



## RESEARCH ARTICLE

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# Leaf Vegetable Seed Germination in Various Concentrations of Organic Liquid Fertilizer Based on Manure



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## Abstract

The use of liquid organic fertilizer (POC) derived from manure is an alternative nutrient source with the potential to enhance seed vigor and early plant growth. This study aimed to analyze the germination dynamics of four horticultural crops (kailan, lettuce, bok choy, and mung beans) and determine the most effective dose of a cow dung-based liquid organic fertilizer. The experiment was conducted at the MARDI Malaysia Organic Farm using a non-factorial Randomized Block Design (RBD) with six POC concentration treatments (0%, 1%, 2%, 3%, 4%, and 5%) and four replications. Observed parameters included germination rate, plant height, number of leaves, root length, fresh weight, and dry weight. Results indicated that the 3-4% POC treatment elicited the best response across most parameters. The highest germination rate was recorded at concentrations of 3-5%, ranging from 20.33% to 23.00%, while the maximum seedling height of 20.38 cm was observed at a 3% dose. The greatest root length was found in the 5% treatment, measuring 17.50 cm for kailan, followed by 9.50 cm for bok choy and 8.75 cm for lettuce. The highest fresh and dry weights, 2.38 g and 0.38 g, respectively, were recorded in mung beans at a 4% concentration. Overall, manure-based POC at a 3-4% dose proved optimal for enhancing germination dynamics and early plant growth without inducing physiological stress.

**Keywords:** Horticultural Plant Growth, Liquid Organic Fertilizer, Manure, Seeds, Seed Germination

## 1. Introduction

Increasing global agricultural productivity remains a critically important topic as food demand rises significantly due to population growth, urbanization, and increased food consumption. This challenge is further compounded by limited arable land, declining soil fertility, and climate fluctuations that impact plant physiological processes from the earliest stages. From an agronomic perspective, the germination phase is a key determinant of subsequent plant growth and overall success. Failure during this early phase often leads to low seedling competitiveness, stunted growth, and reduced productivity (Zhao et al., 2024). Therefore, understanding the physiological dynamics of germination is becoming increasingly vital for developing sustainable cultivation systems.

In conventional cultivation, plant nutrient requirements are primarily met by inorganic fertilizers. Although synthetic fertilizers can produce high yields in the short term, their excessive use has been associated with soil

structure degradation, reduced microbial biodiversity, and the accumulation of toxic ions. Contemporary agricultural practices are shifting toward environmentally friendly approaches, particularly through the use of liquid organic nutrient sources, such as manure-derived liquid fertilizers, organic residues, and compost extracts. The use of liquid organic fertilizers (POC) offers the advantage of providing nutrients in a readily dissolved form that can be absorbed quickly by seedlings, unlike solid organic fertilizers, which require a longer mineralization period (Liu et al., 2023).

Other research indicates that applying liquid organic fertilizer derived from manure can influence seedling chlorophyll content, stem diameter, and the development of the first leaf during the early vegetative phase (Usodri et al., 2025). This effect is closely linked to the quality of germination dynamics, as the first leaf is the organ responsible for supporting initial photosynthesis once the embryo's food reserves begin to deplete. In addition to the type of fertilizer, the concentration of the liquid fertilizer

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applied is also a critical variable. Studies on leafy vegetables demonstrate that a 6% concentration promotes optimal initial biomass growth, whereas concentrations above 8–10% significantly reduce plant performance (Haspari & Suparno, 2023). This finding highlights the physiological limits of seeds in coping with the osmotic pressure of the nutrient solution.

The frequency of POC application also affects seedling response. Three applications are considered sufficient to increase initial leaf chlorophyll content (Rehatta *et al.*, 2024). Increased chlorophyll levels improve photosynthetic efficiency when embryonic reserves are low, enabling seedlings to maintain energy metabolism. Furthermore, POC has been shown to increase leaf area growth, stem diameter, and biomass ratio in young seedlings (Perez *et al.*, 2025). These parameters have a causal relationship with germination success, as seedlings with strong radicles and cotyledons develop more quickly into the independent photosynthesis phase. Furthermore, combining liquid organic fertilizers can improve soil chemical properties, such as cation exchange capacity, pH, and nitrogen and phosphorus availability (Voko *et al.*, 2022). A favorable soil environment in the early phase can reduce the risk of secondary dormancy and imbibition failure.

The interaction of nutrients and microbes in liquid fertilizer solutions can also reduce the incidence of damping-off, a disease caused by fungal pathogens during germination. Fertilizers produced by aerobic fermentation, for example, can support antagonistic microbial populations capable of suppressing organisms that cause embryo damage (Mot *et al.*, 2024). This is relevant because the germination phase is a vulnerable period before protective tissue forms. However, the use of organic liquid fertilizers still carries potential risks, particularly related to solution salinity and nutrient imbalance. Salinity can increase osmotic pressure, making it difficult for water to diffuse into the embryo. If osmotic pressure increases, the embryo will experience physiological dehydration, which inhibits radicle formation and reduces vigor index (Koushafar & Tehrani, 2024). Therefore, appropriate dilution needs to be determined at the germination stage.

These various studies demonstrate that germination studies using manure-based liquid fertilizers still have limitations. Some studies focus on the young vegetative phase, while embryonic responses during the initial 24–72 hour period have not been thoroughly analyzed. Parameters such as radicle emergence rate, initial radicle length, and seed vigor index have rarely been evaluated in the context of organic liquid fertilizers. Therefore, research on germination dynamics using manure-based liquid fertilizers is becoming increasingly relevant. Understanding the physiological responses of seeds to varying concentrations of liquid fertilizer can help determine safe dosages, prevent osmotic stress, and support strong radicle formation.

Based on the explanation above, this study aims to

observe the dynamics of seed germination using liquid fertilizer derived from manure and to determine the appropriate dosage for various seeds. The findings are expected to contribute to the development of sustainable agricultural practices.

## 2. Material and Methods

### 2.1. Place and Time

This research was conducted at the Integrated Organic Farm, Soil, Water and Fertilizer Science Research Center of the Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Selangor, Malaysia, at coordinates 2.9911°N, 101.7016°E, 50 masl, in September–October 2025. The location was chosen because it supports a sustainable organic cultivation system with controlled media and nutrient management. The humid tropical climate, with temperatures of 27–31 °C, is suitable for leafy vegetable germination.

### 2.2. Materials and tools

The research materials included kale, lettuce, bok choy, and mung bean seeds as test objects. The planting medium was a mixture of soil, rice husks, and fermented cow manure, with water as the control. The tools used included a digital scale and a seedling tray with 104 holes. The upper hole diameter was approximately 3 cm. The lower hole diameter was approximately 2 cm. The hole was 4 cm deep, with an oven, a measuring cup, a ruler, a shovel, and a hand sprayer. All equipment was sterilized before use to prevent microbial contamination.

### 2.3. Research methods

This study was a field experiment with a non-factorial Randomized Block Design (RBD). This design was chosen because it allows for homogeneous distribution of treatments under relatively varied field conditions. The single treatment factor tested was the concentration of liquid organic fertilizer (POC) based on cow manure, which was administered at six levels:

**Table 1.** POC Concentration Based on Manure

Code	Treatment	Application Volume
P <sub>0</sub>	Control (0%) without POC	– 0 mL
P <sub>1</sub>	POC 1%	60 mL
P <sub>2</sub>	POC 2%	120 mL
P <sub>3</sub>	POC 3%	180 mL
P <sub>4</sub>	POC 4%	240 mL
P <sub>5</sub>	POC 5%	300 mL

The study used six POC concentrations (0–5%), each replicated 4 times, yielding 24 experimental units. These concentrations were determined based on preliminary tests that indicated a safe range for seed osmotic pressure.

Liquid fertilizer was prepared by anaerobic fermentation of cow dung for 30 days (at a 1:10 ratio with water and a microbial activator), then filtered and diluted according to the treatment. The planting medium, a mixture of soil and rice husks (2:1), was sterilized before use. Kailan, lettuce, bok choy, and mung bean seeds were selected based on their uniform size and good condition.

Seeds were planted in seedling trays (8 seeds per plot), and POC was applied with a hand sprayer every 2 days, while the control received water. The experiment was arranged in a Randomized Block Design (RBD) and conducted in a location with 70% natural light and 70–80% humidity. Parameters observed included germination rate over seven days, plant height, number of leaves, root length, fresh weight, and dry weight. POC analysis included N, P, K, pH, and EC, as per AOAC (2020). Data were analyzed using ANOVA at the 95% level, followed by a 5% LSD test if differences between treatments were detected. Pearson's correlation coefficient ( $r$ ) was used to assess the relationship between POC nutrients and germination rate. Data processing was carried out using SPSS 26 and Microsoft Excel 2021, and the results are presented in graphs and tables.

## 2.4. Research Implementation

### 2.4.1. Preparation of Planting Media

Before planting, the planting medium is prepared by mixing soil with rice husks to increase soil fertility and pore space.

### 2.4.2. Seed Planting

Planting the seeds is done in a tray. Seeds are planted in seedling trays (8 seeds per plot). Treatment with Kandang liquid organic fertilizer (POC) at concentrations of 0%, 1%, 2%, 3%, 4%, and 5%. Kailan, Lettuce, Pakchoy, and Green Bean seeds were randomly planted in the Tray according to the treatment.

### 2.4.3. Maintenance

During the growing period, the plants are maintained by watering them in the morning and evening and removing weeds in the polybag area. The plants are also inspected periodically to ensure there are no disturbances that could affect their growth.

### 2.4.4. Fertilization

At this stage, the plants were fertilized according to the treatment specified in the study: liquid organic fertilizer (POC) concentrations of cow dung at 0%, 1%, 2%, 3%, 4%, and 5%. For kale, lettuce, bok choy, and mung beans, fertilizer was applied every 2 days by evenly spraying around the plant area with a hand sprayer.

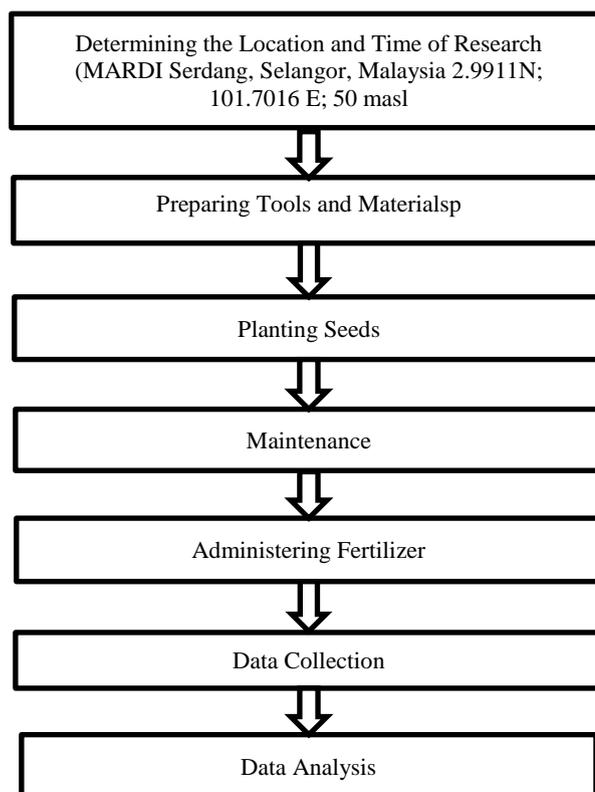
## 2.5. Data retrieval

Data collection involves measuring predetermined

**Table 2.** Average seed germination rate at various concentrations of manure-based liquid fertilizer for four types of test

parameters, such as root length, shoot length, leaf number, fresh weight, dry weight, and germination rate. These observations aim to monitor plant development over time.

## 2.6. Flow diagram



**Figure 1.** Research Implementation Flowchart

## 3. Results and Discussion

Based on field observations, several data points for the observed variables were collected. The results of the analysis showed that the effect of Liquid Manure concentration on the growth of four types of Kailan plants (*Brassica oleracea* Alboglabra Group), Lettuce (*Lactuca sativa*), Pakchoy (*Brassica rapa* subsp. *Chinensis*), and Mung beans (*Vigna radiata* L.) showed significant differences between treatments.

### 3.1. Germination Rate

Seed growth rate was observed to reflect the seed's ability to absorb nutrients and utilize them for initial physiological processes, such as radicle and plumule formation. Liquid fertilizers at different concentrations elicited varying responses across plant species. In general, increasing the concentration of liquid fertilizer to a certain level accelerated seed growth, but at excessively high doses, growth rates tended to decline due to the solution's osmotic pressure. The average seed growth rates for each plant species are presented in Table 2.

plants

Fertilizer Concentration	Types of Plants			
	Kailan	Lettuce	Pakchoy	Mung beans
Control	17.00 ± 0.30 a	15.17 ± 0.10 bc	22.50 ± 0.60 b	18.00 ± 0.30 a
1%	22.17 ± 0.20 b	7.67 ± 0.20 a	23.00 ± 0.70 b	21.50 ± 0.20 b
2%	23.00 ± 0.10 c	13.17 ± 0.50 ab	22.33 ± 0.30 b	21.67 ± 0.10 b
3%	23.00 ± 0.40 c	19.50 ± 0.40 c	20.33 ± 0.30 a	21.33 ± 0.10 b
4%	23.00 ± 0.50 c	20.50 ± 0.40 c	23.00 ± 0.30 b	19.00 ± 0.20 ab
5%	23.00 ± 0.20 c	20.83 ± 0.30 c	22.17 ± 0.20 b	20.83 ± 0.30 b

Based on Table 2, the application of liquid organic fertilizer derived from cow manure produced different growth responses in kale, lettuce, bok choy, and mung beans. In general, a concentration of 3–4% yielded the best initial growth, while 5% showed no significant improvement. This finding indicates that this range represents the optimal level of nutrient availability for seed metabolism.

Kailan showed the most stable growth, with growth values increasing from 17.00 (control) to 23.00 at 2–5% concentration. Lettuce responded optimally at 3–5% concentration (19.50–20.83%), presumably related to the high phosphorus requirement for plumule and radicle formation. In bok choy, the highest growth rate occurred at 4% concentration (23.00), while at 3% concentration it decreased slightly, indicating sensitivity to osmotic stress. Mung bean growth increased steadily up to 3%, but decreased at 4% concentration, indicating a physiological limit to the effects of excess nutrients.

These results support the findings of Mot et al. (2024) that humic compounds in POC increase water absorption and amylase enzyme activation, and are in line with Koushafar & Tehrani (2024), who found that high osmotic pressure can inhibit growth. Nutrient effectiveness must

also be balanced because both nutrient deficiencies and excesses can reduce photosynthesis and biomass growth (Agusta et al., 2022). Phosphorus plays an important role in radicle growth and the transition to the vegetative phase (Hadiyanto, 2021). Therefore, a moderate concentration (around 3%) is an efficient and safe dose to increase early plant growth without causing physiological stress, while supporting the principles of precision agriculture and organic input efficiency.

### 3.2. Plant Height (Cm)

Plant height parameters were used to describe the effect of manure-based liquid fertilizer on seedling vertical growth. Plant height measurements are important indicators for assessing early physiological activity, particularly cell division and elongation, which are influenced by the availability of macronutrients such as nitrogen, phosphorus, and potassium. The higher the plant growth value, the better the seed's ability to utilize nutrients to support the development of young stem and leaf tissue. Liquid fertilizers with different concentrations are expected to produce variations in plant height responses across test plant types. The average plant height for each treatment is presented in Table 3.

**Table 3.** Average plant height (cm) at various concentrations of liquid manure fertilizer

Fertilizer Concentration	Types of Plants			
	Kailan	Selada	Pakchoy	Kacang Hijau
Control	4.13 ± 0.90 a	1.13 ± 0.20 a	3.63 ± 0.10 a	18.38 ± 0.30 a
1%	4.38 ± 0.40 a	1.13 ± 0.20 a	3.88 ± 0.30 ab	19.25 ± 0.40 ab
2%	4.25 ± 0.30 a	2.00 ± 0.20 b	4.50 ± 0.20 cd	19.63 ± 0.40 ab
3%	4.25 ± 0.30 a	2.13 ± 0.20 b	4.38 ± 0.10 bcd	20.38 ± 0.50 b
4%	4.50 ± 0.20 a	2.25 ± 0.20 b	4.00 ± 0.10 abc	19.75 ± 0.60 ab
5%	4.13 ± 0.10 a	2.00 ± 0.20 b	4.63 ± 0.20 d	19.88 ± 0.20 ab

Based on Table 3, each plant type exhibits a different growth response to the concentration of manure-based liquid fertilizer. Generally, a concentration of 3–4% yields the best plant height growth because it provides macronutrients such as N, P, and K, which support cell division and elongation.

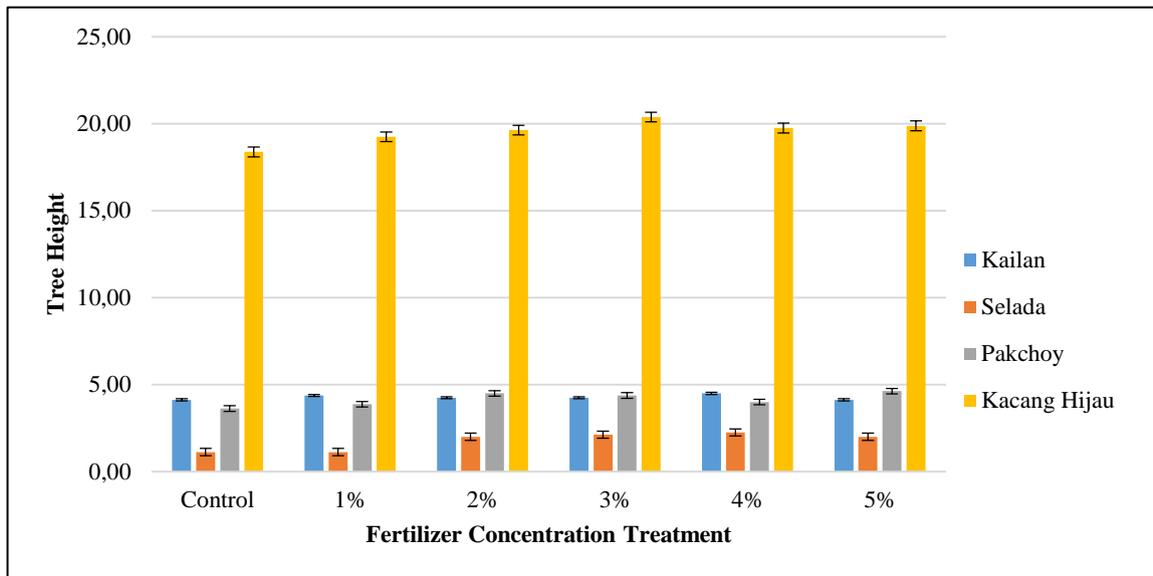
Kailan showed the most significant increase in plant height, from 4.50 cm in the 4% treatment. Lettuce also increased from 2.25 cm, albeit at a slower rate. Pakchoy maintained stable growth at 3–4 cm, indicating good

tolerance to concentration variations. Meanwhile, mung beans remained relatively constant at 19–20 cm, indicating strong adaptability to the organic content of the media.

The decrease in growth at a concentration of 5% indicates a hormetic mechanism: moderate doses stimulate growth, while high doses inhibit growth due to increased osmotic pressure that interferes with water absorption (Habibi & Elfarisna, 2018). Nutrients are very important in determining vertical growth, especially nitrogen and phosphorus, which support

stem and root tissue formation (Hendriyanto et al., 2019). Furthermore, the natural hormones auxin, gibberellin, and cytokinin in organic fertilizers promote increased vegetative growth (Lumbantoruan, 2015; Bey et

al., 2006). Overall, visual data show a pattern of increased growth at liquid fertilizer concentrations of 3–4%, followed by a decline at the highest concentrations.



**Figure 1.** Diagram of plant height (cm) of sprouts at various concentrations of manure-based liquid fertilizer.

### 3.3. Root Length (CM)

Root length parameters are used to assess the extent to which manure-based liquid fertilizer influences the development of plant root systems during the early growth phase. Increased root length generally indicates better nutrient absorption efficiency and a conducive growing

medium environment. Variations in liquid fertilizer concentration are expected to elicit different responses across plant types, depending on their physiological adaptation to nutrient availability and the osmotic conditions of the solution. The average root length values of the four test plant types are presented in Table 4.

**Table 4.** Average root length (cm) at various concentrations of manure-based liquid fertilizer

Fertilizer Concentration	Types of Plants			
	Kailan	Lettuce	Pakchoy	Mung beans
Control	2.50 ± 0.60 a	2.38 ± 0.40 a	3.38 ± 0.30 a	22.00 ± 0.30 b
1%	2.88 ± 0.50 a	2.50 ± 0.30 a	4.38 ± 0.40 a	21.00 ± 0.40 ab
2%	9.13 ± 0.50 b	3.75 ± 0.50 a	7.13 ± 0.50 b	22.88 ± 0.50 b
3%	10.75 ± 0.40 b	4.75 ± 0.30 a	7.88 ± 0.60 b	20.25 ± 0.30 ab
4%	10.38 ± 0.30 b	8.75 ± 0.20 b	7.13 ± 0.50 b	18.50 ± 0.10 a
5%	17.50 ± 0.20 seconds	7.50 ± 0.20 b	9.50 ± 0.30 b	18.63 ± 0.40 a

The data in Table 4 show that liquid manure fertilizer increased root length in most plants, especially at concentrations of 2–4%. Kailan, lettuce, and bok choy responded positively, with a significant increase in root length as the fertilizer concentration increased, although at 5% it approached the physiological saturation limit. In contrast, mung beans showed the greatest root length at 2% concentration, but this decreased at higher concentrations due to osmotic pressure inhibiting water absorption. Overall, a moderate concentration (2–4%) was the most effective for supporting optimal root growth, while 5% did not provide additional growth and could even be a limiting factor for some plant species. The results of the root length measurements for seedlings from each treatment were then

visualized in a diagram to clarify growth patterns across liquid fertilizer concentrations. This result confirms the findings of Panjaitan (2023) and Edi & Barus (2023) that organic liquid fertilizer can stimulate root growth at moderate doses, while excess dissolved salts can have a physiologically inhibiting effect on plants.

### 3.4. Number of Leaves (Sheets)

Leaf number was measured to assess the effect of manure-based liquid fertilizer on the development of photosynthetic plant organs during the early growth phase. Leaf number is an important indicator of metabolic activity and the plant's ability to utilize nutrients for new tissue formation. Leaves serve as the center of photosynthesis, so

an increase in leaf number indicates a balance of nutrients, particularly nitrogen and phosphorus, which support vegetative growth. Variations in liquid fertilizer

concentration are expected to produce different responses in each test plant type over the observation period.

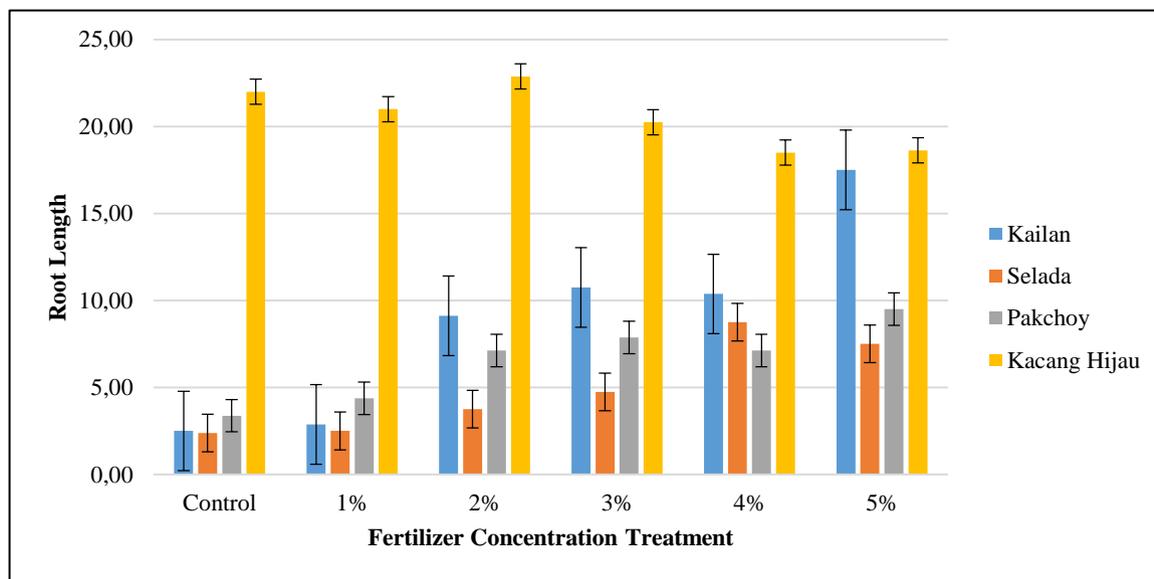


Figure 2. Diagram of root length (cm) of sprouts at various concentrations of manure-based liquid fertilizer

Table 5. Average number of leaves (strands) at various concentrations of liquid manure fertilizer

Fertilizer Concentration	Types of Plants			
	Kailan	Lettuce	Pakchoy	Mung beans
Control	3.88 ± 0.40 a	3.00 ± 0.30 a	4.00 ± 0.30 a	2.00 ± 0.20 a
1%	3.50 ± 0.20 a	2.88 ± 0.10 a	4.00 ± 0.30 a	2.00 ± 0.20 a
2%	3.50 ± 0.20 a	2.50 ± 0.20 a	4.00 ± 0.30 a	2.00 ± 0.20 a
3%	3.50 ± 0.20 a	2.63 ± 0.20 a	4.00 ± 0.30 a	2.00 ± 0.20 a
4%	3.63 ± 0.30 a	3.00 ± 0.30 a	4.00 ± 0.30 a	2.00 ± 0.20 a
5%	3.25 ± 0.20 a	3.00 ± 0.30 a	4.00 ± 0.30 a	2.00 ± 0.20 a

Based on Table 5, liquid manure fertilizer did not significantly affect the number of leaves on all test plants. All plants still had a uniform number of leaves (±2), as genetic factors more influence initial growth. The increase in leaf number across treatments was 2–4%, although the difference was not significant.

The kale plants showed a leaf count of 3, indicating a positive response to the addition of organic nutrients in liquid fertilizer. Lettuce plants maintained a leaf count of 2–3, indicating slow but steady growth. In bok choy, the leaf count increased more rapidly than in other types, reaching 4 in almost all treatments, indicating the plant’s ability to utilize nutrients efficiently. Meanwhile, mung beans showed a relatively constant leaf count (2) across all treatments, as in the early growth phase of this legume, energy allocation is more focused on root and stem formation than on leaf formation.

Overall, these results indicate that increasing the concentration of liquid fertilizer to 3–4% can moderately stimulate new leaf formation, especially in kale and bok choy. Concentrations that are too high (5%) do not provide

any effect.

A significant increase in the number of leaves is likely due to the increased salt content of the solution, which increases osmotic pressure and inhibits cell division in the meristem. This result is consistent with Yusrianti’s (2012) findings, which showed that nitrogen plays an important role in chlorophyll and young leaf tissue formation, while excess nutrients can reduce photosynthetic efficiency.

According to Marginingsih (2018), magnesium in organic fertilizer also plays an important role in chlorophyll formation, which affects leaf area and color. In addition, Setiawati et al. (2017) noted that liquid organic fertilizer increases the availability of organic carbon, which supports photosynthetic activity and vegetative growth. Thus, although the increase in leaf number did not show significant differences between treatments, these results demonstrate that liquid manure fertilizer continues to contribute to the nutritional balance and metabolic efficiency of plants during the early growth phase. The results of calculating the number of leaves (strands) per seedling for each treatment were then visualized in a

diagram to clarify growth patterns across concentrations of this liquid manure-based fertilizer.

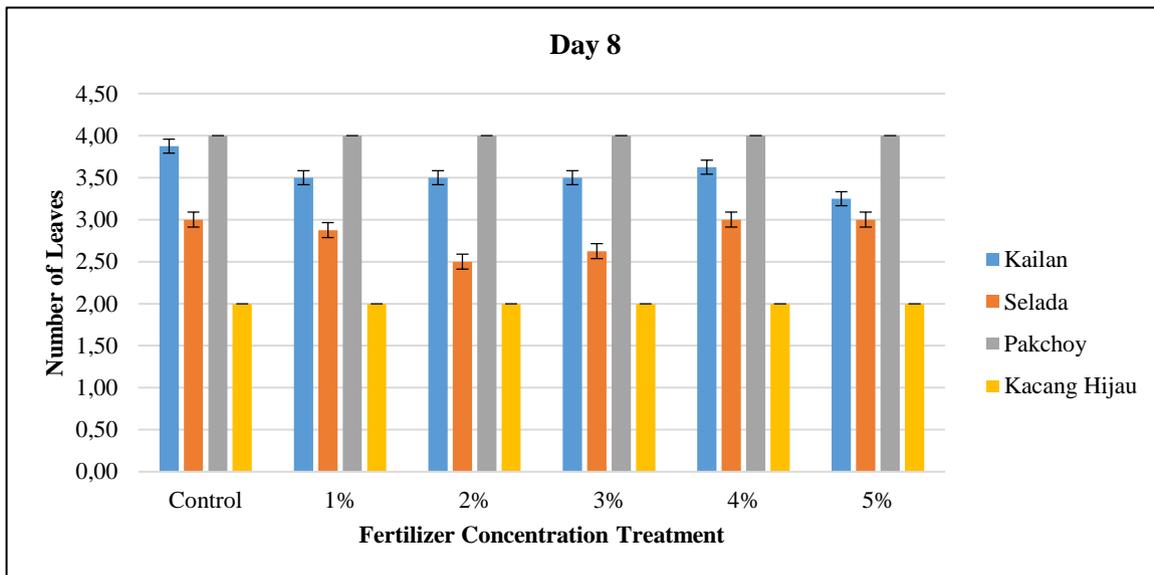


Figure 3. Diagram of the number of leaves (strands) of seedlings in relation to various fertilizer concentration treatments.

3.5. Wet weight (grams)

The wet weight parameter describes a plant's ability to absorb water and store photosynthetic products in vegetative tissues such as stems, leaves, and roots. Higher wet weight values indicate better physiological condition of

the plant, especially in terms of water absorption, nutrient availability, and cellular metabolic efficiency. Variations in liquid fertilizer concentrations elicited different responses across test plant types, consistent with their respective abilities to utilize organic nutrients.

Table 6. Average wet weight of plants (grams) at various concentrations of manure-based liquid fertilizer

Fertilizer Concentration	Types of Plants			
	Kailan	Lettuce	Pakchoy	Mung beans
Control	1.13 ± 0.20 a	0.33 ± 0.01 a	1.39 ± 0.22 a	1.77 ± 0.21 a
1%	0.83 ± 0.21 a	0.20 ± 0.02 a	1.47 ± 0.21 a	1.66 ± 0.21 a
2%	1.11 ± 0.23 a	0.20 ± 0.02 a	1.17 ± 0.21 a	2.00 ± 0.22 a
3%	1.04 ± 0.24 a	0.25 ± 0.03 a	1.42 ± 0.24 a	2.14 ± 0.23 a
4%	1.23 ± 0.23 a	0.38 ± 0.05 a	1.04 ± 0.23 a	2.38 ± 0.24 a
5%	1.16 ± 0.22 a	0.70 ± 0.08 b	1.11 ± 0.24 a	1.50 ± 0.20 a

Based on the data in Table 6, kale plants showed a relatively stable wet weight between treatments, with the highest value of 1.23 grams at a concentration of 4%, indicating that a balanced supply of macro nutrients can support plant metabolic activity without

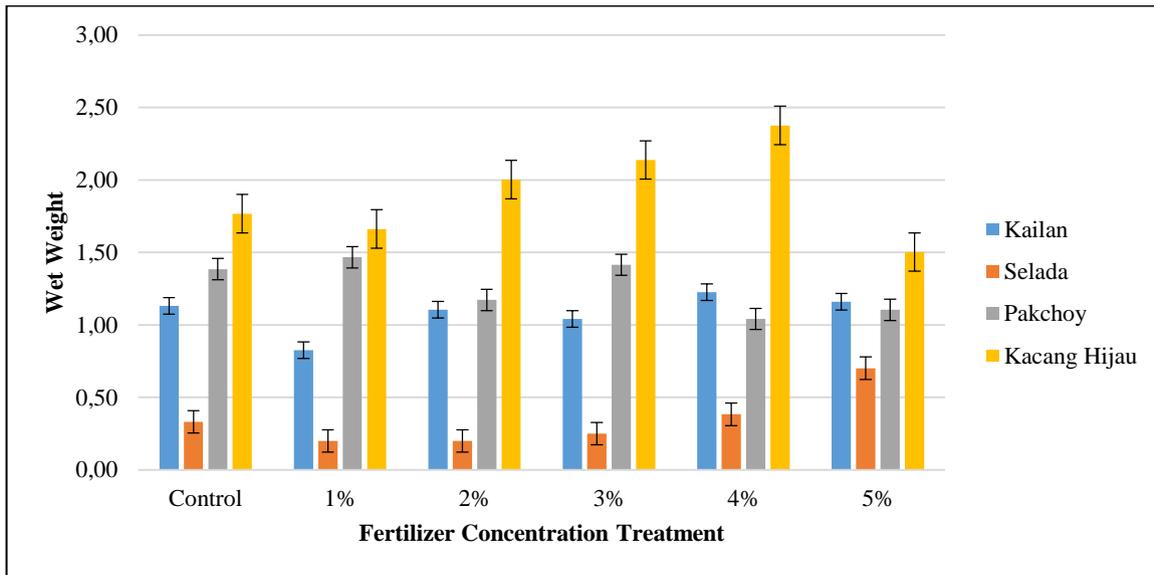
causing physiological saturation. Lettuce, on the other hand, showed the most significant increase in fresh weight with the 5% treatment (0.70 grams) compared to the control (0.33 grams), indicating that this plant requires a higher fertilizer concentration to achieve an optimal response in predominantly water-based leaf tissue. Pakchoy showed fluctuations in wet weight ranging from 1.04–1.47 grams and did not show any significant differences between treatments, indicating that liquid fertilizer concentrations above 2% did not affect biomass accumulation. Meanwhile, mung beans showed an increase in wet weight of up to 2.38 grams at 4% concentration, followed by a decrease at 5% (1.50 grams).

This result indicates that moderate concentrations of

liquid fertilizer provide optimal conditions for water absorption and plant tissue formation, whereas excessively high concentrations can increase osmotic pressure, inhibiting root water absorption. This phenomenon aligns with the findings of Hasyim et al. (2014), who explained that organic fertilizer improves water retention and soil structure, thereby increasing the efficiency of plant nutrient uptake.

3.6. Dry Weight

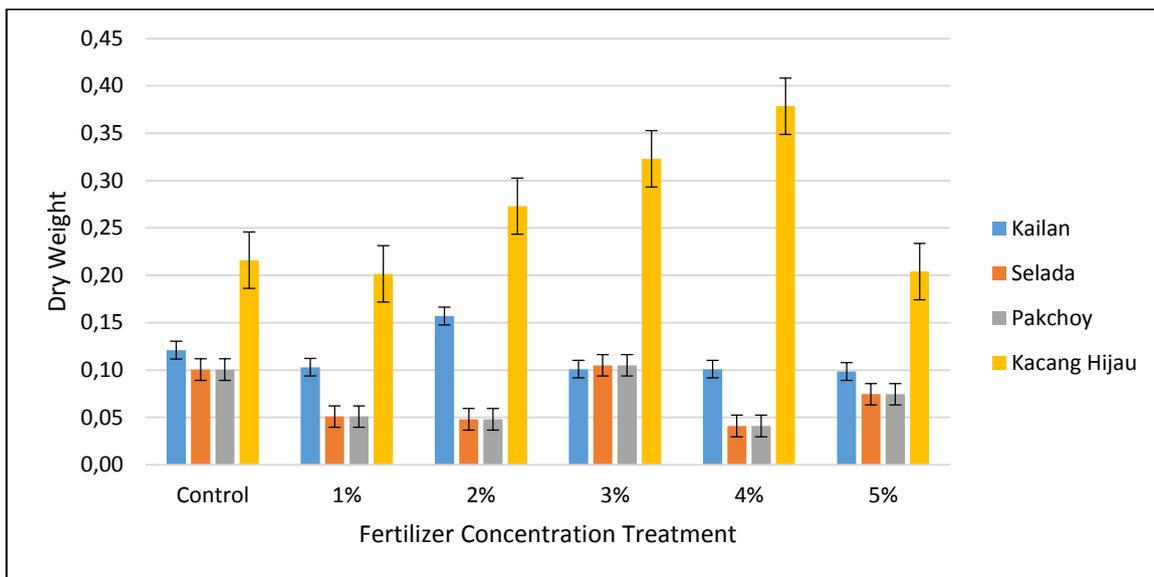
Plant dry weight is an important parameter for assessing biomass accumulation, as it reflects the efficiency of photosynthesis and nutrient utilization during the early growth phase. This parameter describes the amount of organic matter remaining after water evaporation, reflecting the outcome of plant metabolic activity on the nutrient intake provided.



**Figure 4.** Diagram of wet weight (grams) of sprouts against various concentration treatments of manure-based liquid fertilizer

**Table 7.** Average dry weight (grams) of sprouts at various concentrations of manure-based liquid fertilizer.

Fertilizer Concentration	Types of Plants			
	Kailan	Lettuce	Pakchoy	Mung beans
Control	0.12 ± 0.01 a	0.10 ± 0.001 a	0.10 ± 0.003 a	0.22 ± 0.004 a
1%	0.10 ± 0.02 a	0.05 ± 0.003 a	0.05 ± 0.004 a	0.20 ± 0.003 a
2%	0.16 ± 0.05 a	0.05 ± 0.002 a	0.05 ± 0.004 a	0.27 ± 0.004 a
3%	0.10 ± 0.03 a	0.11 ± 0.004 a	0.11 ± 0.005 a	0.32 ± 0.003 a
4%	0.10 ± 0.03 a	0.04 ± 0.003 a	0.04 ± 0.006 a	0.38 ± 0.004 a
5%	0.10 ± 0.03 a	0.07 ± 0.005 a	0.07 ± 0.007 a	0.20 ± 0.005 a



**Figure 5.** Average dry weight (grams) of sprouts for various concentration treatments of manure-based liquid fertilizer.

Based on the data in Table 6, the results show that applying liquid fertilizer derived from manure to kale plants yielded relatively stable dry weight, ranging from 0.10 to 0.16 grams, with the highest value at 2%

concentration (0.16 grams). This result indicates that kale can utilize moderate amounts of nutrients optimally without experiencing nutrient saturation at high doses. This response indicates good metabolic efficiency at medium

concentrations of liquid fertilizer, in line with the opinion of Fitri et al. (2017) that macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) have an important role in the formation of stem, root, and leaf tissue that contributes directly to plant dry weight.

In contrast, lettuce and bok choy showed lower dry weights, ranging from 0.04 to 0.11 grams. The highest value for lettuce was recorded at 3% (0.11 grams), and bok choy showed the same value. This pattern suggests that in leafy plants like lettuce and bok choy, increasing the dose of liquid fertilizer is not always directly proportional to the yield.

Increased dry weight. This result may be due to the high water content in young leaf tissue, leading to a significant portion of the plant's weight being water, not dry biomass. This finding supports research by Una (2020), which shows that natural hormones such as auxin and gibberellin in liquid organic fertilizers can increase cell division and elongation. However, the final dry biomass yield is highly dependent on the efficiency of photosynthate conversion into structural tissue.

Specifically for mung beans, the increase in dry weight from 0.22 grams (control) to 0.38 grams (4%) indicates that this large-seeded plant species has a high metabolic capacity to convert photosynthetic products into dry matter. This result indicates that a moderate concentration of liquid fertilizer provides ideal nutrient availability for permanent tissue formation without inhibiting cellular respiration. According to Fajri and Ramadhan (2020), plant response to fertilizer is highly dependent on the physiological and genetic characteristics of each species, as well as external factors such as humidity and light intensity.

#### 4. Conclusion

Based on the research findings, it can be concluded that the application of manure-based liquid fertilizer

significantly influences the germination dynamics and early seedling growth of various plant species, including kale, lettuce, bok choy, and mung beans, with physiological responses varying among species. Overall, a liquid fertilizer concentration of 2–4% is the most effective in promoting germination and early growth, as evidenced by increased germination rates, root length, shoot height, and accumulation of fresh and dry biomass compared to the control. At this concentration, seed metabolic activity is optimized due to a balanced supply of macronutrients, including nitrogen (N), phosphorus (P), and potassium (K), which support cell division and elongation. Additionally, humic compounds and microorganisms present in the liquid fertilizer enhance nutrient mobilization in the growing medium. The best results were observed in kale and mung beans, where root length and height reached maximum values at concentrations of 3–4%, while lettuce and bok choy exhibited moderate but stable growth at the same doses. Conversely, a higher concentration (5%) reduced growth performance, likely due to increased osmotic pressure that inhibited water and nutrient uptake. Therefore, using manure-based liquid fertilizer at a concentration of 3–4% is the most efficient approach to enhance germination dynamics, early vegetative growth, and physiological efficiency without causing toxic effects, highlighting its potential as an environmentally friendly alternative liquid organic fertilizer for sustainable agricultural systems.

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