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The Effect of Liquid Organic Fertilizer (Lof) Dosage on the Growth, Yield, and Potassium Content of Red Spinach (*Amaranthus tricolor L.*) Plants

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Abstract
Background. Red spinach growth and output can be increased through the use of organic and inorganic fertilizers. A liquid fertilizer created by fermenting organic materials, such as animal manure, serves as a practical option.
Aims. The purpose of this research is to assess the effects of varying amounts of liquid organic fertilizer on the growth, yield, and potassium content of red spinach (*Amaranthus tricolor L.*). Research examining the use of liquid organic fertilizer on red spinach was conducted in cultivated fields located in Banjaran, within the Sumberjaya area of Majalengka. The experiment took place from April to June 2025.
Methods. An experimental method was applied, utilizing a randomized block design (RBD) with six levels of fertilizer doses and four replicates each. Measurements included plant height, number of leaves, stem diameter, relative growth rate, fresh weight per plant and plot, as well as potassium content. The collected data were examined using a one-way analysis of variance (ANOVA). Subsequently, Duncan's Multiple Range Test (DMRT) was applied to determine which treatments showed statistically significant differences.
Conclusion. Findings show that different levels of liquid organic fertilizer have a significant impact on plant height, number of leaves, stem diameter, relative growth rate, fresh weight both per plant and per plot, as well as the potassium content within the plants.
Implementation. Applying 150 mL of liquid organic fertilizer per plant yields the best results across all measured variables.

Keywords: LOF, Growth, Yield, Red Spinach

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INTRODUCTION

According to data from Statistics Indonesia (Badan Pusat Statistik, 2022), the production of red spinach in Indonesia is categorized as low and unstable. Over the past few years, production of red spinach has experienced significant fluctuations. For example, the production

volume stood at 162 thousand tons in 2018, decreased to 160 thousand tons the following year, and decreased again to 157 thousand tons in 2020. Although there was an increase in 2021 and 2022, reaching 170 thousand tons, this condition indicates that red spinach production remains vulnerable to various factors (Syafira et al., 2024)

Increasing red spinach yields is possible by applying both organic and inorganic fertilizers. According to Utomo et al. (2016), *as cited in* (Pangaribuan et al., 2017) Fertilizers are generally classified into two main types: organic fertilizers and inorganic fertilizers. Inorganic fertilizers refer to synthetic fertilizers produced in factories, whereas organic fertilizers are produced through a fermentation process using natural materials. The application of appropriate fertilization techniques is crucial for achieving maximum productivity and promoting agricultural sustainability.

Liquid organic fertilizer is a type of fertilizer in liquid form, produced through a fermentation process from natural materials such as leaves, fruits, animal manure, and other plant residues (Yulianingsih, 2019) This fermentation process allows these materials to be broken down into forms that plants can more easily absorb. The use of liquid organic fertilizer is highly beneficial because it can improve soil fertility and provide essential nutrients for plant growth. Additionally, this fertilizer helps enhance the activity of soil microorganisms, which play a crucial role in the decomposition process and in improving soil structure.

One possible method is to use goat manure as a liquid organic fertilizer. This type of manure is rich in essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which are crucial for promoting healthy plant growth. Liquid organic fertilizer made from goat manure is produced through the fermentation of goat manure with EM4 (Effective Microorganism 4) (Yulianingsih, 2019). According to M. Peni et al., (2023) Goat manure has a C/N ratio of 20–25, which supports a proper decomposition process, thereby making the nutrients contained in the goat manure available to plants. Goat manure can provide both macronutrients (N, P, K) and micronutrients (Ca, Mg, S, Na, Fe, Cu, Mo).

The application of goat manure extract has been shown to significantly improve the ground's condition, making it more friable. In addition, the goat manure extract can also enhance the nutrients it contains, which ultimately contributes beneficially to the productivity of plants, including red spinach. Given this potential, additional investigation is necessary to comprehensively assess how varying doses of liquid organic fertilizer derived from goat manure extract influence the growth, yield, and potassium content of red spinach.

LITERATURE REVIEW

Red spinach (*Amaranthus tricolor* L.) is a horticultural plant that is rich in nutrients and has high economic value. For optimal growth, red spinach requires sufficient nutrients, especially nitrogen (N), phosphorus (P), and potassium (K). Nitrogen plays a role in protein and chlorophyll formation, phosphorus is important for root development and flower formation, while potassium has a role in maintaining water balance and activating enzymes (Rizki & Agustini, 2018).

According to Hairuddin & Arhami Edial (2019)To overcome the problems related to the use of chemical fertilizers and to increase crop productivity, it is necessary to apply fertilization using organic fertilizers. The excessive use of chemical fertilizers can cause soil compaction and degradation. With the increasing use of chemical fertilizers, farmers also face more losses related to the quality of their soil. Therefore, the use of organic fertilizers is necessary to preserve soil sustainability and support sustainable agricultural practices.

Liquid organic fertilizer is a crucial factor in plant growth, as it provides various essential nutrients. In this matter, Sarofina et al., (2021) State that goat manure fertilizer contains a complete range of nutrients necessary for plant growth, including macronutrients such as nitrogen (N), phosphorus (P), and potassium (K).

According to a study by Setyamidjaja (2006), as cited in Yulianingsih (2019), the application of organic fertilizer enhances soil porosity and aeration, enabling plant development and growth, particularly of the roots, to access the nutrients in the soil. Therefore, the application of liquid organic fertilizer derived from goat manure is a practical step to increase agricultural yields and can contribute to improved productivity in horticultural cultivation.

According to Syekhfani (2000), *as cited in* Anjarwati et al., (2017) manure has properties that do not damage the soil and provides both macro and micronutrients. Additionally, manure has functions that increase water-holding capacity, enhance soil microbiological activity, improve cation exchange capacity, and improve soil structure. One type of manure is manure derived from goat feces. This statement is also supported by the study of Sudarto et al. (2003), *as cited in* Ananda et al., (2024) which states that goat manure also enhances the soil's ability to retain water, playing a role in facilitating the mineralization of organic matter into nutrients that plants can directly utilize during their growth period

The research results of Hairuddin & Edial (2019) show that the use of liquid organic fertilizer from goat manure has a significant effect on the plant height parameter of celery. A dosage of 250 mL is considered optimal because it can provide sufficient nutrients without the

risk of damage due to over-fertilization. According to Suryati (2014), *as cited in* Hairuddin & Edial (2019), a dosage of 200 mL in 5 L of water is highly recommended for plant growth. Thus, this dosage became a reference in this study, with the expectation that it would have a significant effect on the growth, yield, and potassium content of red spinach plants.

METHOD

The experiment was conducted on farmers' land in Banjaran Village, Sumberjaya District, Majalengka Regency. This experiment was carried out from April to June 2025. The materials used were red spinach seeds and liquid organic fertilizer derived from goat manure infusion. The tools used included containers for soaking, a hoe, measuring instruments (digital scale, measuring cup, and ruler), a caliper, and an oven.

The research method employed was an experimental design, utilizing a one-factor Randomized Block Design (RBD). The treatments tested consisted of six levels of liquid organic fertilizer (LOF) dosage, namely 0, 100, 150, 200, 250, and 300 mL per plant, each replicated four times, resulting in a total of 24 experimental units. In each treatment, five red spinach plants were used as samples.

Observations of growth variables (plant height, number of leaves per plant, stem diameter, and plant dry weight) were conducted at 15, 22, and 29 days after planting (DAP), while observations of yield (fresh weight per plant and plot) and potassium content in the plant were carried out at 30 DAP.

DISCUSSION

Plant Height

One of the variables that illustrates plant growth is plant height. According to Sitompul and Guritno (1995), *as cited in* (Nuraini & Zahro, 2020) plant height is a commonly observed measurement, both as an indicator of growth and as a parameter used to assess the effects of environmental conditions or applied treatments.

The analysis of variance results show that the Liquid Organic Fertilizer (LOF) dosage has a significant effect on plant height at 15, 22, and 29 days after planting (DAP). Furthermore, the results of the Duncan test for the differences in the mean plant height among treatments are presented in Table 1.

Table 1. Results of Plant Height Analysis

No	Treatment	Plant Height (cm)		
		15 DAP	22 DAP	29 DAP
1	A (control)	4.16 a	7.43 a	12.05 a
2	B (100 mL)	5.55 bc	11.83 c	19.00 bc
3	C (150 mL)	6.27 c	13.70 d	26.83 d
4	D (200 mL)	5.26 b	10.08 bc	19.35 c
5	E (250 mL)	5.28 b	10.93 bc	17.65 b
6	F (300 mL)	4.80 ab	9.53 b	14.15 ab

Note : Mean values followed by the same letters in the same column are not significantly different based on Duncan's Multiple Range Test at the 5% significance level

Based on Table 1, it can be stated that the treatment with a LOF dosage of 150 mL/plant resulted in the highest plant height, except at the 15 DAP observation, where it was not significantly different from the 100 mL/plant dosage. Conversely, the lowest plant height was observed in the treatments with 0 mL/plant and 300 mL/plant dosages. This indicates that a dosage of 150 mL/plant is the optimum dosage to produce relatively tall red spinach plants. Increasing the dosage beyond 150 mL/plant results in lower plant height.

Liquid Organic Fertilizer (LOF) is an organic material that has functions to improve the physical, chemical, and biological properties of the soil. In terms of chemical properties, Liquid Organic Fertilizer (LOF) contributes several essential nutrients required by plants, such as nitrogen (N), phosphorus (P), potassium (K), and several micronutrients that are crucial for the growth of red spinach. In the treatment without LOF (Control), red spinach plants do not receive nutrient contributions from the LOF. This causes the growth of red spinach plants to be inhibited due to nutrient deficiency.

The increase in plant height is closely related to macronutrients such as nitrogen (N), phosphorus (P), and potassium (K). Nitrogen is a primary element for plant growth, especially vegetative growth, and when plants lack nitrogen, they will become stunted Suriatna, (2002) *as cited in* (Valentino Sembiring et al., 2015).

Number of Leaves per Plant

In addition to plant height, the number of leaves is also a variable that represents plant growth. In general, leaves are the main organs responsible for photosynthesis. Observing the number of leaves is essential as one of the growth indicators that can explain the plant growth process. Leaf observation can be based on the function of leaves as light receptors and

photosynthetic organs. The function of leaves is to produce photosynthates, which are essential for plants as a source of energy in the process of plant growth and development.

Febriantami & Nusyirwan (2017) state that leaves are important organs in plant growth; the greater the number of leaves, the better the growth, whereas a lower number of leaves indicates that the plant is not receiving nutrients as needed.

The results of the analysis of variance show that the Liquid Organic Fertilizer (LOF) dosage has a significant effect on the number of leaves per plant at 15, 22, and 29 days after planting (DAP). Furthermore, the results of the Duncan test on the differences in the average number of leaves per plant among treatments are presented in Table 2.

Table 2. Results of Analysis on Number of Leaves per Plant

No	Perlakuan	Number of Leaves (leaves)		
		15 DAP	22 DAP	29 DAP
1	A (control)	4.80 a	8.10 a	11.75 a
2	B (100 mL)	5.43 ab	9.75 c	17.80 bc
3	C (150 mL)	6.40 c	10.80 d	23.35 d
4	D (200 mL)	5.85 bc	9.50 bc	18.95 c
5	E (250 mL)	5.70 bc	8.75 ab	15.70 abc
6	F (300 mL)	5.25 ab	8.45 a	13.85 ab

Note : Mean values followed by the same letters in the same column are not significantly different based on Duncan's Multiple Range Test at the 5% significance level

Based on Table 2, it can be stated that the treatment with a Liquid Organic Fertilizer (LOF) dosage of 150 mL/plant resulted in the highest number of leaves per plant. Conversely, the lowest number of leaves per plant was obtained from the treatments with 0 mL/plant and 300 mL/plant dosages. This indicates that a dosage of 150 mL/plant is an appropriate dosage to produce a relatively high number of leaves in red spinach plants. Increasing the LOF dosage beyond 150 mL/plant results in a lower number of leaves per plant.

Liquid Organic Fertilizer (LOF) derived from goat manure infusion is an organic material that contains various nutrients, including macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients. The availability of nutrients in the soil affects plant growth, such as plant height and the number of leaves. This condition occurs because the formation of new cells in a plant is closely related to the availability of nutrients in the soil. As stated by Yeremia Eva (2016), leaves are important organs in plant growth; a greater number of leaves indicates better plant development. The nitrogen, phosphorus, and potassium (NPK)

content in plants affects leaf width; if the NPK content meets the plant's requirements, the leaves will become wider, and the photosynthesis process will proceed more efficiently.

Haryadi (1991), *as cited in* Yulianingsih (2019), states that the increase in the number of leaves is strongly influenced by nitrogen, phosphorus, and potassium, in addition to environmental factors such as temperature and light. This is also inseparable from the functions of these three elements for plants, namely their ability to stimulate growth. Nitrogen can improve cell division and flower formation, while potassium can activate enzymes and facilitate the absorption of nutrients.

Suriatna (1998), *as cited in* Sembiring et al. (2015), states that phosphorus plays a role in the processes of cell division and respiration, thereby promoting plant growth, including the increase in the number of leaves. If phosphorus is deficient, plant growth, such as leaf development, will be inhibited. Furthermore, Hermanto et al. (2012), *as cited in* Sembiring et al. (2015), state that if the nutrient content of nitrogen (N), phosphorus (P), and potassium (K) in the soil is imbalanced, it will be insufficient to support the increase in the number of leaves.

Stem Diameter

The results of the analysis of variance show that the Liquid Organic Fertilizer (LOF) dosage has a significant effect on stem diameter at 15, 22, and 29 days after planting (DAP). Furthermore, the results of the Duncan test on the differences in the average stem diameter among treatments are presented in Table 3.

Table 3. Results of Stem Diameter Analysis

No	Treatment	Stem Diameter (mm)		
		15 DAP	22 DAP	29 DAP
1	A (control)	0.86 a	1.66 a	3.44 a
2	B (100 mL)	1.08 ab	2.46 b	6.15 b
3	C (150 mL)	1.48 c	3.35 c	8.39 c
4	D (200 mL)	1.29 bc	2.48 b	6.36 b
5	E (250 mL)	1.27 bc	2.44 b	5.76 b
6	F (300 mL)	1.04 ab	2.06 ab	5.14 b

Note : Mean values followed by the same letters in the same column are not significantly different based on Duncan's Multiple Range Test at the 5% significance level

The results of the Duncan test on the average stem diameter observations in Table 3 show a pattern relatively similar to the observations of plant height and number of leaves per plant.

At the 22 DAP and 29 DAP observations, the treatment with a Liquid Organic Fertilizer (LOF) dosage of 150 mL/plant produced the largest stem diameter. Conversely, the smallest stem diameter was observed in the treatment with a dosage of 0 mL/plant. This indicates that to achieve a relatively large stem diameter in red spinach plants, a Liquid Organic Fertilizer (LOF) dosage of 150 mL/plant is required. Increasing the dosage beyond 150 mL/plant results in a smaller stem diameter.

The stem diameter of red spinach is part of the vegetative structure, and its growth is affected by the availability of nutrients such as nitrogen. Setyamijaya (1986), *as cited in* Yulianingsih (2019), states that nitrogen contained in organic fertilizer can affect meristem growth, allowing it to develop. Nitrogen (N) functions to stimulate overall growth, especially during the vegetative phase, by contributing to the formation of chlorophyll, amino acids, enzymes, and other compounds. Firmansyah et al. (2013), *as cited in* Yulianingsih (2019), add that the supply of nitrogen in the form of $NO3^-$ and $NH4^+$ ions affects the growth of red spinach plants. Nitrogen deficiency will result in inhibited plant growth.

Growth Rate

The results of the analysis of variance show that the Liquid Organic Fertilizer (LOF) dosage has a significant effect on the relative growth rate from 15 to 22 days after planting (DAP) and from 22 to 29 DAP. Furthermore, the results of the Duncan test on the differences in the average relative growth rate among treatments are presented in Table 4.

Table 4. Results of Growth Rate Analysis

No	Treatment	Growth Rate (g/day)	
		15 ke 22 DAP	22 ke 29 DAP
1	A (control)	0.0118 a	0.0189 a
2	B (100 mL)	0.0479 ab	0.0971 b
3	C (150 mL)	0.0933 b	0.1732 c
4	D (200 mL)	0.0287 a	0.1014 b
5	E (250 mL)	0.0321 a	0.0882 ab
6	F (300 mL)	0.0289 a	0.0618 ab

Note : Mean values followed by the same letters in the same column are not significantly different based on Duncan's Multiple Range Test at the 5% significance level

Table 4 shows that the highest relative growth rate is obtained in the treatment with a Liquid Organic Fertilizer (LOF) dosage of 150 mL/plant. Plant growth rate reflects the increase

in plant weight per unit of time. The value of the plant growth rate is derived from the analysis of the total dry weight of the plant (Rochman et al., 2017).

Sugito (1995), *as cited in* (Khakim et al., 2019) defines relative growth rate as the rate of plant growth within a specific period, which occurs during the vegetative phase, where growth proceeds rapidly until just before entering the generative phase. This is also supported by Sasli et al. (2022), who state in their study that the relative growth rate increases during the early growth stage but decreases at the end of the growth period in all treatments. In the early phase of growth, plants absorb nutrients and water for chlorophyll formation in the leaves for the photosynthesis process; subsequently, the photosynthates produced are focused on vegetative growth and increasing the plant's dry weight.

Fresh Weight per Plant and per Plot

The results of the analysis of variance show that the Liquid Organic Fertilizer (LOF) dosage has a significant effect on the fresh weight per plant and per plot. Furthermore, the results of the Duncan test on the differences in the average fresh weight per plant and per plot among treatments are presented in Table 5.

Table 5. Results of Fresh Weight Analysis per Plant and per Plot

No	Treatment	Fresh Weight (grams)	
		per Plant	per Plot
1	A (control)	5.62 a	115.37 a
2	B (100 mL)	18.54 b	413.90 bc
3	C (150 mL)	31.64 c	756.39 d
4	D (200 mL)	19.91 b	444.31 c
5	E (250 mL)	13.68 ab	302.65 abc
6	F (300 mL)	10.88 ab	210.90 ab

Note : Mean values followed by the same letters in the same column are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

Table 5 shows that the highest fresh weight per plant and per plot is obtained in the treatment with a Liquid Organic Fertilizer (LOF) dosage of 150 mL/plant. LOF is an organic material that contains various nutrients required by plants. The use of LOF at the appropriate dosage allows effective absorption by the plant. This is in line with Foth (1994), *as cited in* Yulianingsih (2019), who states that determining the proper concentration and dosage in fertilization is crucial, as inappropriate amounts may negatively affect plant growth if they do not meet the plant's requirements.

The research conducted by Yulianingsih (2019) on the use of cow urine Liquid Organic Fertilizer (LOF) in spinach plants shows that cow urine LOF can increase the growth and yield of red spinach, as observed from the measurements of plant height, number of leaves, and fresh weight. The application of 150 cc of cow urine LOF resulted in the highest growth and yield of red spinach.

Based on the research conducted by Anisa Novita et al., (2024) the results of the analysis of variance show that the application of liquid organic fertilizer derived from goat manure and pineapple peel has a significant effect on increasing the fresh weight of *kailan* plants, as indicated by the calculated F-statistic being greater than the critical value from the F-distribution table across all treatments. The calculated F-statistic being much higher than the critical value from the F-distribution table (119.90 > 3.12 at the 5% level of significance) indicates that the variation among treatments has a statistically significant effect. This is further supported by Gathot Subrata Dan and Martha (2017) which states that plant weight is affected by the physical characteristics of the plant, such as plant height, number of leaves, and leaf area.

Potassium Content in Plants

The results of the analysis of variance show that the Liquid Organic Fertilizer (LOF) dosage has a significant effect on the potassium (K) content in the plant. Furthermore, the results of the Duncan test on the differences in the average potassium content in the plant among treatments are presented in Table 6.

Table 6. Results of Potassium (K) Content Analysis in Plants

No	Treatment	Potassium Content (ppm)
1	A (control)	0.74 a
2	B (100 mL)	0.99 b
3	C (150 mL)	1.02 b
4	D (200 mL)	0.77 a
5	E (250 mL)	0.78 a
6	F (300 mL)	0.76 a

Note : Mean values followed by the same letters in the same column are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

The results of potassium content testing using the AAS (Atomic Absorption Spectrophotometry) method show that the application of LOF (Liquid Organic Fertilizer) has a significant effect on the potassium (K) content in the tissue of red spinach plants. According

to the study by Sarofina et al. (2021), goat manure fertilizer specifically contains a complete set of macronutrients, including potassium (K), which is needed for plant growth.

Based on Table 6, it is evident that the treatment with goat manure Liquid Organic Fertilizer (LOF) dosage significantly affects the potassium (K) content in the tissue of red spinach plants, although with a varying pattern. The control treatment (A), with a K content of 0.74 ppm, shows the lowest potassium content and is significantly different from the treatments with 100 mL (B) and 150 mL (C) dosages. This indicates that without the application of Liquid Organic Fertilizer (LOF), the availability of potassium for plant absorption is very limited. The observed decrease in potassium content at higher LOF dosages (200 mL, 250 mL, 300 mL) indicates the presence of a saturation point or even a negative effect resulting from excessive Liquid Organic Fertilizer (LOF) concentration.

The research by Shidiq et al. (2021) states that excessive potassium can disrupt the absorption of other nutrients and increase soil salinity. An excess of nutrients, particularly potassium, has the potential to inhibit the mechanisms of nutrient uptake, thereby causing a disruption in the nutrient balance assimilated by the plant.

Srivastava et al., (2020) explained that the regulation of potassium in plants is complex and implicitly suggested the presence of a homeostatic mechanism controlling potassium uptake. This indicates that potassium absorption has an optimal limit, and excessive potassium supply does not necessarily enhance uptake but may trigger regulatory responses in plants.

CONCLUSION

Based on the results of the analysis, the research can be concluded as follows:

1. Analysis of variance (ANOVA) indicates that the application of liquid organic fertilizer (POC) derived from goat manure has a significant effect on all observed parameters: plant height, leaf number, stem diameter, relative growth rate, fresh weight, and potassium content.

2. Post hoc Duncan tests revealed that a dosage of 150 mL per plant is optimal, as it yields the highest values for all tested variables, including the highest potassium content (1.02 ppm). In contrast, higher dosages (200–300 mL) resulted in reduced growth and lower potassium levels, suggesting potential negative effects from nutrient excess.

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