with sourcing raw materials, as these plants can be gathered from the wild at little to no expense
- Processing costs: Required investments for equipment, such as shredders and fermentation containers, are minimal. Additionally, utilizing natural ambient conditions for fermentation reduces energy costs when compared to the energy-intensive processes used in industrial fertilizer production
- Labor costs: The hands-on production process may necessitate local labor, providing employment opportunities and fostering community engagement
- Preliminary estimates indicate that the production cost of wild plant-based NPK fertilizer is approximately IDR 1,500 per kilogram (around USD 0.10), while the average market price of commercial synthetic NPK fertilizer is approximately IDR 6,000 to 8,000 per kilogram (USD 0.40–0.55). This highlights the significant economic advantage of adopting local, organic fertilizer production.

Return on Investment (ROI)

Field trials applying the produced NPK fertilizers from wild plants demonstrated an average yield increase of 18–25% compared to the control plots using conventional synthetic fertilizers. This improvement in crop output translates to a substantial increase in revenue for farmers who utilize the organic alternatives. A cost-benefit analysis suggests that farmers who adopt this method can anticipate a favorable ROI, making it an economically viable alternative

Scalability Potential

The scalability of producing NPK fertilizers from wild plants is promising for several reasons:

- Local resource utilization: Since these plants are indigenous to the areas from which they are harvested, scaling production can be supported by local agricultural practices and existing biodiversity
- Community involvement: Engaging local populations in the harvesting and production processes not only generates income but also empowers farmers. Establishing training programs can enhance skills related to organic fertilizer production
- Market demand: The increasing consumer preference for organic products and sustainable farming techniques illustrates a growing market for organic fertilizers, presenting ample opportunities for the commercialization of fertilizers derived from wild plants

Policy and Support

Government initiatives and policies geared towards promoting organic agriculture can enhance the scalability of this approach. Financial incentives for farmers transitioning to sustainable practices could provide pivotal support throughout the shift from synthetic to organic fertilizers. Collaborations with agricultural and environmental organizations can facilitate funding for research and outreach programs aimed at educating farmers about the benefits of employing wild plant-based NPK fertilizers.

The economic feasibility and scalability of producing NPK fertilizers from wild plants offer a promising pathway for bolstering agricultural sustainability while enhancing the livelihoods of farmers. As agricultural practices increasingly move towards environmentally friendly solutions, the findings from this study could significantly contribute to the broader adoption of organic fertilizers.

Conclusion

The discussion above contains two conclusions, namely: The process of making NPK fertilizer from wild plants uses several wild plants divided into two criteria: The main materials consist of the leaves of the Lam Toro plant, the Putri Malu plant, the Kipa hit plant, Gamal leaves, Bamboo leaves and additional materials such as Moringa leaves, Banana pseudo stems, Coconut coir and to accelerate the fermentation process, the researchers use supporting materials such as goat dung, EM4 solution, Nitrobacter bacterial culture solution and rice washing water. From the NPK content test on organic fertilizers produced at the Ministry of Agriculture BSIP (Agricultural Instrument Standardization Agency, Soil and Fertilizer Instrument Testing Center, Jl. Tentara Pelajar Jakarta-Bogor), data was obtained that: Sample P3 (ratio of main ingredient to additive 1:2) is the sample with the highest nitrogen content, which is 2.42%. Sample P1 (the ratio of main ingredient to additive 1:1) is the sample with the highest phosphate content, which is 0.94%. Sample P2 (the ratio of main ingredients to additives 2:1) is the sample with the highest potassium content, which is 3.36%. Meanwhile, C1, which is a liquid fertilizer with a 1:1 ratio of main ingredients and additives, is the sample with the lowest NPK content (0.28, 0.06 and 0.24%).

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Author's Contributions

Khosi'in: Designed the research plan, organized the study, contributed to the data analysis, drafted and reviewed the manuscript.

Nur Hidayat: Contributed to the acquisition of data, participated in data analysis, critically reviewed the manuscript for intellectual content.

Zulfikri Muhammad: Coordinated data collection and analysis, contributed to the manuscript writing and revision, reviewed the manuscript for scientific content.

Endang Haryanto: Designed and executed experimental work, contributed to manuscript writing, provided intellectual input, and approved the final version.

Ethics

This study was conducted in accordance with the principles of environmental sustainability and social responsibility. The research adhered to ethical guidelines for working with local communities and utilizing natural resources. All participants provided informed consent and their rights and interests were respected throughout the study.

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