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# Effect of Combined Application of ZA Fertilizer and Goldensoil G-03 Organic Powder Fertilizer on the Growth and Yield of Lumbu Putih Garlic (*Allium sativum* L.)

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**ABSTRACT**

*Garlic (Allium sativum L.) is a valuable horticultural crop in Indonesia, widely used both as a culinary staple and for its medicinal properties. This study was conducted from October 2024 to January 2025 in Paras Hamlet, Kembangbelor Village, Pacet District, Mojokerto Regency, East Java, to determine the optimal combination of ZA fertilizer and Goldensoil G-03 organic powder fertilizer (POP) for enhancing garlic growth and yield. The research employed a factorial design with two factors using a Split Plot Design (RPT) with three replications. The main plots consisted of ZA fertilizer applications at 200 kg/ha (Z1), 300 kg/ha (Z2), and 400 kg/ha (Z3), while the sub-plots included Goldensoil G-03 POP treatments: no POP (G0), 100 g/20 kg inorganic fertilizer (G1), 200 g/20 kg (G2), and 300 g/20 kg (G3). Data were analyzed using ANOVA and the HSD test at a 5% significance level. The research results showed that the independent application of 400 kg/ha ZA fertilizer had a significant effect on garlic growth and yield. However, the independent application of Goldensoil G-03 did not have a significant impact on garlic growth and yield.*

## 1. INTRODUCTION

Garlic (*Allium sativum* L.) is a highly sought-after horticultural commodity in Indonesia due to its high economic value. It is commonly used as a cooking spice and is also utilized in medicinal treatments (Sulistyaningsih, 2020). Garlic offers various health benefits, including helping to lower blood pressure, treating respiratory disorders, and addressing other health issues. It is typically cultivated in highland areas, as it requires low temperatures and adequate sunlight to grow optimally (Waluyo, 2020).

The Ministry of Agriculture (2023), reported that the average garlic consumption in Indonesia was 398,566 tons in 2021, increasing to 555,958 tons in 2022, and slightly decreasing to 552,375 tons in 2023. However, domestic garlic production has not been able to meet national demand. Factors such as improper seed selection, suboptimal land management, and inadequate fertilization contribute to low harvest yields. Data from the Central Statistics Agency (BPS, 2023), indicate a decline in garlic production, from 45,092 tons in 2021 to 30,582 tons in 2022, before rising again to 39,254 tons in 2023. As a result, Indonesia still relies on garlic imports to meet its needs. A possible solution to this issue is to enhance cultivation efficiency, starting from seed selection to harvesting.

The challenge in increasing the production and yield of Lumbu Putih garlic variety is its small bulb size. This smaller bulb size is due to a lack of sufficient nutrients to support its growth (Yelni & Sari, 2020). However, Lumbu Putih garlic has the advantage of being able to grow well in both lowland and highland areas, unlike most other garlic varieties that generally thrive only in highland regions (Setiawan, 2020). Its upright and slender shape is another benefit, as it prevents rainwater from accumulating on the leaves, making it more resistant to diseases, especially

during the rainy season. Given these advantages, the Lumbu Putih garlic variety has great potential to become a nationally developed garlic variety (Titisari *et al*., 2019).

The small size of garlic bulbs can be addressed by providing optimal nutrients. Fertilization is a key factor in efforts to enhance the growth and yield of garlic plants. The use of recommended fertilizers is expected to produce economically beneficial results (Hendarto *et al.,* 2021). An essential macronutrient for promoting plant growth is nitrogen (N), which is readily available to plants in a relatively short time (Kristina *et al.,* 2023). Nitrogen plays a crucial role in stimulating plant growth, particularly in the stems, branches, and leaves. Additionally, micronutrients such as sulfur (S) support plant growth by aiding in bulb formation (Iswahyudi *et al.*, 2022). ZA fertilizer (*Ammonium sulfate*) is one of the fertilizers that contains essential elements like nitrogen and sulfur, which help improve the growth and yield of garlic plants (Putra, 2013).

The Ministry of Agriculture (2022), reported that Goldensoil G-03 organic powder fertilizer (POP) contains beneficial microorganisms such as *Azotobacter* sp., *Azospirulina* sp., *Bacillus* sp., *Lactobacillus* sp., *Nitrosomonas* sp., *Trichoderma* sp., and *Pseudomonas* sp. It is enriched with several endophytic bacteria and essential macro- and micronutrients, including organic carbon (39.34%), C/N ratio (7.75%), nitrogen (5.08%), phosphorus (8.24%), potassium (5.4%), as well as calcium (Ca), magnesium (Mg), sulfate ($SO_4$), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), boron (B), and molybdenum (Mo). These nutrients play a vital role in supporting garlic plant growth. Goldensoil G-03 POP provides long-term nutrient availability and enhances garlic plant development. This study aims to determine the optimal combination of ZA fertilizer and Goldensoil G-03 POP dosage to improve the growth and yield of garlic plants. This study is expected to provide insights into the effects of applying different doses of ZA fertilizer and Goldensoil G-03 POP on optimizing garlic growth, thereby supporting the improvement of garlic growth and yield.

## 2. MATERIALS AND METHODS

This research will be conducted from October 2024 to January 2025 in Paras Hamlet, Kembangbelor Village, Pacet District, Mojokerto Regency, East Java (7° 38′55″ S−112° 33′28″ E). Pacet District is located at an average altitude of 590 meters above sea level, with an annual rainfall of 202 mm, air humidity ranging from 66% to 77%, and temperatures between 22 °C and 30 °C. This study is a factorial experiment with two factors, designed using a Split Plot Design (SPD) and repeated three times. The main plot consists of ZA fertilizer doses: 200 kg/ha (Z1), 300 kg/ha (Z2), and 400 kg/ha (Z3). The subplots consist of the dose of organic powder fertilizer (POP) of the Goldensoil G-03 brand: without Goldensoil G-03 POP (G0), 100 g/20 kg of inorganic fertilizer (G1), 200 g/20 kg of inorganic fertilizer (G2), and 300 g/20 kg of inorganic fertilizer (G3).

### 2.1. Design of Experiment

The experimental plots were constructed with a length of 1 m, a width of 1 m, a height of 0.4 m, and a spacing of 0.5 m between plots, with a planting distance of 15×15 cm. The seeds used were garlic seeds of the Lumbu Putih variety. The combination treatment of ZA fertilizer and POP Goldensoil G-03 resulted in 12 treatment variations, with each treatment repeated 3 times, giving a total of 36 experimental units. Each experimental unit consisted of 25 plants (Figure 1).

The fertilizers used in this study included NPK 15:15:15, ZA fertilizer, Goldensoil G-03 fertilizer, SP-36 fertilizer, and MKP Pak Tani fertilizer. The base fertilization using SP-36 fertilizer at a rate of 487.5 kg/ha was applied after land preparation. NPK 15:15:15 fertilizer was applied at a rate of 400 kg/ha at 15 and 30 days after planting (DAP). ZA fertilizer was applied twice at 20 and 50 DAP according to the treatment doses. Goldensoil G-03 fertilizer was applied once at 20 DAP according to the treatment doses. MKP Pak Tani fertilizer was applied at 50 DAP with a dose of 200 kg/ha. The pesticides used included a combination of insecticides of the brands Triget, Abasel, and Marsal, with an adhesive agent of the Agristick brand, and supplemented with foliar fertilizer of the Antonik brand at a dose of 14.3 g.

Data collection was carried out at 14–63 days after planting (DAP) by measuring plant length, number of leaves, leaf width, and stem diameter. Post-harvest observations included fresh biomass weight per plot, dry biomass weight per plot, bulb diameter, bulb weight per plant, bulb weight per plot, bulb weight per hectare, number of cloves per bulb, and clove weight per bulb. The research data were analyzed using analysis of variance (ANOVA) with a linear model

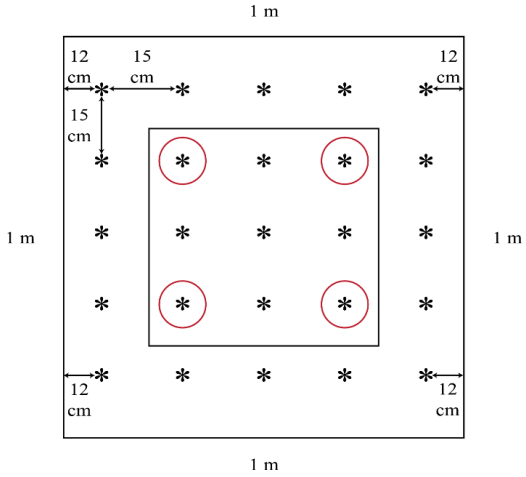


Figure 1. Experimental plot layout (○ : Sample plant, * : Garlic plant)

approach based on the method by Gomez & Gomez (1995). If the treatments showed a significant effect, a Honestly Significant Difference (HSD) test at the 5% level was conducted (Sastrosupadi, 1995).

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## 3. RESULTS AND DISCUSSION

### 3.1. Vegetative Growth

The study results revealed that the combination of ZA fertilizer and Goldensoil G-03 POP had a significant interaction effect on garlic plant length at 42–49 days after planting (DAP). Meanwhile, the application of ZA fertilizer alone had a highly significant impact on plant length at 28–35 DAP, the number of leaves at 28–42 DAP, and stem diameter, but it did not influence leaf width.

The length of garlic plants at 42 and 49 days after planting (DAP) tended to increase with higher doses of ZA fertilizer and the addition of Goldensoil G-03 POP (Table 1). The higher the dose of ZA fertilizer and Goldensoil G-03 POP, the longer the garlic plants grew, although some treatments did not show significant differences. The combination of ZA and Goldensoil G-03 POP fertilizers provides dual benefits, where organic fertilizers improve overall soil condi-

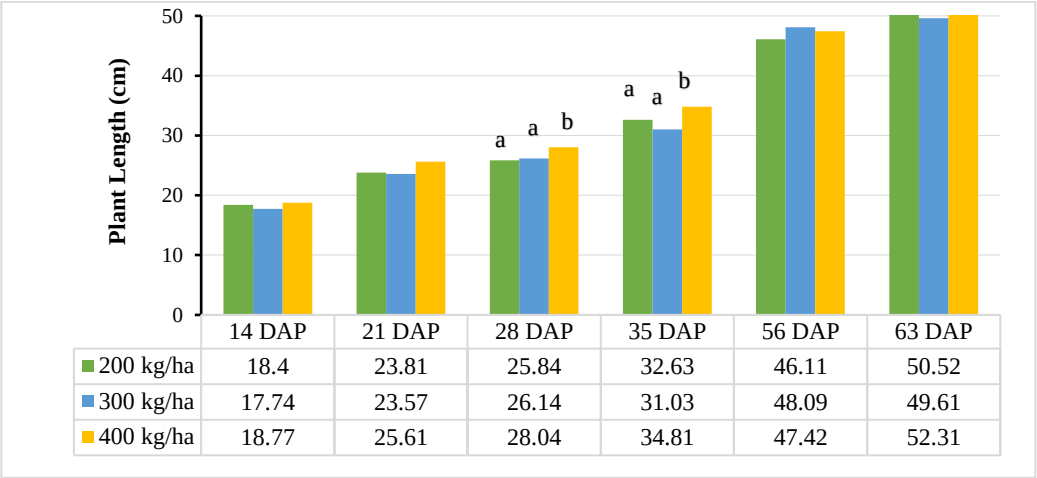
Table 1. Average length (cm) of garlic plants aged 42 – 49 DAP due to za and Goldensoil G-03 POP fertilizer treatment

| DAP | ZA Fertilizer (kg/ha) | Goldensoil G-03 POP (g/20 kg inorganic fertilizer) | | | |
|---|---|---|---|---|---|
| | | 0 | 100 | 200 | 300 |
| 42 | 200 | 36.44 ab | 35.28 a | 35.90 a | 36.62 ab |
| | 300 | 36.89 abc | 37.22 abc | 35.76 a | 39.39 cd |
| | 400 | 37.23 abc | 38.61 bc | 36.97 abc | 41.39 d |
| | HSD 5% | | | 2.63 | |
| 49 | 200 | 39.76 a | 40.89 ab | 41.18 ab | 41.36 abc |
| | 300 | 40.13 a | 40.11 a | 40.24 a | 44.11 bcd |
| | 400 | 40.96 bc | 43.83 bcd | 44.63 cd | 46.85 d |
| | HSD 5% | | | 3.35 | |

Note: Numbers with the same letter at the same age indicate no significant difference according to the 5% HSD test.

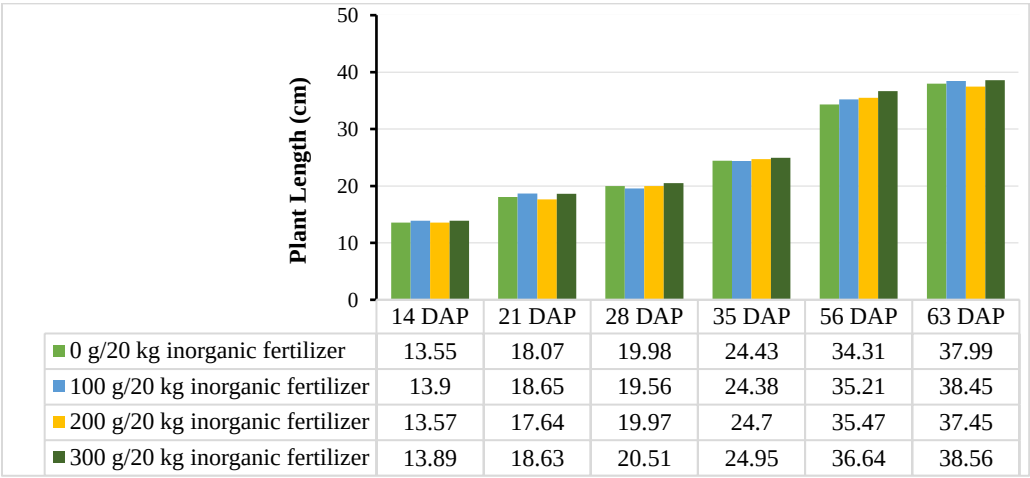
tions and increase long-term nutrient availability, while ZA fertilizers provide nitrogen and sulfur in a form that is easily absorbed by plants to support rapid growth. According to Bancin *et al.* (2016), sulfur in ZA fertilizers helps the formation of enzymes and vitamins that are important for plant metabolism.

The length of garlic plants at 42 and 49 days after planting (DAP) tended to increase with higher doses of ZA fertilizer and the addition of Goldensoil G-03 POP (Table 1). The higher the dose of ZA fertilizer and POP Goldensoil G-03, the longer the garlic plants grew, although some treatments did not show significant differences. The combination of ZA and Goldensoil G-03 POP fertilizers provides dual benefits, where organic fertilizers improve overall soil conditions and increase long-term nutrient availability, while ZA fertilizers provide nitrogen and sulfur in a form that is easily absorbed by plants to support rapid growth. According to Bancin *et al.* (2016), sulfur in ZA fertilizers helps the formation of enzymes and vitamins that are important for plant metabolism.




| | 14 DAP | 21 DAP | 28 DAP | 35 DAP | 56 DAP | 63 DAP |
|---|---|---|---|---|---|---|
| 200 kg/ha | 18.4 | 23.81 | 25.84 | 32.63 | 46.11 | 50.52 |
| 300 kg/ha | 17.74 | 23.57 | 26.14 | 31.03 | 48.09 | 49.61 |
| 400 kg/ha | 18.77 | 25.61 | 28.04 | 34.81 | 47.42 | 52.31 |

Figure 2. Average plant length due to ZA fertilizer treatment

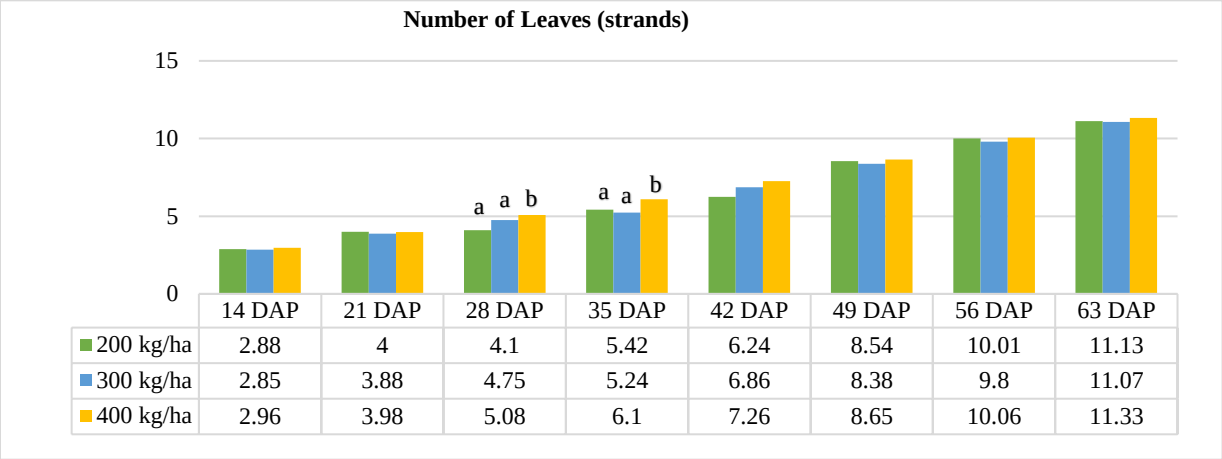



| | 14 DAP | 21 DAP | 28 DAP | 35 DAP | 56 DAP | 63 DAP |
|---|---|---|---|---|---|---|
| 0 g/20 kg inorganic fertilizer | 13.55 | 18.07 | 19.98 | 24.43 | 34.31 | 37.99 |
| 100 g/20 kg inorganic fertilizer | 13.9 | 18.65 | 19.56 | 24.38 | 35.21 | 38.45 |
| 200 g/20 kg inorganic fertilizer | 13.57 | 17.64 | 19.97 | 24.7 | 35.47 | 37.45 |
| 300 g/20 kg inorganic fertilizer | 13.89 | 18.63 | 20.51 | 24.95 | 36.64 | 38.56 |

Figure 3. Average plant length due to Goldensoil G-03 POP treatment

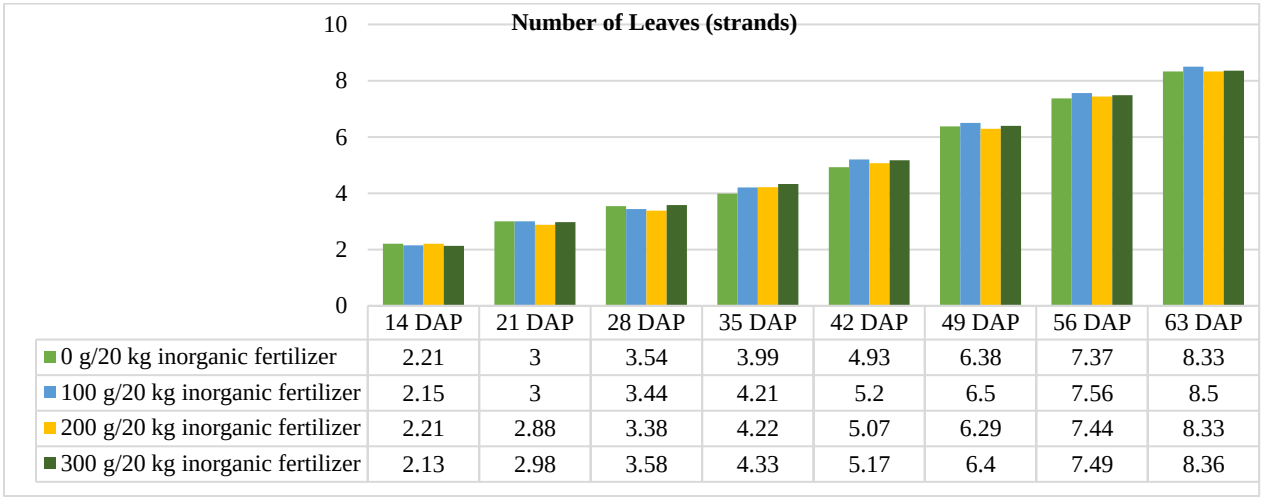
Differences in ZA fertilizer doses affect the length of garlic plants (Figure 2). According to Putra (2013), the application of ZA fertilizer at a dose of 400 kg/ha increases the availability of nutrients in the soil, especially nitrogen, which supports garlic growth. This leads to faster plant growth. Hamdani *et al.* (2023), ZA fertilizer supports the acceleration of vegetative growth, allowing plants to grow larger, with broader and greener leaves. The nitrogen content in this fertilizer plays a role in improving protein quality.

The results of the analysis of variance show that the single factor of 400 kg/ha ZA fertilizer treatment has a very significant effect on the number of plant leaves at the age of 28 - 42 DAP (Figure 4). Wahyudi *et al.* (2015), added that plant growth is generally characterized by an increase in plant height and depends on the availability of N, P, and K nutrients. During the vegetative phase, growth occurs rapidly until plant organs reach their maximum size, before slowing down in the generative phase.




| | 14 DAP | 21 DAP | 28 DAP | 35 DAP | 42 DAP | 49 DAP | 56 DAP | 63 DAP |
|---|---|---|---|---|---|---|---|---|
| 200 kg/ha | 2.88 | 4 | 4.1 | 5.42 | 6.24 | 8.54 | 10.01 | 11.13 |
| 300 kg/ha | 2.85 | 3.88 | 4.75 | 5.24 | 6.86 | 8.38 | 9.8 | 11.07 |
| 400 kg/ha | 2.96 | 3.98 | 5.08 | 6.1 | 7.26 | 8.65 | 10.06 | 11.33 |

Figure 4. Average number of leaves due to ZA fertilizer treatment




| | 14 DAP | 21 DAP | 28 DAP | 35 DAP | 42 DAP | 49 DAP | 56 DAP | 63 DAP |
|---|---|---|---|---|---|---|---|---|
| 0 g/20 kg inorganic fertilizer | 2.21 | 3 | 3.54 | 3.99 | 4.93 | 6.38 | 7.37 | 8.33 |
| 100 g/20 kg inorganic fertilizer | 2.15 | 3 | 3.44 | 4.21 | 5.2 | 6.5 | 7.56 | 8.5 |
| 200 g/20 kg inorganic fertilizer | 2.21 | 2.88 | 3.38 | 4.22 | 5.07 | 6.29 | 7.44 | 8.33 |
| 300 g/20 kg inorganic fertilizer | 2.13 | 2.98 | 3.58 | 4.33 | 5.17 | 6.4 | 7.49 | 8.36 |

Figure 5. Average number of leaves due to Goldensoil G-03 POP treatment

The average result of the highest number of plant leaves at the age of 28 DAP in the treatment of 400 kg/ha ZA fertilizer was 5.08 strands, while the average result of the fewest number of plant leaves was in the treatment of 200 kg/ha ZA fertilizer was 4.10 strands (Figure 4). The average result of the largest number of plant leaves at the age of 35 DAP in the treatment of 400 kg/ha ZA fertilizer was 6.10 strands, while the average result of the fewest number of plant leaves was in the treatment of 200 kg/ha ZA fertilizer was 5.24 strands.

Single factor of ZA fertilizer treatment there is a very significant difference in the diameter of the garlic plant stem. The average result of the largest plant stem diameter in the treatment of 400 kg/ha ZA fertilizer is 11.59 mm, while the average result of the smallest plant stem diameter in the treatment of 200 kg/ha ZA fertilizer is 9.65 mm (Table 2). According to Febryanto *et al.* (2023), the length of garlic plants is influenced by several factors, such as adequate nutrients and growth hormones. Auxin found at the tip of the plant plays a role in stimulating cell division, enlargement, and elongation, which contributes to an increase in plant height.

Table 2. Observation of parameters stem diameter and leaf width

| Treatment | Observation of Vegetative Parameters | |
|---|---|---|
| | Stem Diameter (mm) | Leaf Width (cm) |
| ZA fertilizer (kg/ha) | | |
| 200 | 9.65 a | 1.83 |
| 300 | 10.05 a | 1.82 |
| 400 | 11.59 b | 1.97 |
| HSD 5% | 1.80 | ns |
| POP Goldensoil G-03 (g/20 kg inorganic fertilizer) | | |
| 0 | 7.99 | 1.38 |
| 100 | 7.91 | 1.45 |
| 200 | 7.73 | 1.40 |
| 300 | 7.67 | 1.38 |
| HSD 5% | ns | ns |

Note: Numbers with the same letter at the same age indicate no significant difference according to the 5% HSD test (ns = not significant)

### 3.2. Generative Growth

The results showed that the combination treatment of ZA and Goldensoil G-03 POP fertilizers did not provide significant interaction on the weight of bulbs per garlic plant. The single factor of ZA fertilizer treatment had a very significant effect on the wet weight of the stubble per plot, dry weight of the stubble per plot, bulb diameter, bulb weight per plant, bulb weight per plot, bulb weight per hectare, and the number of cloves per bulb.

Table 3. Effect of ZA and Goldensoil G-03 POP fertilizers on plant generative parameters

| Treatment | Observation of Generative Parameters | | |
|---|---|---|---|
| | Fresh Weight (g) | Dry Weight (g) | Tuber Weight Per Plant (g) |
| ZA fertilizer (kg/ha) | | | |
| 200 | 1085.42 a | 419.55 a | 12.37 a |
| 300 | 1032.43 a | 302.78 a | 12.53 a |
| 400 | 1240.80 b | 486.34 b | 15.87 b |
| HSD 5% | 197.16 | 17.01 | 3.17 |
| POP Goldensoil G-03 (g/20 kg inorganic fertilizer) | | | |
| 0 | 854.03 | 291.13 | 10.67 |
| 100 | 842.60 | 314.58 | 10.36 |
| 200 | 835.94 | 332.31 | 10.05 |
| 300 | 826.08 | 270.64 | 9.68 |
| HSD 5% | ns | ns | ns |

Note: Numbers with the same letter at the same age indicate no significant difference according to the 5% HSD test (ns = not significant)

The average wet weight of the stover per m² was the largest in the 400 kg/ha ZA fertilizer treatment, which was 1240.80 g, while the average wet weight of the stover per m² was the smallest in the 300 kg/ha ZA fertilizer treatment, which was 1032.43 g. The average dry weight of the stover per m² was the largest in the 400 kg/ha ZA fertilizer treatment, which was 486.34 g, while the average dry weight of the stover per m² was the smallest in the 300 kg/ha ZA fertilizer treatment, which was 302.78 g. The average tuber weight per plant was the largest in the 400 kg/ha ZA fertilizer treatment, which was 15.87 g, while the average tuber weight per plant was the smallest in the 200 kg/ha ZA fertilizer treatment, which was 12.37 g (Table 3). In line with Saptorini *et al*. (2019), ZA fertilizer is highly nutritious, particularly in nitrogen, which contributes to faster plant growth and enhanced production. Nitrogen functions as a component of protein and cell nuclei, thus supporting larger plant growth, especially in increasing the number of tubers.

The average result of the largest plant tuber diameter was in the 400 kg/ha ZA fertilizer treatment, which was 38.51 mm, while the average result of the smallest plant tuber diameter was in the 200 kg/ha ZA fertilizer treatment, which was 31.09 mm. The average result of the number of cloves per tuber was the largest in the 400 kg/ha ZA fertilizer treatment, which was 15.65 cloves, while the average result of the number of cloves per tuber was the smallest in the 200 kg/ha ZA fertilizer treatment, which was 8.97 cloves (Table 4). According to Fauziah *et al*. (2018), it is explained that another element contained in ZA fertilizer is sulfur (S) which is used in the formation of tubers.

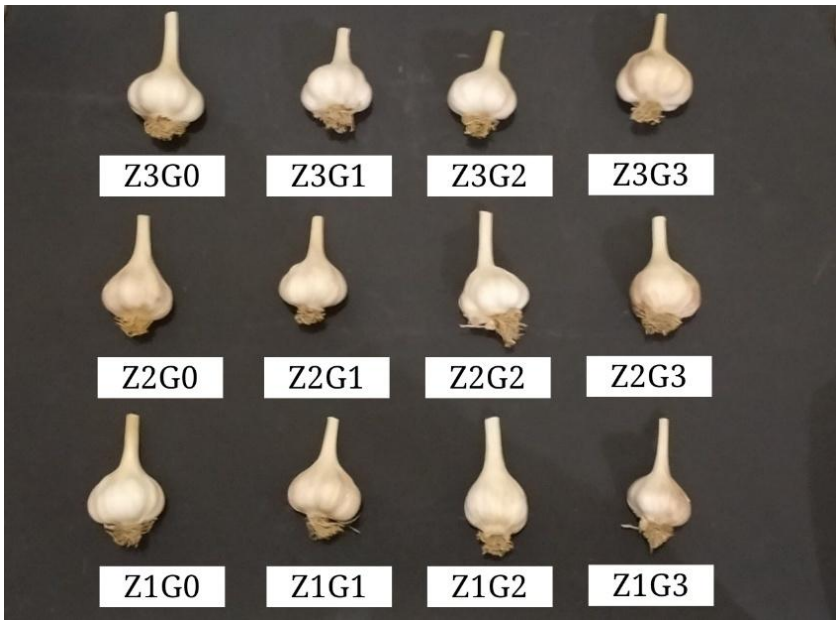



Figure 6. Garlic bulbs produced with different doses of ZA fertilizer (Z) and POP Goldensoil G-03 (G): Z1 (200 kg/ha); Z2 (300 kg/ha); Z3 (400 kg/ha); G0 (Without POP Goldensoil G-03; G1 (100 g/20 kg); G2 (200 g/20 kg; G3 (300 g/20 kg).

Table 4. Effect of ZA and POP Goldensoil G-03 fertilizers on plant generative parameters

| Treatment | Observation of Generative Parameters | | |
|---|---|---|---|
| | Tuber Diameter (mm) | Number of Cloves Per Bulb (Cloves) | Clove Weight Per Bulb (g) |
| ZA fertilizer (kg/ha) | | | |
| 200 | 31.09 a | 8.97 a | 1.29 |
| 300 | 34.12 a | 1.86 a | 1.02 |
| 400 | 38.51 b | 1.65 b | 1.36 |
| HSD 5% | 4.55 | 6.27 | ns |
| POP Goldensoil G-03 (g/20 kg inorganic fertilizer) | | | |
| 0 | 25.31 | 9.57 | 0.90 |
| 100 | 26.26 | 8.17 | 1.04 |
| 200 | 26.33 | 8.61 | 0.99 |
| 300 | 25.81 | 10.14 | 0.74 |
| HSD 5% | ns | ns | ns |

Note: Numbers with the same letter at the same age indicate no significant difference according to the 5% HSD test (ns = not significant)

Table 5. Effect of ZA and POP Goldensoil G-03 fertilizers on plant generative parameters

| Treatment | Observation of Generative Parameters | |
|---|---|---|
| | Weight of Tubers per Plot (g) | Berat Umbi per Hektar (Ton) |
| ZA fertilizer (kg/ha) | | |
| 200 | 232.08 a | 2.105 a |
| 300 | 260.38 a | 2.115 a |
| 400 | 392.86 b | 2.972 b |
| HSD 5% | 151.17 | 0.8 |
| POP Goldensoil G-03 (g/20 kg inorganic fertilizer) | | |
| 0 | 203.31 | 1.877 |
| 100 | 200.67 | 1.955 |
| 200 | 246.15 | 1.687 |
| 300 | 235.19 | 1.672 |
| HSD 5% | ns | ns |

Note: Numbers with the same letter at the same age indicate no significant difference according to the 5% HSD test (ns = not significant)

The average yield of tuber weight per m² was the largest in the 400 kg/ha ZA fertilizer treatment, which was 392.86 g, while the average yield of tuber weight per m² was the smallest in the 200 kg/ha ZA fertilizer treatment, which was 232.08 g. The average yield of tuber weight per hectare was the largest in the 400 kg/ha ZA fertilizer treatment, which was 2.972 tons, while the average yield of tuber weight per hectare was the smallest in the 200 kg/ha ZA fertilizer treatment, which was 2.105 tons (Table 5). According to Wahyudi *et al.* (2015), the rise in photosynthate, reflected in the total dry weight of plants, represents its accumulation in plant organs. The total dry weight is a product of the plant's growth and development. This aligns with the irreversible increase in plant size and dry weight, indicating the expansion of protoplasm through both cell enlargement and an increase in cell number.

## 4. CONCLUSION

The combination treatment of 400 kg/ha ZA fertilizer and 300 g/20 kg inorganic fertilizer produced the best results for plant length parameters between 42 and 49 DAP. Meanwhile, the application of 400 kg/ha ZA fertilizer alone resulted in optimal outcomes for plant length (28–35 DAP), number of leaves (28–42 DAP), stem diameter, wet and dry weight of stumps per plot, bulb diameter, bulb weight per plant, bulb weight per plot, bulb weight per hectare, and the number of cloves per bulb. The use of Goldensoil G-03 POP did not have a significant impact on the growth and yield of garlic plants. Further research is recommended to be conducted more comprehensively by adding observation parameters such as average leaf area, chlorophyll content, harvest index, and variations of additional organic materials in garlic cultivation.

## AUTHOR CONTRIBUTION STATEMENT

| Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KWS | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | |
| Mak | ✓ | ✓ | | | | | | | | ✓ | | ✓ | | |
| FDD | ✓ | ✓ | | | | | | | | ✓ | | ✓ | | |

| | | | |
|---|---|---|---|
| C: Conceptualization | Fo: Formal Analysis | O: Writing - Original Draft | Fu: Funding Acquisition |
| M: Methodology | I: Investigation | E: Writing - Review & Editing | P: Project Administration |
| So: Software | D: Data Curation | Vi: Visualization | |
| Va: Validation | R: Resources | Su: Supervision | |

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