# GROWTH AND DEVELOPMENT OF TEA SEEDLINGS GMB 7 CLONE THROUGH ORGANIC FERTILIZER AND COW MANURE

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**ABSTRACT**

The amount of tea production in Indonesia has always experienced a downward trend. Tea plants' high and low production cannot be separated from soil quality and nutrient availability. The quality of topsoil is declining, so it is necessary to add cow manure and vermicompost to improve the soil's physical properties and positively influence the growth of tea seedlings. This study aims to determine the response of cow manure and vermicompost to the growth of tea seedlings and obtain the dose of cow manure and vermicompost that can provide the best results in the growth of tea seedlings. The experimental method used a Randomized Block Design (RBD) consisting of 10 treatments with various compositions of cow manure compost and vermicompost as a mixture of topsoil planting media added with Urea and EM4 fertilizers. The treatment arrangement was as follows: A = 100% topsoil (control); B = 200 g cow manure + 60 g vermicompost; C = 200 g cow manure + 80 g vermicompost ; D = 200 g cow manure + 100 g vermicompost; E = 300 g cow manure + 60 g vermicompost; F = 300 g cow manure + 80 g vermicompost G = 300 g cow manure + 100 g vermicompost; H = 450 g cow manure + 60 g vermicompost; I = 450 g cow manure + 80 g vermicompost; J = 450 g cow manure + 100 g vermicompost. The results showed that a combination of cow manure and vermicompost showed the best results on the chlorophyll index of the leaves. The topsoil treatment was far superior to the other treatments in terms of plant height, number of leaves, and leaf area parameters. It is suspected that andisol topsoil has a more stable physico-chemical balance supporting tea seedlings' growth.

**Keywords**: Growth; Organic manure; Planting media; Vermicompost; Tea

## INTRODUCTION

Tea (Camellia sinensis) is a globally significant beverage crop, and its cultivation plays a vital role in the economies of many countries. Soil fertility and nutrient management practices heavily influence tea's productivity and quality. There has been a growing interest in sustainable agricultural practices, particularly using organic fertilizers, to enhance soil health and crop performance in recent years. Long-term use of chemical fertilizers can lead to nutrient imbalances, decreased organic matter content, and damaged soil structure. This impacts reducing the population of soil microbes that play an important role in the decomposition of organic matter and nutrient provision.

Organic fertilizers, such as cow manure and vermicompost, have been recognized for their potential to improve soil structure, increase microbial activity, and provide essential nutrients to plants. Cow manure is rich in nitrogen, phosphorus, and potassium, which are crucial for plant growth. Vermicompost, produced through the decomposition of organic matter by earthworms, is known to enhance plant growth by supplying nutrients and plant growth regulators (Blouin, 2019). The selection of cow dung and vermicompost as sources of organic fertilizer in tea cultivation is usually based on a number of agronomic, ecological, and economic considerations. These fertilizers can increase organic matter content and improve soil structure, contain macronutrients (N, P, K) in a more stable form, and are slow to decompose, making them suitable for perennial crops such as tea.

Several studies have demonstrated the positive effects of vermicompost on plant growth. A meta-analysis revealed that vermicompost applications led to average increases of 26% in commercial yield, 13% in total biomass, 78% in shoot biomass, and 57% in root biomass. The optimal effect was observed when vermicompost constituted 30% to 50% of the soil volume, with cow manure being an effective feedstock for vermicompost production. (Blouin, 2019)

Research by Wulandari et al. (2015) showed that the application of 75 g/ g/polybag of vermicompost fertilizer can produce an increase in the growth of oil palm seedlings, such as the number of leaves, seedling height, and stem circumference. The results of research by(Situmorang et al., 2020) showed that the application of vermicompost fertilizer had a significant effect on the growth of plant height, stem circumference, number of leaves, crown fresh weight, root fresh weight, and root dry weight of oil palm seedlings, with the best treatment found at a dose of 80 g/polybag.

In the context of tea cultivation, the application of vermicompost has shown promising results. A study conducted in Tripura, India, investigated the impact of rubber leaf vermicompost on tea yield and soil health. The findings indicated that vermicompost application improved tea leaf production and enhanced the population of beneficial earthworms in tea plantations (Chaudhuri et al., 2021).

Despite these positive outcomes, research specifically focusing on the combined application of cow manure and vermicompost as amendments in the growing media for tea seedlings, particularly the GMB 7 clone, remains limited. Understanding the synergistic effects of these organic fertilizers could provide valuable insights into sustainable nutrient management practices for tea cultivation.

Therefore, this study aims to evaluate the growth responses of GMB 7 tea seedlings to different combinations of cow manure and vermicompost in the growing media. The findings are expected to contribute to the development of sustainable fertilization strategies that enhance tea seedling growth and soil health.

## MATERIALS AND METHODS

The experiment was conducted in the experimental field of the Tea and Cinchona Research Centre Gambung, Bandung, West Java, at an altitude of 1,250 meters above sea level, the soil order is Andisols, the climate type at PPTK Gambung is type B, the rainfall reaches 60-100 mm/month according to the classification of Schmidt and Fergusson (1951). The experiment was conducted from November 2022 to March 2023. Planting materials consisted of 4-month-old GMB 9 clone seedlings, a mixture of planting media used, namely Andisol top soil mixed with cow manure and vermicompost fertilizer, Urea and EM4 fertilizers, and 12 cm x 25 cm polybags. Treatment with 100% topsoil is the control treatment. The tools used include chlorophyll meters and documentation tools.

The experimental method used a Randomized Group Design (RGD) consisting of 10 treatments with various compositions of cow manure compost and vermicompost as a mixture of topsoil planting media added with Urea and EM4 fertilizers. The treatment arrangement was as follows:

A = 100% topsoil (control)

B = 200 g cow manure + 60 g vermicompost
C = 200 g cow manure + 80 g vermicompost
D = 200 g cow manure + 100 g vermicompost
E = 300 g cow manure + 60 g vermicompost
F = 300 g cow manure + 80 g vermicompost
G = 300 g cow manure + 100 g vermicompost
H = 450 g cow manure + 60 g vermicompost
I = 450 g cow manure + 80 g vermicompost
J = 450 g cow manure + 100 g vermicompost

Each treatment was repeated three times, so that there were 30 experimental units, and each experimental unit consisted of five tea plant seedlings, so that the total number was 10 x 3 x 5 = 150 plants. The analysis design used a Randomized Block Design (RBD). Data on the growth parameters of tea seedlings were processed using analysis of variance (ANOVA). The multiple comparison test, Duncan's multiple range test (DMRT), was conducted to detect significant differences at an α-value of 5%.
Experiment implementation includes land preparation, cow manure and vermicompost preparation, planting media preparation and planting of seedlings, and maintenance. Observations include analysis of cow manure and vermicompost, as well as temperature and humidity data.

The planting media used was a mixture of cow manure, vermicompost fertilizer, and topsoil that had been cleaned of twigs, rocks, and weeds. Each treatment of planting media mixture was added with 2 g of Urea fertilizer and 10 mL of EM4 mixed with 500 mL of water, then the planting media mixture was covered and allowed to stand for one week. After the planting media were ready for use, the planting media mixture was put into polybags and arranged according to the experimental layout. The planting media was watered to maintain its moisture before planting.

The seedlings used were 4 months old from the Tea and Cinchona Research Centre. Seedlings were planted in polybags with a mixture of prepared planting media. Planting begins with inserting the planting media until 1/3 to 2/3 of the polybag is filled. Then, the seedlings are planted in the polybag, and then the remaining planting media is inserted until it is full, with a note that the seedlings should not be pressed too much so that the roots can develop properly.

Growth observations include:
**Plant Height is** measured using a measuring instrument or ruler. Plant height is measured from the leaf axil, where the shoot grows, to the highest point of the plant. Plant height observations were made at the beginning of transplanting, 4 weeks after transplanting (WAT), 8 WAT, 12 WAT, and 16 WAT.
**Number of Leaves**, calculated based on leaves that have opened completely. Observations can be made at the beginning of transplanting, 4 WAP, 8 WAP, 12 WAP, and 16 WAP.
**Leaf Chlorophyll Index was** observed at 8 WAP and 16 WAP using a chlorophyll meter. Chlorophyll was measured at the base of the leaf, the middle of the leaf, and the tip of the leaf, and then averaged.
**Leaf area was** measured using the ImageJ application. The calculation of leaf area is done by photographing or scanning leaves that open perfectly and then calculating using the ImageJ application. Measurements were taken at 8 WAP and 16 WAP.

## RESULTS AND DISCUSSION

### Results

#### Analysis of Cow Manure and Vermicompost

The laboratory analysis results of the manure and vermicompost used showed that the cow manure and vermicompost had pH values of 8.90 and 7.35, respectively. The pH value contained in the fertilizer is still included in the minimum standard according to the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019 concerning the minimum requirements for organic fertilizers, biological fertilizers, and soil conditioners, namely 4-9 (Table 1).

**Tabel 1. Results of Nutrient Analysis of Cow Manure and Vermicompost Fertilizer**

| Parameter | Cow manure | Vermicompost |
|---|---|---|
| pH | 8.90 | 7.35 |
| Organic C (%) | 35.49 | 26.35 |
| Total N (%) | 2.20 | 1.31 |
| C/N | 16.13 | 20.11 |
| $P_2O_5$ (%) | 0.07 | 0.22 |
| $K_2O$ (%) | 2.39 | 0.18 |

Source: Soil Fertility and Plant Nutrition Laboratory, 2023

#### Temperature and Humidity

The results of temperature measurements taken during the study showed that the average temperature during the study (November 2022 - March 2023) was 23.52 °C, while the maximum average temperature during the study was 28.64

ºC and the minimum average temperature was 20.28 ºC.

**Plant Height**

The results of statistical analysis of plant height (Table 2) showed that the provision of cow manure and vermicompost had a significant effect on plant height. The treatment of 300 g cow manure mixed with 100 g of vermicompost gave a higher increase than the other treatments at 4 WAP, followed by the treatment of 450 g cow manure mixed with 100 g of vermicompost more higher increase than the other treatments at 16 WAP but not significant diferrence with treatment 450 g cow manure + 80 g vermicompost.

**Number of leaves**

The results of the statistical analysis of the number of leaves (Table 3) showed that the application of cow manure and vermicompost gave a significantly different effect on the number of leaves. The only topsoil treatment where the number of leaves was more significant than the combined treatment of cow manure and vermicompost. This is due to several things, such as Andisols soil from Gambung has properties that are very supportive of plant growth, including high cation exchange capacity (CEC), which allows efficient retention and release of nutrients (Ćirić et al., 2023).

**Chlorophyll content index**

The results of statistical analysis of the leaf chlorophyll index (Table 4) showed that the provision of cow manure and vermicompost had a significant effect on the leaf chlorophyll index. The application of 450 g cow manure plus 100 g vermicompost increased the chlorophyll index of leaves from 8 WAP to 16 WAP which was higher than other treatments but not significantly different from those treated with 80 g vermicompost with the same amount of 450 g cow manure.

**Leaf area**

The results of the statistical analysis of leaf area (Table 5) show that the provision of cow manure and vermicompost gives a real effect on leaf area. However, when compared as a whole, topsoils treatment alone gives the best leaf area compared to other treatments.

**Discussion**

**Analysis of Cow Manure and Vermicompost**

According to the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019, the content of N-Total and K2O in cow manure is 2.20% and 2.39% and is included in the minimum standard, but the P2O5 content (0.07%) does not fall into the minimum standard regarding the minimum requirements for organic fertilizers, biological fertilizers and soil conditioners, which is a minimum of 2%. The content of nitrogen (1.31%), P2O5 (0.22%), and potassium (0.18%) in vermicompost fertilizer did not meet the minimum standard of N, P, and K content of 2%. The C-organic content in cow manure (35.49%) and vermicompost fertilizer (26.35%) tended to be high and met the minimum standard of Minimum Requirements for Organic Fertilizers, Biofertilizers, and Soil Improvers, which is 15%. The C/N value of cow manure (16.13) and vermicompost (20.11) is still included in the minimum standard of Minimum Requirements for Organic Fertilizers, Biofertilizers and Soil Improvers, which is less than or equal to 25.

**Temperature and Humidity**

According to Arfemilano et al. (2022), tea plants can grow optimally at temperatures of 13-25°C. Referring to Cheserek et al. (2015), the average temperature is still included in the standard and optimal temperature range of 18-30 °C. Maximum temperatures exceeding 30ºC and minimum temperatures below about 14ºC cause a decrease in growth rate.(Arfemilano Muflih & Fiky Y. Suratman, 2022). Challinor et al. (2007) also found that tea grows in average temperature conditions of more than 25-26 °C.

The average humidity from November 2022 to March 2023 is above 70%. This humidity is still included in the optimal humidity range for tea plants above 70%. According to Effendi et al. (2010), the ideal rainfall for tea plant growth is 2000 mm/year, or rainfall with a value of 60 mm month-1 for no more than 2 months, and relative humidity during the day is greater than 70%. Air humidity between 70-90% can spur the growth of tea plant seedlings under the best conditions (Setiawan et al., 2020).

**Plant Height**

The results of the statistical analysis showed that the treatment with 100% topsoil showed the best plant height compared to the combination treatment of cow manure and vermicompost.

Overall, the use of topsoil is much better than the media treatment mixed using cow manure and vermicompost. This can be caused by Andisols' topsoil, which contains many nutrients and an acidic pH, which are needed for the growth of the seedlings.

**Table 2. Effect of Cow Manure and Vermicompost on Tea Plant Height at 0-16 WAP**

| Treatment | Plant height (cm) | | | | |
|---|---|---|---|---|---|
| | 0 WAP | 4 WAP | 8 WAP | 12 WAP | 16 WAP |
| A = 100% topsoil (control) | 38.41 e | 39.12 e | 39.31 e | 39.91 e | 40.31 f |
| B = 200 g cow manure + 60 g vermicompost | 11.97 ab | 12.42 a | 12.73 a | 13.04 a | 13.24 ab |
| C = 200 g cow manure + 80 g vermicompost | 11.35 ab | 12.31 a | 12.64 a | 12.81 a | 13.17 ab |
| D = 200 g cow manure + 100 g vermicompost | 10.35 ab | 10.92 a | 11.29 a | 12.05 a | 12.88 ab |
| E = 300 g cow manure + 60 g vermicompost | 16.44 c | 17.24 bc | 17.69 bc | 18.04 bc | 18.35 cd |
| F = 300 g cow manure + 80 g vermicompost | 8.43 a | 9.31 a | 9.62 a | 10.01 a | 10.92 a |
| G = 300 g cow manure + 100 g vermicompost | 16.87 c | 18.36 c | 18.73 c | 19.37 c | 20.17 d |
| H = 450 g cow manure + 60 g vermicompost | 23.01 d | 23.70 d | 24.29 d | 24.88 d | 25.71 e |
| I = 450 g cow manure + 80 g vermicompost | 23.20 d | 24.23 d | 24.71 d | 25.61 d | 25.99 e |
| J = 450 g cow manure + 100 g vermicompost | 12.68 b | 13.37 ab | 13.84 ab | 14.39 ab | 15.83 bc |

Note: Numbers followed by different letters in the same column indicate significant differences based on Duncan's multiple range test

**Table 3. Effect of cow manure and vermicompost on number of leaves at 0-16 WAP**

| Treatment | Number of leaves | | | | |
|---|---|---|---|---|---|
| | 0 WAP | 4 WAP | 8 WAP | 12 WAP | 16 WAP |
| A = 100% topsoil (control) | 10.44 d | 10.67 f | 10.67 c | 10.44 e | 10.44 d |
| B = 200 g cow manure + 60 g vermicompost | 5.22 a | 5.00 abc | 4.39 a | 5.06 ab | 5.89 b |
| C = 200 g cow manure + 80 g vermicompost | 5.72 ab | 6.11 cd | 5.94 ab | 5.67 bc | 6.00 b |
| D = 200 g cow manure + 100 g vermicompost | 4.33 a | 3.67 a | 4.00 a | 5.00 ab | 5.50 ab |
| E = 300 g cow manure + 60 g vermicompost | 7.56 c | 6.89 de | 7.00 b | 7.22 cd | 7.89 c |
| F = 300 g cow manure + 80 g vermicompost | 4.11 a | 4.28 ab | 4.11 a | 3.56 a | 4.11 a |
| G = 300 g cow manure + 100 g vermicompost | 7.00 bc | 7.33 de | 6.89 b | 7.33 cd | 7.56 c |
| H = 450 g cow manure + 60 g vermicompost | 7.56 c | 7.78 e | 7.78 b | 7.56 d | 8.33 c |
| I = 450 g cow manure + 80 g vermicompost | 7.67 c | 7.00 de | 7.00 b | 7.00 cd | 8.00 c |
| J = 450 g cow manure + 100 g vermicompost | 4.67 a | 5.22 bc | 4.56 a | 4.44 ab | 6.00 b |

Note: Numbers followed by different letters in the same column indicate significant differences based on Duncan's multiple range test

**Table 4. Effect of Cow Manure and Vermicompost on Leaf Chlorophyll Index at 8 and 16 WAP**

| Treatment | chlorophyll content index (CCI) | |
|---|---|---|
| | 8 WAP | 16 WAP |
| A = 100% topsoil (control) | 63.21 ab | 74.62 ab |
| B = 200 g cow manure + 60 g vermicompost | 55.43 a | 70.50 a |
| C = 200 g cow manure + 80 g vermicompost | 59.00 ab | 68.54 a |
| D = 200 g cow manure + 100 g vermicompost | 55.75 a | 69.76 a |
| E = 300 g cow manure + 60 g vermicompost | 65.36 abc | 76.24 ab |
| F = 300 g cow manure + 80 g vermicompost | 53.70 a | 66.32 a |
| G = 300 g cow manure + 100 g vermicompost | 60.53 ab | 76.42 ab |
| H = 450 g cow manure + 60 g vermicompost | 87.17 c | 100.67 c |
| I = 450 g cow manure + 80 g vermicompost | 80.59 bc | 98.47 bc |
| J = 450 g cow manure + 100 g vermicompost | 67.98 abc | 86.29 abc |

Note: Numbers followed by different letters in the same column indicate significantly different based on Duncan's multiple range test

**Table 5. Effect of Cow Manure and Vermicompost on The Leaf Area of Seedlings at 8 and 16 WAP**

| Treatment | Leaf Area (cm2) | |
|---|---|---|
| | 8 WAP | 16 WAP |
| A = 100% topsoil (control) | 27.24 e | 27.94 e |
| B = 200 g cow manure + 60 g vermicompost | 10.26 b | 11.16 abc |
| C = 200 g cow manure + 80 g vermicompost | 10.17 b | 11.01 ab |
| D = 200 g cow manure + 100 g vermicompost | 11.54 bc | 13.19 bcd |
| E = 300 g cow manure + 60 g vermicompost | 13.57 bcd | 14.97 bcd |
| F = 300 g cow manure + 80 g vermicompost | 6.29 a | 7.80 a |
| G = 300 g cow manure + 100 g vermicompost | 14.44 cd | 15.97 d |
| H = 450 g cow manure + 60 g vermicompost | 16.42 d | 17.32 d |
| I = 450 g cow manure + 80 g vermicompost | 15.40 cd | 17.08 d |
| J = 450 g cow manure + 100 g vermicompost | 13.82 bcd | 15.58 cd |

Note: Numbers followed by different letters in the same column indicate significant differences based on Duncan's multiple range test

Andisols are soils that contain high enough organic matter so that the soil is quite good at supplying nitrogen for plants. High organic matter content is needed for tea plants because tea plants always maintain a vegetative stage, and high production (Wulansari & Eko Pranoto, 2019) In addition, the air humidity of the research was high at 81.1-82.4%, which resulted in increased induction of tea seedling growth (Hindersah et al., 2016). High moisture can increase the speed of photosynthesis; with rapid photosynthesis, it will increase the production of carbohydrates that function to increase nutrient absorption (Anjarsari, 2015) .

Plant height increase is also thought to be influenced by the availability of nitrogen. The element N is the main nutrient in the growth and production of tea plants. According to Leghari et al. (2016), nitrogen fertilizer is needed by plants for the formation and growth of vegetative parts such as leaves, stems, and roots.

**Number of leaves**

The control treatment using andisol topsoil showed the highest number of leaves. Andisols topsoil has a crumbly and stable structure, supporting good aeration and drainage for tea seedlings (Wulansari et al., 2021). Manure and vermicompost can cause the media to become denser, especially as it shrinks due to organic matter decomposition, which can inhibit root penetration and limit access to oxygen and water (Sayara et al., 2020)

**Chlorophyll content index**

Leaf chlorophyll is a key indicator of leaf greenness, and it is often used to investigate leaf nutrient deficiencies and changes in chlorophyll (Ali MM et al., 2017)

The combination of 450 g of manure up to 80 g and 100 g of vermicompost showed a higher chlorophyll content index than the other treatments. According to Dewi (2016), the addition of cow manure can increase and encourage the growth of organs related to photosynthesis. Leaves that receive a sufficient nitrogen supply will form leaves that have wider leaf blades with higher chlorophyll content, so that plants can produce high amounts of carbohydrates to support vegetative growth. The application of vermicompost is also thought to affect the chlorophyll index of the leaves because it contains macro and micro nutrients that play a role in the growth of tea seedlings, improving soil structure and increasing the absorption of water and nutrients in the soil. The K and Mg nutrients found in vermicompost are related to the movement of water into cells. According to (Ishfaq et al., 2022), the element Mg is needed as a constituent of chlorophyll. Chlorophyll is a green leaf substance that has an important role in photosynthesis. In addition, the size of the leaves will increase the rate of photosynthesis.

**Leaf Area**

Leaf helps supply remobilized nitrogen in the development of green plant biomass and it affects photosynthesis by transforming solar radiation to chemical energy (Bianculli et al., 2019)

The treatment of a combination of cow manure and vermicompost as a mixture of planting media in tea nurseries that showed lower yields compared to Andisol Gambung topsoil can be caused by several main factors, namely the chemical and physical composition of the media, nutrient availability, and biological properties of the organic materials used.

According to Suhardjo (2020), a mixture of cow manure and vermicompost can have limitations, such as: Slower mineralization, so the release of nitrogen and other nutrients takes longer than direct nutrient availability from Andisol (Suharjo et al., 2020). The C/N ratio is higher in cow manure, which may cause temporary nitrogen immobilization by soil microorganisms (Suthar, 2009). Vermikompost has a higher salt content, which can increase the salinity of the medium and inhibit the uptake of water and nutrients by the roots of young tea plants (Edwards et al., 2010).

## CONCLUSION

The planting medium using Andisols topsoil is superior to the mixture of cow manure and vermicompost. Vermicompost and cow manure gave chlorophyll content index the same as the control, or even more than the control. Although vermicompost and cow manure have long-term benefits for improving soil fertility, at the tea plant nursery stage, media with more stable characteristics, such as Andisol, are more suitable.

## ACKNOWLEDGMENTS

We would like to thank you for your assistance and cooperation, especially the Gambung Tea and Cinchona Research Center, which has provided the research location, the staff, and field technicians, and the field supervisors.

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