# The role of organic fertilizer on the morphology and physiology of red ginger

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**Abstract.** Excessive inorganic fertilizers can exacerbate the impact of climate change on the agricultural sector, with an impact on decreasing soil fertility and crop production. The study aims to examine the role of the type and dosage of organic fertilizer on the morphology and physiology of red ginger. The study used a Completely Randomized Block Design with a Split Plot pattern with two factors: the type of organic fertilizer for the main plot, and the dosage as a subplot. The type of organic fertilizer consists of three levels: cow, goat, and chicken manure. The fertilizer dosage with three levels is 10; 20 and 30 tons $ha^{-1}$. The fertilizer affects the morphology of red ginger, namely the number of shoots. Goat manure fertilizer with a dose of 30 tons ha-1 shows the highest number of shoots, namely 15.58 shoots. The type of fertilizer affects the physiology of red ginger, namely chlorophyll content and leaf area index. Goat manure fertilizer shows the highest chlorophyll content and leaf area index, namely 48.98 mg $g^{-1}$ and 0.88 cm. Organic fertilizer can encourage plant growth and yield by reducing the impact of climate change.

## 1 Introduction

Dependence on chemical fertilizers can exacerbate the impacts of climate change, leading to decreased soil health and fertility, and reduced agricultural production. Chemical fertilizers contribute to soil degradation by reducing microbial diversity, disrupting nutrient cycling processes, and disrupting the ecological balance necessary for healthy plant growth and agricultural productivity [1]. This poses a significant challenge to food security in the face of climate change [2]. The impact of chemical fertilizers on climate change is increased greenhouse gas emissions during their production and application [3]. This issue encourages efforts to mitigate environmental degradation through environmentally friendly fertilization, such as organic fertilizers. One strategic step in applying organic fertilizers is for medicinal

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plants like red ginger, which require not only high productivity but also optimal quality of active ingredients.

Red ginger is a medicinal plant with high flavonoid, phenol, terpenoid, and essential oil content, thus exhibiting anti-inflammatory, antioxidant, and antimicrobial activities [4]. The potential of red ginger, the trend of natural lifestyles, and increasing public awareness of health post-COVID-19 pandemic have driven increased consumption of red ginger-based products. However, ginger production in Indonesia remains relatively low. One of the obstacles to red ginger cultivation is soil degradation and decreased nutrient absorption efficiency due to the continuous use of chemical fertilizers. Organic fertilizers containing animal manure can improve soil health by enhancing soil structure, water retention, and encouraging microbial activity, which is essential for nutrient availability [5]. This supports root growth and plant nutrient uptake. Applying organic fertilizer to red ginger plants can support photosynthesis, thereby increasing leaf growth and producing higher yields.

Various sources of organic animal manure fertilizer have varying compositions and benefits related to nutrient release rates, microbial activity, and soil health. Goat manure can enhance rhizome and root growth of red ginger in agroforestry systems. Cow manure contains high levels of organic matter and balanced nutrients, thus promoting soil structure and moisture retention [6]. Organic matter can result in increased root biomass, thus promoting plant growth. Microbial communities associated with various types of animal manure can enhance soil enzymatic activity, which is essential for nutrient cycling and uptake. This increased biological activity can enhance plant stress resistance and improve nutrient uptake efficiency. Chicken manure contains high levels of potassium, which plays a role in maintaining osmotic balance and water regulation in plant cells, thus influencing stomatal opening and photosynthesis. Chicken manure treatment can increase photosynthesis rates under drought conditions [7]. Integrating organic fertilizers into agricultural practices not only supports the growth and yield of red ginger but also serves as a sustainable approach that addresses the challenges of soil health degradation and climate change. The novelty of the research is comparing several types of organic animal manure fertilizer with several doses to examine its effect on the morphology and physiology of red ginger which has not been studied previously. This study aims to examine the role of the type and dose of various types of animal manure fertilizer on the morphology and physiology of red ginger.

## 2 Materials and Methods

The research was conducted in Sukosari, Jumantono, Karanganyar Regency, Central Java, Indonesia with coordinates 07°38.070' South Latitude and 110°56.851" East Longitude with an altitude of 176 meters above sea level (masl). The research location has rainfall of 110-335 mm from November 2024 to April 2025. The research used a Completely Randomized Block Design with a Split plot pattern consisting of two factors, namely the type of organic fertilizer as the main plot and the fertilizer dose as a subplot with 3 replications. The type of organic fertilizer consists of three levels, namely cow, goat and chicken manure. The fertilizer dose consists of three levels, namely 10; 20; and 30 tons.ha$^{-1}$. In one treatment combination there are twenty-four ginger plant populations. The ginger planting distance used is 25 x 25 cm. The materials used are red ginger rhizomes of the Jahiran 1 variety, cow, goat and chicken manure fertilizer. The observed variables are plant height, number Leaf height, number of tillers, chlorophyll content, and leaf area index. Plant height, number of leaves, number of tillers, and leaf area index were observed twenty-four weeks after planting. Chlorophyll content was observed sixteen weeks after planting using the Arnon 1949 method and measured with a UV-Vis spectrophotometer at wavelengths of 645 nm and 663 nm. Leaf area was calculated using the leaf length x width method. Data were analyzed using the Analysis of Variance test at the 5% level to determine the effect of treatment factors on the observed variables. If significant, a Duncan's Multiple Range Test at the 5% level was used to test for significant differences.

# 3 Results and Discussion

## 3.1 Red Ginger Morphology

The results showed that the type and dosage of organic fertilizer had no effect on red ginger plant height (Table 1). Red ginger plant height ranged from 64.64 cm to 80.50 cm, with the highest average value at 77.49 cm in the 30 ton ha$^{-1}$ treatment. This indicates a tendency for plant height to increase with increasing organic fertilizer dosage. Based on the average results, goat manure fertilizer showed the highest plant height compared to chicken and cow manure treatments. This is supported by the high organic matter and organic carbon content of goat manure. The high organic matter and organic carbon in goat manure play an important role in improving soil structure, increasing aeration and drainage, thus allowing for more effective water retention. This encourages root growth and facilitates water absorption [5]. The addition of organic manure fertilizer can reduce soil density and increase water retention capacity, thus supporting plant growth.

**Table 1.** The Role of Organic Fertilizer Type and Dose on Red Ginger Plant Height (cm)

| **Types of Fertilizer** | **Dose (ton ha$^{-1}$)** | | | | **Average** |
|---|---|---|---|---|---|
| | **0** | **10** | **20** | **30** | |
| Cow Fertilizer | 68.42±2.48 | 68.75±9.84 | 64.64±6.90 | 75.38±1.54 | 69.30 |
| Goat Fertilizer | 72.08±4.13 | 76.08±14.60 | 74.13±5.49 | 76.58±3.92 | 74.72 |
| Chicken Fertilizer | 69.75±8.76 | 62.92±11.14 | 70.50±11.04 | 80.50±10.24 | 70.92 |
| Average | 70.08 | 69.25 | 69.75 | 77.49 | - |

Description: (±) = Standard deviation; (-) = No interaction between fertilizer type and dose

The results showed that the type and dosage of organic fertilizer affected the number of red ginger leaves (Table 2). This may be due to the slow-release nature of organic fertilizer nutrients. However, the highest number of leaves was found in the goat manure treatment. This is driven by the higher organic matter and organic carbon content in goat manure compared to cow or chicken manure. Organic matter plays a role in improving soil physical properties, increasing water retention and soil aggregate stability [5]. This supports root activity in absorbing nutrients, especially nitrogen, which plays a role in leaf formation and vegetative plant growth [8]. Furthermore, the organic matter from goat manure plays a role in increasing the soil's cation exchange capacity, preventing nutrient leaching and maintaining plant availability in a form that can be absorbed by plants. Stable nutrient availability and maintained soil moisture create optimal physiological conditions for photosynthesis and leaf tissue formation.

**Table 2.** The Role of Organic Fertilizer Type and Dose on the Number of Red Ginger

| **Types of Fertilizer** | **Dose (ton ha$^{-1}$)** | | | | **Average** |
|---|---|---|---|---|---|
| | **0** | **10** | **20** | **30** | |
| Cow Fertilizer | 78.17±8.52 | 87.33±22.31 | 74.83±9.78 | 95.00±3.04 | 83.83 |
| Goat Fertilizer | 98.50±11.82 | 107.83±32.34 | 94.00±9.54 | 92.17±14.75 | 98.13 |
| Chicken Fertilizer | 83.67±20.14 | 60.33±22.88 | 87.67±28.94 | 96.50±18.36 | 82.04 |
| Average | 86.78 | 85.17 | 85.50 | 94.56 | - |

Description: (±) = Standard deviation; (-) = No interaction between fertilizer type and dose

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The results showed that the type and dosage of organic animal manure fertilizer affected the number of red ginger shoots (Table 3). The highest number of shoots was found in the goat manure treatment with an average of 13.19, significantly different from the cow manure (9.33) and chicken manure (10.04). Furthermore, there was a tendency for an increase in the number of shoots at the 30 ton ha$^{-1}$ dose compared to the other doses. This is due to the different composition of organic matter and nutrient content in each type of fertilizer. Goat manure contains high levels of organic matter and organic carbon with a balanced C/N ratio, thus providing nutrients more stably [9]. This organic matter improves soil structure, increases porosity, and increases water-holding capacity. Loose, well-drained soil creates an optimal rooting environment, supports rhizome development and the formation of new shoots, which directly contributes to an increase in the number of shoots. In addition to improving soil physical properties, organic matter from goat manure also increases soil microbial activity, which plays a role in decomposition and mineralization processes. Nitrogen plays a role in stimulating vegetative growth and shoot formation, while phosphorus supports root system development and the formation of new rhizomes. Adequate and balanced nutrient availability enables plants to produce more shoots [10].

**Table 3.** The role of organic fertilizer type and dosage on the number of red ginger shoots

| Types of Fertilizer | Dose (ton ha$^{-1}$) | | | | Average |
|---|---|---|---|---|---|
| | **0** | **10** | **20** | **30** | |
| Cow Fertilizer | 8.33±0.76 | 9.75±2.64 | 9.00±1.80 | 10.25±0.43 | 9.33a |
| Goat Fertilizer | 12.08±1.77 | 14.67±5.16 | 11.42±1.88 | 14.58±3.92 | 13.19b |
| Chicken Fertilizer | 9.75±2.64 | 7.50±2.25 | 8.83±3.50 | 14.08±4.40 | 10.04a |
| Average | 10.05a | 10.64ab | 9.75a | 12.98b | - |

Description: Numbers followed by the same letter in the column indicate no significant difference based on the 5% DMRT; (±) = Standard deviation; (-) = No interaction between fertilizer type and dose

## 3.2 Red Ginger Plant Physiology

Chlorophyll content is a primary indicator of photosynthetic capacity, which is strongly influenced by nutrients, particularly nitrogen, which plays a crucial role in chlorophyll synthesis. The results showed that the type of organic fertilizer significantly affected the chlorophyll content of red ginger leaves, while the dosage of organic fertilizer had no significant effect (Table 4). Based on the average results, the highest chlorophyll content was obtained in the goat manure treatment (48.61). Goat manure provided the highest yield due to its high organic matter and organic carbon content, as well as a balanced C/N ratio [11]. The abundant organic matter content plays a role in improving soil structure, increasing water retention, and increasing the soil's cation exchange capacity [12]. This allows essential nutrients such as nitrogen, magnesium, and iron to be more easily absorbed by plant roots. Nitrogen is the main component of chlorophyll molecules, while magnesium functions as the atomic nucleus in the chlorophyll structure [13]. With sufficient availability of both elements, the chlorophyll formation process is optimal, resulting in greener leaves and increased photosynthetic activity. Furthermore, the organic matter in goat manure also improves the life of soil microorganisms, which aid in the mineralization of nutrients into forms readily absorbed by plants. Increased chlorophyll content reflects higher photosynthetic efficiency, which ultimately supports optimal vegetative growth and biomass formation in red ginger plants.

**Table 4.** The role of organic fertilizer type and dosage on red ginger chlorophyll content (mg $g^{-1}$)

| Types of Fertilizer | Dose (ton $ha^{-1}$) | | | | Average |
|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | |
| Cow Fertilizer | 35.08±13.70 | 39.69±16.39 | 49.74±18.43 | 47.40±21.96 | 42.98 a |
| Goat Fertilizer | 46.89±18.45 | 40.40±18.85 | 53.34±6.12 | 53.94±20.74 | 48.61 b |
| Chicken Fertilizer | 55.43±13.54 | 48.18±23.04 | 52.11±20.25 | 36.30±19.92 | 46.00 a |
| Average | 45.80 | 42.76 | 51.73 | 45.88 | - |

Description: Numbers followed by the same letter in the column indicate no significant difference based on the 5% DMRT; (±) = Standard deviation; (-) = No interaction between fertilizer type and dose

The leaf area index in red ginger plants is an important indicator that reflects the plant's ability to capture light for photosynthesis and vegetative growth [14]. The results showed that the type of organic fertilizer significantly affected the leaf area index of red ginger, while the dosage of organic fertilizer did not significantly affect it (Table 5). The highest leaf area index value was found in the goat manure treatment with an average of 0.88. Differences between fertilizer types indicate that the quality of organic matter and the availability of nutrients contained in the fertilizer play a significant role in influencing leaf formation and expansion. Goat manure has a high organic matter and organic carbon content, as well as an ideal C/N ratio to support the mineralization process [15]. High organic matter can improve soil structure, increase water holding capacity, and increase cation exchange capacity. Improved physical and chemical properties of the soil create an ideal rooting environment, increasing nutrient absorption such as nitrogen, phosphorus, and potassium. Nitrogen is a key component in the formation of protein and chlorophyll, which play an important role in photosynthesis and leaf growth. Meanwhile, phosphorus supports the development of a strong root system, thus optimizing nutrient absorption. Under these conditions, plants fed with goat manure were able to produce larger leaf areas, as reflected in the highest leaf area index values. Large leaf area indicates high photosynthetic capacity, which in turn increases biomass accumulation and vegetative growth of red ginger plants.

**Table 5.** The role of the type and dose of organic fertilizer on the leaf area index of red ginger ($cm^2$)

| Types of Fertilizer | Dose (ton $ha^{-1}$) | | | | Average |
|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | |
| Cow Fertilizer | 0.56±0.20 | 0.55±0.15 | 0.62±0.22 | 0.71±0.32 | 0.61 a |
| Goat Fertilizer | 0.96±0.37 | 0.69±0.29 | 0.81±0.24 | 1.07±0.17 | 0.88 b |
| Chicken Fertilizer | 0.55±0.08 | 0.67±0.12 | 0.72±0.08 | 0.94±0.34 | 0.72 a |
| Average | 0.69 | 0.63 | 0.71 | 0.90 | - |

Description: Numbers followed by the same letter in the column indicate no significant difference based on the 5% DMRT; (±) = Standard deviation; (-) = No interaction between fertilizer type and dose

# 4 Conclusion

The type of organic fertilizer plays a role in the morphological and physiological growth of red ginger. Goat manure fertilizer at a dose of 30 tons $ha^{-1}$ provided the best results for all morphological and physiological parameters, namely plant height of 76.58 cm, number of leaves of 92.17, number of tillers of 14.58, chlorophyll content of 53.94, and leaf area index of 1.07. These results indicate that goat manure fertilizer can increase the growth of red ginger. Organic fertilizer can encourage plant growth and yield by reducing the impact of climate change.

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