

Growth and Yield Response of Soybean (*Glycine max L. Merril*) to the Combination of Compost and NPK Mutiara (16-16-16)

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ABSTRAK

This study aims to determine the growth and yield response of soybean (*Glycine max L. Merril*) to the combination of compost and NPK Mutiara (16-16-16). The experiment was arranged in a factorial Randomized Block Design (RBD) consisting of 2 treatment factors, Compost and NPK Mutiara (16-16-16) with 3 replications. The observed parameters included plant height, number of leaves (strands), number of branches, number of pods filled and seed weight per plant. The results showed that the application of compost and NPK Mutiara fertilizers had a significant effect on plant height, where the calculated F-value of both factors was $98.88 > 3.07 > 2.21$. The number of leaves was also significantly affected, with an F-value of $123.61 > 3.07 > 2.21$. However, the number of branches was not significantly affected, as the F-value ($-27.28 < 2.21 < 3.07$) indicated no significant difference. Meanwhile, fruit (seed) weight showed a significant effect, with an F-value of $146.23 > 3.07 > 2.21$.

INTRODUCTION

Efforts to enhance soybean production can be achieved through improvements in cultivation practices, particularly in the selection of suitable growing media. Appropriate growing media play a crucial role in determining seedling growth performance. Ideally, the media should be light, inexpensive, easily obtainable, well-aerated, and fertile to support optimal seedling development (Anggraeni, 2018).

Compost fertilizer is one of the most natural and effective soil conditioners compared to synthetic alternatives. Generally, compost contains low levels of macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), but it provides adequate amounts of essential micronutrients required for plant growth. As a soil conditioner, compost helps prevent erosion, surface runoff, and soil cracking, while maintaining soil moisture (Sutanto, 2019).

NPK Mutiara (16-16-16) is a compound fertilizer formulated by combining the essential nutrients nitrogen (N), phosphorus (P), and potassium (K). To reduce fertilization costs, compound fertilizers are often used as an alternative to single-nutrient fertilizers. The nutrient requirements of a plant species depend on its growth stage, type, and climatic conditions (Hasibuan, 2021).

The application of compost fertilizer and NPK Mutiara (16-16-16) fertilizer doses is expected to increase soybean yield. This is because soils that have long been subjected to high levels of inorganic fertilizers often produce suboptimal results when immediately converted to organic cultivation. The integration of organic and inorganic fertilizers offers a promising solution for improving the growth and productivity of soybean (*Glycine max* L. Merrill). Over time, the proportion of inorganic fertilizers should be gradually reduced to obtain healthier crops suitable for consumption.

Based on this background, the present study was conducted under the title: "Growth and Yield Response Compost and NPK Mutiara (16-16-16) Fertilizer Application on the Growth and Yield of Soybean (*Glycine max* L. Merrill).

TINJAUAN PUSTAKA

The growth and yield response of soybean (*Glycine max* L. Merrill) to the combination of compost and NPK Mutiara (16-16-16) fertilizers can be explained through several interrelated agronomic and soil science theories, particularly the Integrated Nutrient Management Theory, Soil Fertility Theory, and Liebig's Law of the Minimum. These theories provide a conceptual basis for understanding how nutrient balance and soil properties influence plant growth and productivity.

The growth requirements for soybean plants include temperature, day length, humidity, and rainfall. Temperature fluctuations during the growth process greatly affect soybean development. Compared to the rainy season, soybean growth during the dry season, with air temperatures around 20–30°C, is considered more optimal and produces better seed quality. Day length is one of the factors causing low soybean productivity because soybeans are sensitive to the duration of sunlight exposure. Air humidity directly affects the seed maturation process; higher humidity accelerates pod ripening, resulting in less optimal seed formation.

Rainfall required to meet water needs during soybean growth is around 350–550 mm. Either a shortage or excess of water will affect soybean production (Adisarwanto, 2014).

NPK fertilizer is a compound fertilizer that contains a complete set of essential nutrients. NPK Mutiara fertilizer contains 16% nitrogen (N), 16% phosphorus (P), and 16% potassium (K). Plants can grow well and develop properly if all the essential nutrients they require are adequately supplied (Saifudin, 2007).

The Integrated Nutrient Management (INM) theory emphasizes the balanced and efficient use of both organic and inorganic fertilizers to sustain soil fertility and enhance crop productivity (FAO, 2006). Organic fertilizers such as compost improve soil physical structure, increase microbial activity, and enhance the soil's capacity to retain nutrients and moisture. In contrast, inorganic fertilizers like NPK Mutiara provide readily available macronutrients—nitrogen (N), phosphorus (P), and potassium (K)—that support rapid plant growth and yield formation.

According to the Soil Fertility Theory (Brady & Weil, 2019), soil fertility is the ability of soil to supply essential nutrients to plants in adequate amounts and proper balance. Fertile soil provides both macronutrients (N, P, K) and micronutrients (Fe, Zn, Mn, Cu, B) necessary for physiological and biochemical processes in plants. Compost contributes organic matter and essential micronutrients, improving soil aeration and water retention. NPK fertilizers, on the other hand, directly supply the primary nutrients required for vegetative and generative growth.

Liebig's Law of the Minimum (Liebig, 1840) states that plant growth is limited by the scarcest essential nutrient, even if all other nutrients are available in sufficient quantities. This principle highlights the importance of balanced nutrient management. If one nutrient—such as phosphorus or potassium—is deficient, crop productivity will not improve even with an excess of other nutrients. The integration of compost and NPK fertilizers ensures that nutrient deficiencies are minimized, allowing soybean plants to achieve optimal growth and yield potential.

Based on these theories, the combination of compost and NPK Mutiara (16-16-16) fertilizers is expected to enhance soybean growth parameters—such as plant height, number of leaves, branches, and pods—and ultimately increase yield. The organic component (compost) improves soil quality and nutrient availability over time, while the inorganic component (NPK) provides immediate nutrient supply for active growth stages.

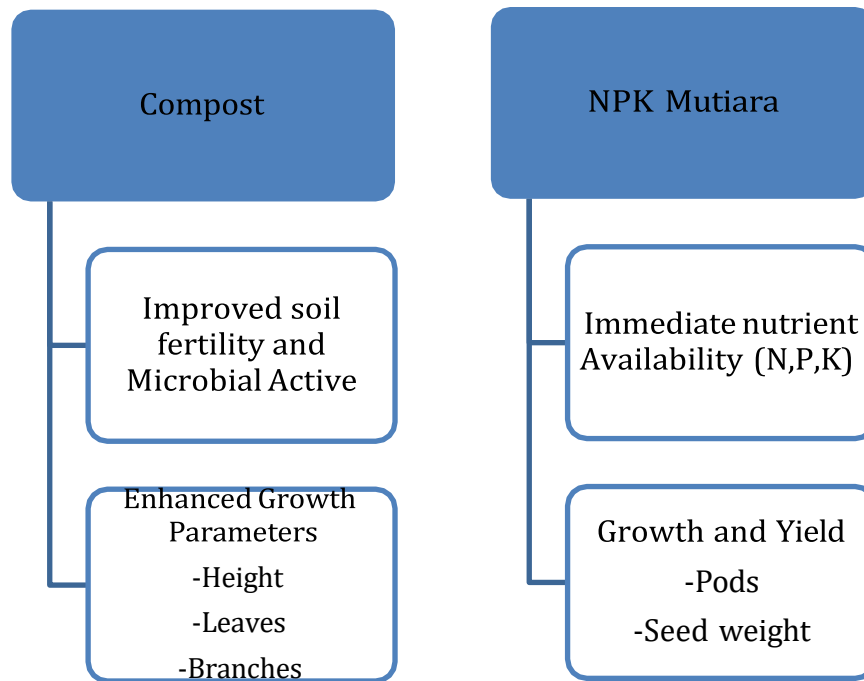


Figure 1. Conceptual Framework

METODOLOGI

Location

This research was conducted on farmland located in Tigapanah Village, Tigapanah District, Karo Regency, North Sumatra.

Materials

The materials used were soybean seeds, compost fertilizer, and NPK Mutiara fertilizer (16-16-16).

Tools

The tools used included a hoe, machete, measuring tape, raffia rope, bucket, electric backpack sprayer, knife, ruler, camera, calculator, label board, weighing scale, marker, and writing instruments.

Method

This research employs a Factorial Randomized Block Design (RBD) consisting of two treatment factors and three replications, as follows:

Factor I: Compost Fertilizer (symbol: "K")

- K₀: 0 g/plot (control, no treatment)
- K₁: 300 g/plot
- K₂: 500 g/plot
- K₃: 700 g/plot

Factor II: NPK Mutiara (16-16-16) Fertilizer (symbol: "N")

- N₀: 0 g/plot (control, no treatment)
- N₁: 20 g/plot
- N₂: 40 g/plot
- N₃: 60 g/plot

The research data were analyzed using a Factorial Randomized Block Design (RBD) with analysis of variance (ANOVA), followed by a Least Significant Difference (LSD) test to compare treatment means. The mathematical model of the Factorial Randomized Block Design is presented as follows (Montgomery, 2019):

$$Y_{ijk} = \mu + \rho_i + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \varepsilon_{ijk}$$

Where:

- $Y_{(ijk)}$: Observation value from the i th block, j th level of factor A, and k th level of factor B
- μ : Overall mean effect
- ρ_i : Effect of the i th block
- α_j : Effect of the j th level of factor A (compost fertilizer)
- β_k : Effect of the k th level of factor B (NPK Mutiara fertilizer)
- $(\alpha\beta)_{jk}$: Interaction effect between factors A and B
- ε_{ijk} : Experimental error associated with each observation

Thus, there will be 16 treatment combinations with 3 replications, resulting in a total of 48 experimental plots.

RESEARCH RESULT

After conducting the experiment, data were collected for various parameters, then processed and analyzed to obtain the following results:

PlantHeight

Measurement of plant height was carried out on selected sample plants. The measurement was taken from the base of the stem to the growing point using a measuring tape. Plant height measurements began at 2 weeks after planting (WAP) and were recorded at one-week intervals until 7 weeks after planting.

The following table presents the results of the analysis of variance (ANOVA) for the plant height of soybean (*Glycine max L. Merrill*) as affected by the application of compost fertilizer (K) and NPK Mutiara fertilizer (M) from 2 to 7 weeks after planting (WAP).

Table 1. Analysis of Variance (ANOVA) for Plant Height of Soybean at 2 to 7 Weeks After Planting (WAP)

| Age (WAP) | Treatment | F-value | F-table (5%) | F-table (1%) | Notation |
|-----------|-----------------|---------|--------------|--------------|----------|
| 2 | Compost (K) | 0.29 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 0.35 | 2.92 | 4.51 | ns |
| | K × M | 0.43 | 2.21 | 3.07 | ns |
| 3 | Compost (K) | 192.79 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 26.29 | 2.92 | 4.51 | ** |
| | K × M | 27.88 | 2.21 | 3.07 | ** |
| 4 | Compost (K) | 278.79 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 33.46 | 2.92 | 4.51 | ** |
| | K × M | 36.62 | 2.21 | 3.07 | ** |
| 5 | Compost (K) | 526.92 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 56.18 | 2.92 | 4.51 | ** |
| | K × M | 64.10 | 2.21 | 3.07 | ** |
| 6 | Compost (K) | 62.66 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 8.21 | 2.92 | 4.51 | ** |
| | K × M | 9.45 | 2.21 | 3.07 | ** |
| 7 | Compost (K) | 802.42 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 92.28 | 2.92 | 4.51 | ** |
| | K × M | 98.88 | 2.21 | 3.07 | ** |

Based on the analysis of variance (ANOVA) results presented in the table above, it can be seen that at 2 weeks after planting (WAP), plant height was not significantly affected by the treatments. At 3 WAP, the treatments had a highly significant effect on plant height, and this highly significant effect continued at 4 WAP, 5 WAP, 6 WAP, and 7 WAP. This indicates that the application of compost and NPK Mutiara fertilizers had a progressively greater influence on soybean plant height as the plants developed.

Table 2. Analysis of Variance (ANOVA) for Soybean Leaves at 2 to 7 Weeks After Planting (WAP)

| Age (WAP) | Treatment | F-value | F-table (5%) | F-table (1%) | Notation |
|-----------|-----------------|---------|--------------|--------------|----------|
| 2 | Compost (K) | 2.13 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 1.39 | 2.92 | 4.51 | ns |
| | K × M | 2.76 | 2.21 | 3.07 | * |
| 3 | Compost (K) | 1.06 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 0.26 | 2.92 | 4.51 | ns |
| | K × M | 1.79 | 2.21 | 3.07 | ns |
| 4 | Compost (K) | 64.06 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 10.50 | 2.92 | 4.51 | ** |
| | K × M | 7.89 | 2.21 | 3.07 | ** |
| 5 | Compost (K) | 685.72 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 100.25 | 2.92 | 4.51 | ** |
| | K × M | 86.89 | 2.21 | 3.07 | ** |
| 6 | Compost (K) | 1037.05 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 162.08 | 2.92 | 4.51 | ** |
| | K × M | 134.34 | 2.21 | 3.07 | ** |
| 7 | Compost (K) | 1029.09 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 120.57 | 2.92 | 4.51 | ** |
| | K × M | 123.61 | 2.21 | 3.07 | ** |

Based on the analysis of variance (ANOVA) results presented in the table, at 2 weeks after planting (WAP) the treatments had a significant effect on the number of leaves. At

3 WAP, there was no significant effect on the number of leaves. At 4 WAP, the treatments showed a highly significant effect, which continued at 5 WAP, 6 WAP, and 7 WAP, indicating that the application of compost and NPK Mutiara fertilizers had a strong influence on the leaf development of soybean plants as growth progressed.

Table 3. Analysis of Variance (ANOVA) for Branches of Soybean at 2 to 7 Weeks After Planting (WAP)

| Age (WAP) | Treatment | F-value | F-table (5%) | F-table (1%) | Notation |
|-----------|-----------------|---------|--------------|--------------|----------|
| 2 | Compost (K) | 0.39 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 2.54 | 2.92 | 4.51 | ns |
| | K × M | 0.77 | 2.21 | 3.07 | ns |
| 3 | Compost (K) | 0.56 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 1.69 | 2.92 | 4.51 | ns |
| | K × M | 0.56 | 2.21 | 3.07 | ns |
| 4 | Compost (K) | 9.00 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 1.50 | 2.92 | 4.51 | ns |
| | K × M | 1.20 | 2.21 | 3.07 | ns |
| 5 | Compost (K) | 868.99 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 109.86 | 2.92 | 4.51 | ** |
| | K × M | 102.16 | 2.21 | 3.07 | ** |
| 6 | Compost (K) | 970.44 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 148.45 | 2.92 | 4.51 | ** |
| | K × M | 123.98 | 2.21 | 3.07 | ** |
| 7 | Compost (K) | 230.33 | 2.92 | 4.51 | ** |
| | NPK Mutiara (M) | 89.40 | 2.92 | 4.51 | ** |
| | K × M | -27.28 | 2.21 | 3.07 | ns |

Based on the analysis of variance (ANOVA) table above, it can be seen that at 2 weeks after planting (WAP), the treatment had a significant effect on the number of soybean branches; at 3 WAP, it had no significant effect on the number of branches; at 4 WAP, it also had no significant effect; at 5 WAP, the treatment had a highly significant effect on the number of branches; and at 6 WAP, it showed a highly significant effect on the number of branches.

Table 4. Analysis of Variance (ANOVA) for Pods of Soybean at 10 Weeks After Planting (WAP)

| Age (WAP) | Treatment | F-value | F-table (5%) | F-table (1%) | Notation |
|-----------|-----------------|---------|--------------|--------------|----------|
| 10 | Compost (K) | 206.59 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 25.84 | 2.92 | 4.51 | ns |
| | K × M | 52.09 | 2.21 | 3.07 | ns |

Based on the analysis of variance (ANOVA) table above, it can be seen that at 10 weeks after planting (WAP), the treatment had a highly significant effect on the number of filled pods in soybean plants. According to the results of the Duncan's Multiple Range Test (DMRT) conducted on the number of filled pods under the treatments of compost fertilizer (K) and NPK Mutiara fertilizer (M), the average number of filled pods per plant can be observed as follows.

Table 5. Analysis of Variance (ANOVA) for Seeds of Soybean at 10 Weeks After Planting (WAP)

| Age (WAP) | Treatment | F-value | F-table (5%) | F-table (1%) | Notation |
|-----------|-----------------|---------|--------------|--------------|----------|
| 10 | Compost (K) | 697.95 | 2.92 | 4.51 | ns |
| | NPK Mutiara (M) | 72.50 | 2.92 | 4.51 | ns |
| | K × M | 146.23 | 2.21 | 3.07 | ns |

DISCUSSION

Effectiveness of Compost Application on the Growth and Yield of Soybean (*Glycine max* L. Merrill)

Compost is one of the organic fertilizers made from organic materials derived from plant residues or other living organisms that have undergone structural changes during the composting process. Compost cannot be made from inorganic materials because, in general, the composting process involves decomposition, and inorganic materials cannot be decomposed.

The organic materials contained in compost fertilizer are rich in both macro- and micronutrients. Compost functions as a source of nutrients and as a growing medium for plants (Sucipto, 2012).

Based on the results of the conducted research, compost dosage showed a significant effect on the plant height of soybean from 2 to 7 weeks after planting (WAP). The treatment K2 (500 g/plot) produced an average plant height of 20.83 cm, significantly higher than K0 (0 g/plot, control) with 5.33 cm, K1 (300 g/plot) with 20.67 cm, and K3 (700 g/plot) with 20.58 cm.

Similarly, the number of leaves from 2 to 7 WAP under treatment K2 (500 g/plot) was 24.25, significantly higher compared to K0 (6.08), K1 (23.08), and K3 (23.83). The number of branches from 2 to 7 WAP in treatment K2 (500 g/plot) reached 8.17, significantly higher than K0 (1.17), K1 (7.75), and K3 (7.83).

For the number of filled pods at 10 WAP, treatment K2 (500 g/plot) produced 25.17 pods, significantly higher than K0 (6.92), K1 (25.08), and K3 (23.33). The seed weight per plant at 10 WAP in treatment K2 (500 g/plot) was 59.58 g, significantly higher than K3 (49.42 g) and K1 (56.50 g).

These results are consistent with the findings of Hasibuan (2013), who stated that fertilizer dosage must be precise—neither too little nor too much—to avoid inefficiency and potential root damage. If the dosage is too low, it may not significantly affect plant growth, while excessive dosages can disrupt nutrient balance and cause root toxicity.

The use of compost or organic fertilizer in soil provides several benefits, including improving soil fertility, enhancing soil structure to become more friable and crumbly, and improving the soil's chemical properties, thereby making nutrients more readily available for plant absorption. It also enhances soil water and air regulation, helping to maintain more stable soil temperatures. Additionally, compost increases the soil's nutrient-holding capacity, making nutrients more easily dissolved in water, and improves the activity of soil microorganisms.

To obtain high-quality compost, attention must be given to the composting process and the degree of compost maturity. Well-matured compost minimizes the risk of phytotoxicity and contains higher nutrient levels compared to immature compost (Rukmana, 2018).

Effectiveness of NPK Mutiara Fertilizer on the Growth and Yield of Soybean (*Glycine max* L. Merrill)

NPK Mutiara (16-16-16) fertilizer is a type of compound fertilizer containing both macro- and micronutrients. It is usually in the form of sky-blue granules and is hygroscopic, meaning it dissolves easily in water, allowing for rapid nutrient absorption by plants. Additionally, it is neutral and does not acidify the soil. NPK Mutiara (16-16-16) contains at least three macronutrients—Nitrogen (N), Phosphate (P_2O_5), and Potassium (K_2O)—as well as two important micronutrients, Calcium (CaO) and Magnesium (MgO).

Based on the results of the conducted research, the dosage of NPK Mutiara fertilizer significantly affected soybean plant growth and yield. Plant height from 2 to 7 weeks after planting (WAP) under treatment M_0 (0 g/plot control) reached 20.83 cm, showing a significant difference compared to M_3 (60 g/plot) 15.25 cm, M_1 (20 g/plot) 15.50 cm, and M_2 (40 g/plot) 15.83 cm.

The number of leaves from 2 to 7 WAP under treatment M_0 (0 g/plot control) was 23.83, significantly higher than M_3 (60 g/plot) 17.50, M_1 (20 g/plot) 17.83, and M_2 (40 g/plot) 18.08. Similarly, the number of branches from 2 to 7 WAP under M_0 (0 g/plot control) was 7.08, significantly greater than M_3 (60 g/plot) 5.98, M_1 (20 g/plot) 5.92, and M_2 (40 g/plot) 6.08. The number of filled pods at 10 WAP under M_0 (0 g/plot control) was 23.17, significantly higher than M_1 (20 g/plot) 16.33, M_3 (60 g/plot) 18.83, and M_2 (40 g/plot) (*data continuation required*). At a dosage of 40 g/plot, the number of filled pods reached 22.17, and the pod weight at 10 weeks after planting (WAP) under treatment M_0 (0 g/plot control) was 53.92 g, showing a significant difference compared to M_1 (20 g/plot) with 38.83 g, M_3 (60 g/plot) with 41.58 g, and M_2 (40 g/plot) with 46.25 g.

This finding aligns with the opinion of Wibawa (2013), who explained that optimal plant growth can be achieved when the essential nutrients required for plant growth and yield are available in sufficient, balanced, and optimal doses. Furthermore, Hardjowigeno (2014) added that good plant growth must be supported by the availability of nutrients that meet plant requirements and are present in balanced proportions. Similarly, Darmawan and Baharsyah (2011) stated that adequate and balanced nutrient availability influences metabolic processes within plant tissues. The NPK fertilizer provides essential nutrients needed by soybean plants, thereby positively affecting seed formation and overall yield.

In line with the opinion of Rumabutar and Sudiarso (2019), the quality of seeds produced by plants is influenced by the macronutrients N, P, and K. According to Harun and Ammar (2001), seed weight is largely determined by the number and size of pods — the greater the number of pods, the more seeds are produced, resulting in heavier total seed weight. The higher number of seeds formed leads to an increase in total seed weight. This occurs because the photosynthetic products from the vegetative phase are stored as food reserves in the generative phase, in the form of carbohydrates accumulated as seeds (Van Roekel, 2015).

CONCLUSIONS AND RECOMMENDATIONS

After conducting data analysis and discussion, several conclusions from this study can be drawn as follows:

1. The results showed that the application of compost fertilizer had a highly significant effect on plant height, number of leaves, number of branches, number of filled pods, and pod weight.
2. The results also indicated that the application of NPK Mutiara fertilizer had a highly significant effect on plant height, number of leaves, number of branches, number of filled pods, and pod weight.
3. The combined effectiveness of compost and NPK Mutiara fertilizer significantly affected plant height, number of leaves, number of filled pods, and pod weight, while the number of branches was not significantly affected by the treatments.

The recommendations from this study are as follows:

1. It is advised not to use the combination treatment of K₀ (0 g/plot control) with M₁ (20 g/plot), M₂ (40 g/plot), or M₃ (60 g/plot), as this combination may cause plant mortality in soybeans.
2. Further research is recommended on the use of compost and NPK Mutiara fertilizer dosages for **other** horticultural and secondary crops (palawija) to evaluate their broader effectiveness.

ADVANCED RESEARCH

Future studies should explore the long-term effects of combining compost and NPK Mutiara fertilizers on soil fertility, nutrient balance, and microbial activity. It is also recommended to investigate the optimization of dosage ratios to achieve sustainable yield improvement in soybean cultivation while minimizing chemical fertilizer dependency.

Moreover, advanced research could expand the application of these fertilizer combinations to other horticultural and secondary crops, assessing their influence on

growth physiology, yield components, and crop quality under different agroecological conditions. Integration with precision agriculture technologies, such as soil nutrient mapping and controlled fertilizer application, would also provide valuable insights for improving fertilizer efficiency and environmental sustainability.

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