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Effectiveness of Concentration of Liquid Organic Fertilizer from Rabbit Urine and Dosage of Rabbit Manure on the Growth and Yield of Red Lettuce (*Lactuca Striva L.*)

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Abstract. This study aims to assess the effectiveness of various concentrations of liquid organic fertilizer (POC) from rabbit urine and doses of rabbit manure on the growth and yield of red lettuce (Lactuca striva L.). The research was conducted in February–March 2024 in Tebel Barat Village, Gedangan District, Sidoarjo Regency. The research design used was a Randomized Block Design (RBD) with two treatment factors. The first factor was the concentration of rabbit urine POC, which consisted of three levels, namely 20 ml/l water, 40 ml/l water, and 60 ml/l water. The second factor was the dose of rabbit manure fertilizer with three levels, namely 1.5 tons/ha, 3 tons/ha, and 4.5 tons/ha. Each treatment combination was repeated three times, resulting in 27 experimental plots. Data analysis was performed using analysis of variance (ANOVA) and followed by BNJ test. The variables observed included the number of leaves, plant height, root length, wet weight, dry weight, and harvest index. The results showed an interaction between treatments, with the best results obtained from the combination of 60 ml/l rabbit urine POC and 3 tons/ha manure for the variables of number of leaves, fresh weight, and dry weight. For the plant height variable, the highest results were obtained from the rabbit urine POC treatment at 60 ml/l water, while the manure fertilizer dose treatment showed no significant difference. As for the root length and harvest index variables, the treatments did not show any significant differences.

Keywords: Red lettuce, Rabbit urine POC, Rabbit manure

1 Introduction

Indonesia is a country with a wide variety of plants, including lettuce. Lettuce belongs to the Asteraceae family and is divided into four categories: stem lettuce (Asparagus lettuce or Stem lettuce), leaf lettuce (Cutting lettuce or Leaf lettuce), soft lettuce (Cos lettuce or Romaine lettuce), and head lettuce or egg lettuce (Head lettuce)[1].

Red leaf lettuce is a variety of leaf lettuce that has attractive leaves with distinctive red, broad, thin, clustered, and curly characteristics, as well as a crisp texture. These characteristics give red leaf lettuce high business prospects and economic value. Currently, red lettuce is in high demand by the public because it is rich in nutritional value. Every 100 grams of red lettuce contains 2.90 grams of carbohydrates, 0.20 grams of fat, and 1.20 grams of protein, as well as important minerals such as 25 mg of phosphorus, 0.50 mg of iron, and 22 mg of calcium. Red lettuce is also rich in vitamins, including 162 mg of vitamin A, 0.04 mg of vitamin B, and 8 mg of vitamin C. Meanwhile, red lettuce is not only high in nutrients but also has a higher flavonoid content compared to other vegetables such as onions, green lettuce, and chili peppers[2]. The development of red lettuce shows positive potential in supporting efforts to improve public nutrition and farmers' income. Red lettuce, as a type of vegetable, has many benefits because it contains antioxidants such as beta-carotene. This substance can be transformed into vitamin A after consumption, providing health benefits, especially for the heart[3]. Soil conditions greatly affect its ability to support plant growth. Quality soil generally has adequate organic content, good structure, and a balanced nutrient content. If soil quality declines, such as through compaction or a reduction in organic matter, agricultural productivity will also be affected. To prevent land degradation and maintain sustainable agricultural yields, the appropriate use of organic fertilizers is necessary, considering factors such as quantity, quality, and continuity of application. Currently, public understanding of organic fertilizers is quite good , and their use has also become part of the government's program to increase soil fertility and

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crop productivity[4]. In order to increase crop production, balanced fertilization is needed. Fertilization is one of the main methods of providing nutrients to plants. Nutrients for plants can be provided through the addition of fertilizers in general. There are two types of fertilizers that are commonly used, namely inorganic fertilizers and organic fertilizers[5].

To ensure that agricultural land use remains sustainable, organic fertilizers are essential. Organic fertilizers improve soil fertility, increase the number of microorganisms in the soil, and enhance water absorption and retention. There are two types of organic fertilizers: liquid and solid. Compost or manure is the term used to describe solid organic fertilizers, while liquid organic fertilizers are called Liquid Organic Fertilizers (LOF).[6] Liquid organic fertilizer solution is a liquid produced through the decomposition of organic materials derived from plant residues, agro-industrial waste, and animal manure[7]. Liquid organic fertilizer (POC) is currently produced in large quantities, and one of the types used in this study is POC from rabbit urine. Liquid organic fertilizer derived from rabbit urine has a fairly high nutrient content, including N 4%, P2O5 2.8%, and K2O 1.2%.[8] The use of organic fertilizer from rabbit urine contributes to increased soil fertility and crop productivity[9].

In addition to utilizing rabbit urine POC in this study, the use of rabbit solid waste was also maximized to improve soil fertility. This waste plays an important role in improving the physical properties of the soil, including increasing soil aggregation, improving aeration and percolation, and releasing ions and metals in the soil to make them available and absorbable by plants[10]. According to Anggrayni (2018), the application of rabbit manure fertilizer at a dose of K_2 446 g/polybag had a significant effect on leaf chlorophyll content, fresh weight of cobs, leaf area, root volume, and dry weight of sorghum plants[11]. Rabbit manure contains higher levels of N, P, and K nutrients, namely 2.72%, 1.1%, and 0.5% higher than other livestock manure such as cow, buffalo, sheep, horse, pig, and even chicken manure[12].

Margianto's (2023) research results state that applying rabbit urine at a concentration of 40 ml produces more optimal mustard plant growth compared to urine treatments at concentrations of 30 ml/L and 20 ml/L[13]. According to Jahidah (2018), applying 3 tons of rabbit manure per hectare together with N, P, and K fertilizers showed the best results in chili plant growth, including the number of leaves, fresh plant weight, dry plant weight, and number of fruits. Meanwhile, the application of 3.98 tons of rabbit manure per hectare together with N, P, and K fertilizers showed the best results in red chili pepper production, with fruit weight reaching a peak of 90.71 grams[14].

This study addresses two research questions: how to determine the interaction between combinations of rabbit urine and solid fertilizer doses on the growth and yield of red lettuce; how to determine the effect of rabbit urine doses on the growth and yield of red lettuce; and how to determine the effect of solid rabbit fertilizer on the growth and yield of red lettuce. This study aims to determine the interaction between combinations of urine and rabbit solid fertilizer doses on the growth and yield of red lettuce plants, to determine the effect of rabbit urine doses on the growth and yield of red lettuce plants, and to determine the effect of rabbit solid fertilizer on the growth and yield of red lettuce plants. Based on this description.

2 Method

This study was conducted on land in the village of Tebel Barat, Gedangan District, Sidoarjo Regency. It was carried out from February to March. The materials used in this study included red lettuce seeds, rabbit urine, rabbit manure, EM4, molasses, soil, and water. The equipment used included black polybags measuring 25 cm x 30 cm, buckets or drums, tarpaulins, measuring cups, scales, rulers, writing instruments, table paper, sacks, trowels, and cell phones.

The research began with the cultivation of red selda. Before planting, the seeds were soaked in warm water for about 1 hour. Cultivation was carried out using seedling trays filled with a mixture of soil and solid organic fertilizer in a 2:1 ratio. The seeds were planted in holes in the trays 1 cm deep, one seed per hole. Watering was carried out in the morning and evening.

Next, make rabbit urine POC and rabbit manure fertilizer. To make POC, follow these steps: Pour rabbit urine into a prepared drum, add molasses and fermenter/Em4 (Azotobacter and Ruminobacter), stir well for about 3 to 4 hours. Cover the drum and place it in a location protected from direct sunlight and rain. Leave it for 7 days, and on the 8th day, open the rabbit urine mixture and stir it using a pump (aerator) that is lifted up and down through a hose, at a minimum height of 4 meters, for 6-7 hours. This stirring process aims to evaporate ammonia, which is toxic to plants, and reduce odors. The rabbit urine mixture is now liquid organic fertilizer and ready for use. Meanwhile, to make rabbit manure fertilizer, the composition for the solid organic fertilizer production ratio is 2:1:1, which means that rabbit manure is combined with straw/leaves and plant waste in this ratio. Leaf litter and plant litter are chopped and then mixed with rabbit manure. The purpose of this mixture is to accelerate the composting process of food crop waste, especially straw and corn leaves, which are difficult to decompose. The mixture is then treated with a solution

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of effective microorganisms to stimulate the growth of organisms that act as decomposers. The moisture content during the composting process is maintained within the range of 30–40%.

After fermenting rabbit urine POC and mature rabbit manure, the next step is to prepare the planting medium. The medium used in this study was soil that had been dried beforehand and mixed with rabbit manure according to the specified ratio. The soil and rabbit manure were mixed thoroughly, then the mixture was placed in polybags measuring 25cm x 30cm. The next process was planting. Planting was carried out when the red lettuce seedlings were 14-21 days old since sowing, or could be identified by seedlings that already had 3-5 leaves. The planting process was carried out in the afternoon. Before removing or extracting the seedlings, the sowing medium is watered first to facilitate the removal of seedlings without damaging the roots. Next, the seedlings are transferred to 25cm x 30cm polybags, with one red lettuce seedling per polybag. After that, the plants are watered until the soil reaches optimal capacity.

After the planting process, maintenance is carried out. The main factors in maintenance are watering, transplanting, fertilizing, and pest control. Watering is done twice a day, in the morning and afternoon, regularly and in sufficient amounts depending on the moisture content of the medium in the polybag. Transplanting is carried out if there are plants that die or experience abnormal growth after one week of being transferred to the polybag, with preparations made in advance. Fertilizer is applied through drenching or watering at a dose appropriate to the first factor. Weeding can be done manually, using natural pesticides, or by mechanical methods. The weeding process, in turn, is carried out mechanically at all times.

The final process is harvesting. Harvesting is carried out by pulling out the entire red lettuce plant based on an age range of 40 to 60 days after sowing (DAS). The variables observed are the number of leaves, plant height (cm), root length (cm), wet weight (g), and dry weight (g). All data from the observations were processed using analysis of variance. If there were significant or very significant differences in the results, they were followed up with a Honest Significant Difference (HSD) test.

3 Results And Discussion

3.1 Results

3.1.1 Number of leaves

The results of the analysis of variance show that rabbit urine POC and rabbit manure have an interaction effect on the number of red lettuce leaves. The average BNJ test results are presented in Table 1.

Table 1. Average Effect of Rabbit Urine POC and Rabbit Manure on the Number of Red Lettuce Leaves (Pieces)

Treatment	Plant age									
	7 days after sowing		14 days after sowing		21 days		28 days		35 days after sowing	
Rabbit urine POC 20 ml and rabbit PK 1.5 tons	4.33	bc	6.67	ab	9.33	ab	14.0	ab	17.33	ab
Rabbit urine POC 20 ml and rabbit PK 3 tons	3.67	ab	6.00	ab	7.33	ab	9.3	a	13.00	a
Rabbit urine POC 20 ml/l and rabbit PK 4.5 tons	3.33	a	5.00	a	6.67	a	10.3	a	11.33	a
Rabbit urine POC 40 ml and rabbit PK 1.5 tons	4.67	bc	7.0	ab	9.00	ab	10.0	a	1:00	a
Rabbit urine POC 40 ml and rabbit PK 3 tons	4.33	bc	6.33	ab	7.33	ab	11.0	a	13.67	a
Rabbit urine POC 40 ml and rabbit PK 4.5 tons	3.67	ab	5.33	a	6.33	a	8.3	a	11.00	a
Rabbit urine POC 60 ml and rabbit PK 1.5 tons	4.00	abc	6.00	ab	8.00	ab	12.3	a	14.33	ab
Rabbit urine POC 60 ml and rabbit PK 3 tons	6.33	d	8.33	b	11.67	b	19.0	b	21.33	b
Rabbit urine POC 60 ml and rabbit PK 4.5 tons	4.67	bc	6.67	ab	8.00	ab	10.7	a	13:00	a
BNJ	0.98		2.57		4.43		6.13		7.42	

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Note: hst = days after planting; Numbers accompanied by the same letter in the same column are not significantly different (SD).

The average number of leaves was measured when the plants were 7 to 35 days old. The data shown in Table 1 indicates that the rabbit urine POC and rabbit manure treatments showed a significant interaction, with the highest results obtained from the rabbit urine POC treatment at a concentration of 60 ml/l water and rabbit manure at a dose of 3 tons/ha, which yielded the highest results, namely 6.33, 8.3, 11.67, 19, and 21.33, respectively. The lowest results were observed in the interaction between rabbit urine POC at a concentration of 20 ml/l water and rabbit manure at a dose of 4.5 tons/ha at plant ages of 7 and 14 days after sowing, with averages of 3.33 and 5. At 21, 28, and 35 days after planting, the lowest results were observed in the interaction between rabbit urine POC at a concentration of 40 ml/l water and rabbit manure at a dose of 4.5 tons/ha, with an average of 6.33, 8.3, and 11.

3.1.2 Plant height

The effect of rabbit urine POC showed significant differences at 7, 14, 21, and 28 days after sowing, but at 35 days after sowing, the treatment with rabbit urine POC showed no significant effect ( ) on the height of red lettuce plants. Meanwhile, rabbit manure treatment showed significant results at 7 days, 14 days, but at 21 days, 28 days, and 35 days, the results were not significant. The average plant height as a response of red lettuce plants to the application of rabbit urine POC and rabbit manure is presented in Table 2.

Table 2. Average POC of Rabbit Urine and Rabbit Manure on Red Lettuce Plant Height

Treatment	Plant height (cm)				
	7 days after sowing	14 days after sowing	21 days after sowing	28 days	35 days
Rabbit urine POC 20ml	13.60 b	16.47 a	22.20 a	29.00 a	37.10
Rabbit urine POC 40ml	12.23 a	17.43 a	24.83 b	29.40 a	42.27
Rabbit urine POC 60 ml	14.87 c	20.50 b	28.83 c	35.83 b	45.13
BNJ	0.79	1.33	1.01	2.03	tn
Rabbit PK 1.5 tons	13.57	19.20	25.70	32.20	43.10
Rabbit PK 3 tons	14.67	18.67	26.17	33.80	43.43
Rabbit PK 4.5 tons	12.47	16.53	24.00	28.23	37.97
BNJ	tn	tn	tn	tn	tn

Note: Figures accompanied by the same letter in the same column are not significantly different (BNJ 5%). tn = not significant

Average plant height data was measured when the plants were 7 to 35 days old. The data shown in Table 2 shows significant differences in the rabbit urine POC concentration treatment but no significant differences in the rabbit manure dosage treatment, as well as no significant results in the interaction between the two treatments. The rabbit urine POC treatment yielded the highest results at a concentration of 60 ml/l at 7, 14, 21, and 28 days after planting, with average results of 15 cm, 21.57 cm, 28.6 cm, and 35.8 cm. The lowest results were obtained in the treatment with a rabbit urine POC concentration of 40 ml/l water at 7 days after planting, with an average result of 12.23 cm. At 14 days, 21 days, and 28 days, the lowest results were found in the treatment with a rabbit urine POC concentration of 20 ml/l water, with average results of 16.47 cm, 22.2 cm, and 29 cm. At 35 days old, the rabbit urine POC and rabbit manure treatments were relatively similar, ranging from 37.10 cm to 45.13 cm for the rabbit urine POC treatment. Meanwhile, the manure treatment ranged from 37.97 cm to 43.43 cm.

3.1.3 Root length

The effect of rabbit urine POC and rabbit manure fertilizer was not significantly different on root length. The average root length of red lettuce plants is presented in Table 3.

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Table 3. Average Effect of Rabbit Urine POC and Rabbit Manure on the Root Length of Red Lettuce Plants

Treatment	Root Length (cm)
Rabbit urine POC 20ml	18.80
Rabbit urine POC 40ml	17.97
Rabbit urine POC 60 ml	22.23
BNJ	tn
Rabbit PK 1.5 tons	21.10
PK Rabbit 3 tons	20.07
Rabbit PK 4.5 tons	17.83
BNJ	tn

Note: tn = not real

The data in Table 3 shows that root length in the rabbit urine POC and rabbit manure treatments was relatively the same in both treatments, ranging from 17.97 cm to 22.23 cm in the rabbit urine POC concentration treatment. Meanwhile, in the manure dose treatment, it ranged from 17.83 cm to 21.10 cm.

3.1.4 Fresh Weight and Dry Weight

The analysis of variance results showed that rabbit urine POC and rabbit manure had an interaction effect on the wet weight and dry weight of red lettuce plants. The average BNJ test results are presented in Table 4.

Table 4. Average Effect of Rabbit Urine POC and Rabbit Manure on Wet Weight and Dry Weight of Red Lettuce Plants

Treatment	Wet weight	Dry weight
Rabbit urine POC 20 ml and rabbit manure 1.5 tons	46.13 ab	4.20 a
Rabbit urine POC 20 ml and rabbit PK 3 tons	20.90 a	2.80 a
Rabbit urine POC 20 ml and rabbit PK 4.5 tons	17.37 a	2.97 a
Rabbit urine POC 40 ml and rabbit PK 1.5 tons	28.80 a	3.53 a
Rabbit urine POC 40 ml and rabbit PK 3 tons	40.67 ab	9.57 ab
Rabbit urine POC 40 ml and rabbit PK 4.5 tons	22.13 a	3.10 a
Rabbit urine POC 60 ml and rabbit PK 1.5 tons	36.00 a	7.13 a
Rabbit urine POC 60 ml and rabbit PK 3 tons	70.57 b	16.57 b
Rabbit urine POC 60 ml and rabbit PK 4.5 tons	20.53 a	4.03 a
BNJ	40.06	7.81

Note: Numbers accompanied by the same letter in the same column are not significantly different (SD). tn = not significant

The data in Table 4 shows the average wet weight and dry weight measured when the plants were 35 days old. The data shown in Table 4 indicates that the rabbit urine POC and rabbit manure treatments showed a significant interaction, with the highest results obtained from the rabbit urine POC treatment at a concentration of 60 ml/l water with rabbit manure at a dose of 3 tons/ha, with an average of 70.57 g for wet weight and 16.57 g for dry weight. Meanwhile, the lowest result was found in the rabbit urine POC treatment with a concentration of 20 ml/l water with rabbit manure at a dose of 4.5 tons/ha, with an average result of 17.37 g for wet weight and the lowest result for dry weight in the rabbit urine POC treatment at 20 ml/l water + rabbit manure at a dose of 3 tons/ha with a result of 2.80 g.

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3.1.5 Harvest Index

The effect of rabbit urine POC and rabbit manure fertilizer was not significantly different on the harvest index. The average harvest index of red lettuce is presented in Table 5.

Table 5. Average Effect of Rabbit Urine POC and Rabbit Manure on the Harvest Index of Red Lettuce Plants

Treatment	Root Length (cm)
Rabbit urine POC 20ml	1.77
Rabbit urine POC 40ml	1.95
Rabbit urine POC 60 ml	1.98
BNJ	tn
Rabbit PK 1.5 tons	1.97
PK Rabbit 3 tons	1.92
Rabbit PK 4.5 tons	1.80
BNJ	tn

Note: tn = not real

The data in Table 5 shows that the harvest index in the rabbit urine POC and rabbit manure treatments was relatively the same in both treatments, ranging from 1.77 g to 1.98 g in the rabbit urine POC concentration treatment. Meanwhile, in the rabbit manure fertilizer dose treatment, it ranged from 1.80 g to 1.97 g. According to Nurhalimah (2023), this can be influenced by wet weight and total consumption weight; when the wet weight has a high value, it causes the harvest index value to be lower. However, when the total consumption weight is higher, the harvest index increases[15]. Additionally, according to (Lutfiana, 2023), the harvest index is also influenced by several factors, one of which is the combination of treatments. A combination of treatments can also inhibit or aid growth, or even have no effect on growth[16].

3.2 Discussion

The results of the analysis of variance show that the treatment of rabbit urine POC and rabbit manure shows that the combination of the two treatments has a significant effect on growth and yield, such as the number of leaves, plant height, wet weight, and dry weight of red lettuce plants. This is thought to be due to the interaction between rabbit urine POC and rabbit manure in fulfilling the nutrients needed in the vegetative phase of red lettuce plants. According to Annisa (2021), with adequate nutrient availability during growth, plant metabolism becomes more active, resulting in better elongation, division, and differentiation of cells, thereby promoting better yields[17].

According to Handayani (2020), plant development, including plant length, number of leaves, and stem diameter, is influenced by organic matter content, particularly organic carbon. The higher the organic matter content, the more optimal plant growth tends to be[18]. The results of Ummah's (2022) research state that goat manure, both feces and rabbit urine, has a higher content of N, P, and K nutrients, namely 2.72%, 1.1%, and 0.5%, respectively, when compared to other livestock manure such as horses, cows, buffaloes, sheep, chickens, and pigs.states that plants that obtain sufficient nutrients will show more active new leaf growth. The addition of nitrogen also contributes to stimulating the growth of plant parts that play an important role in the photosynthesis process, such as leaves[19]. The same thing was also stated by Hartini (2019). The amount of nutrients absorbed by the roots will affect the amount of organic and mineral matter transferred to other parts of the plant, including for leaf formation, which will ultimately increase the number of leaves. Most of the nitrogen absorbed by the roots will rise to the leaves and interact with carbohydrates to form proteins that support leaf formation[20]. According to Cahyadi (2024), the role of nitrogen nutrients is to accelerate the vegetative growth of plants, such as plant height, stem size, and leaf formation[21]. However, according to Hardiana (2024), excess or even deficiency of nutrients can inhibit the plant's ability to absorb nutrients optimally, thereby inhibiting the plant's metabolic processes[22].

Plant height is one of the observations used to determine vegetative growth. Yusdian (2020) states that plant height is often used as one of the parameters observed, both to indicate the growth rate of plants and to assess the effects of certain environmental factors or treatments[23]. According to Ais (2024), sufficient available nitrogen can play a role

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in accelerating plant height growth because the nitrogen content in the soil can be utilized by plants during cell division and enlargement, thereby stimulating plant height formation[24]. In addition to nitrogen, phosphorus also plays a role in the cell division process in plant height[25]. The phosphorus in rabbit manure also plays a role in stimulating plant growth, particularly in terms of cell division and cell elongation. When plants receive an adequate supply of phosphorus nutrients, it helps them to undergo vegetative growth, such as plant height growth.

According to Aswar (2024), root length is an important indicator of plant growth because it plays a role in the absorption of water and minerals needed for photosynthesis. The larger the root area, the more efficiently plants utilize water. An increase in root length generally corresponds to an increase in root surface area ( ), thereby expanding the contact area between the roots and the soil. This allows for maximum absorption of water and minerals, especially through young roots that have many root hairs. These root hairs play an important role in the absorption process because they increase the surface area in contact with the soil[26]. According to Ummah (2022), the length of a plant's roots affects its effectiveness in absorbing nutrients from the soil[19]. Longer roots are usually triggered by the abundant availability of soil nutrients, thereby increasing the roots' ability to absorb nutrients in the soil[27]. The phosphorus and calcium content in rabbit manure can support root growth, thereby helping the roots absorb water and nutrients. However, according to Cun (2023)[28] , excessive nitrogen content can suppress root length and surface area, as well as inhibit root growth and root biomass[28]. The potassium nutrient content in rabbit manure also plays a role in influencing yield. In addition to its role in photosynthesis and respiration, potassium also plays a role in starch formation, enzyme activation, stomata opening, plant physiological processes, cellular metabolic processes, improving the root system, and strengthening stems[29].

The results above show that the application of rabbit urine POC and rabbit manure fertilizer can increase plant weight. This is due to an increase in the number of leaves and plant height ( ). According to Margianto (2023), plant dry weight reflects the accumulation of organic compounds synthesized by plants from inorganic materials such as water and carbon dioxide[13]. Nutrients absorbed through the roots also play a role in increasing dry weight[30]. The wet weight of plants will increase in line with the increase in dry weight. According to Hardiana (2024), during the growth phase, most of the energy assimilated by plants is used for the formation and development of organs in the vegetative phase, namely leaves, stems, and roots, thereby increasing plant production[22].

4 Conclusion

The treatment of rabbit urine POC and the application of rabbit manure resulted in significant interactions on several observation variables, including the number of leaves, fresh weight, and dry weight, with the highest results obtained from the treatment of 60 ml of rabbit urine POC + 3 tons of rabbit manure. However, the plant height observation variable did not show any interaction results but showed significant differences in the rabbit urine POC treatment. Meanwhile, the manure treatment did not show any significant differences, with the rabbit urine POC treatment yielding the highest results at 60 ml. Meanwhile, the root length and harvest index variables showed no significant differences in each treatment. Based on the results of this study, it can be concluded that the application of rabbit urine POC concentration and manure dosage can increase the growth and production of red lettuce due to the availability of sufficient nutrients.

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