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Research Article

Growth and yield of radish (*Raphanus sativus* L.) treated with different organic manure on alluvial soil

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ABSTRACT

The productivity of radish plants can be increased using improved varieties and fertilizing the soil to increase its fertility. Using organic fertilizers can improve soil structure and increase productivity on the land. This study aimed to determine the effect of applying organic fertilizer on the growth and yield of radish on alluvial soil. The study was conducted in July-December 2021, using a randomized block design with five treatments and five replications. The treatments were types of organic fertilizers consisting of control, goat manure, chicken manure, ashes (remaining ash from burning leaves), and cow manure. Each type of organic fertilizer was applied with a dose of 6 tons ha^{-1}. The observation shows that the application of chicken manure significantly improves both the vegetative and the generative variables of radish crops. The results of the farm analysis showed that the use of chicken manure yielded more significant benefits, with R/C values of 2.40 and a B/C ratio of 1.40.

Keywords: farm analysis; productivity enhancement; soil fertility

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INTRODUCTION

Radish (*Raphanus sativus* L.) is an annual tuber vegetable plant that is short-lived, only 40-90 days, and in the form of a shrub or bush. Radish is an annual plant because it is only produced once a year; after that, the plant dies. The lifespan of radishes varies according to the variety and environmental conditions where it is planted.

Radish plants can grow at an altitude of approximately 1,500 m above sea level with air temperatures between 15.5 to 21.1 °C and humidity of 70 to 90%, with sufficient sunlight and adequate groundwater conditions. Suitable rainfall for radish crops is 1,000-1,900 mm per year. Radish plants cannot withstand high rainfall during their growth period because it can cause tuber rotting, and the risk of disease attacks is relatively high (Mutini et al., 2022). Water needs can naturally be met from rainwater. How much water is needed will have an impact on growth. If there is excess water, plants will generally be susceptible to disease. On the other hand, if there is a lack of water, the plant will experience drought, which can ultimately result in death.

Radish plants require fertile soil with good structure, contain lots of organic matter, and the top layer does not contain gravel (small stones). Apart from that, good soil acidity (soil pH) is between 5-6. The ideal soil type is andosol. Less fertile soil is easily waterlogged. When the soils contain lots of gravel, the growth of radish tubers is obstructed. The lack of organic material can be overcome by applying manure or organic material (Sunarjono, 2015).

Efforts to increase radish production are using superior varieties and increasing soil fertility. Efforts made to improve soil fertility include using solid or liquid organic fertilizer. Organic fertilizer contains macro and micronutrients that plants need, even in small amounts. The use of organic fertilizer can not only improve soil structure but also indirectly increase land productivity. To maintain and increase soil organic matter, it is necessary to add organic fertilizer (Suswana & Maulana, 2023).

Providing organic matter positively affects the growth of radishes because it can increase the content of macro and micronutrients in the soil. Based on research by Pant and Oli (2021) providing goat manure containing 0.89% N can significantly increase the root diameter and the leaf length at almost all stages of the development of the forty-day radish and the plant height at harvest. Sa'id et al. (2022) showed that radishes with cow manure treatment have the highest water and crude fiber content. Radishes with chicken manure treatment have the highest ash, protein, carbohydrate, and energy content. Radishes with cow manure treatment have the highest iron, manganese, phosphorus, cadmium, and zinc levels. In contrast, calcium and potassium have the same values when treating chicken and cow manure. Plant litter ash is the white ash remaining from plant litter that is wholly burned at a temperature of 500–600 °C for 2-3 hours and mainly contains mineral nutrients such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and silicate (Berg & McClaugherty, 2020). Plant litter has a high N content (≥2.5%), a low C/N ratio (≤32:1), and a relatively low lignin and polyphenol content. It decomposes more quickly and can provide an adequate supply of nutrients in agroecosystems (Partey et al., 2014). Providing ash left over from burning, especially wood-made, can reduce acidity because the ash contains the element potassium (Fahruni, 2015). Potassium is essential in plant growth and development. According to Johnson et al. (2022), Potassium, absorbed as K+, is crucial for protein and carbohydrate formation, particularly in young cells or protein-rich plant parts, supporting plant growth and development. This statement is also by research conducted by Wulandari et al. (2014) who researched the combination of planting media to the number of cucumber plants in polybag with the composition of growing media soil mixed with chicken manure and sand. The research results showed a significant effect on plant height, fruit number of cucumber, fruit weight, and plant dry weight, where the best results come from planting media using chicken manure fertilizer.

This study aimed to investigate the effect of organic fertilizer on the growth and yield of radish in alluvial soil. It is also to assess the continuity of radish cultivation efforts by considering the cost-benefit ratio.

MATERIALS AND METHODS

The material used in the study was radish seeds. The seeds were sown thinly and evenly along the furrow and then covered with soil. The distance between plants was 20 cm x 10 cm with a bed width of 1-1.2 m, a bed height of 20-50 cm, and given silver plastic mulch, a distance between beds of 40-50 cm, and a bed length of about 4 m. Seeds grew four days after planting. At the age of 2-3 weeks from planting, mounds were made by raising the soil along the rows of plants. In addition, weeding was carried out by removing stunted plants—fertilization using NPK fertilizer as basic fertilizer.

The study used a randomized block design with five treatments and five replications. The treatments were types of organic fertilizers consisting of control, goat manure, chicken manure, ashes (remaining ash from burning leaves), and cow manure. This activity was conducted in a demonstration garden at the BPTP West Kalimantan in July - December 2021.

The experimental procedure included (i) land preparation, liming with 1.5 tons ha^{-1} of dolomite as ameliorant, and application of NPK fertilizer as basic fertilizer, and 6 tons ha^{-1} of manure treatments at the time of tillage. The NPK fertilizers are 200 kg NPK 16:16:16 ha^{-1} and 150 kg SP-36 ha^{-1}, (ii) bedding, (iii) planting, (iv) maintenance and applying additional fertilizer in the form of 300 kg NPK ha^{-1} and 200 kg KCl ha^{-1} (given when the plants are 15-20 and 35-40 day after planting/dap), (v) weeding, (vi) pest and

plant disease control, (vii) harvesting, Variables observed were plant height, leaf number, wet tuber weight, dry tuber weight, and production in tiles (width of 1-1.2 m, and length of 4 m) converted in tons ha^{-1}.

Several analytical methods determine which treatment is most profitable for farmers. The total cost (Total Cost) is obtained by adding up the fixed costs (Fixed Cost/FC) with the variable costs (Variable Cost/VC). The calculation of total revenue (Total Revenue/TR) is the multiplication of the yield (Y) and the selling price (Py). Revenue is the difference between total revenue (TR) and total costs (TC). Benefit Cost Ratio (B/C Ratio) or Profit Index (PI) compares the benefits and profits obtained by a business with the costs incurred in that business in the future. If the B/C value = 1. The company is worth running if the B/C value is <1, or not feasible because it cannot return the capital invested. Revenue Cost Ratio (R/C) analysis is a comparison between total revenue and total costs, where Revenue (R) is the amount of revenue and Cost (C) is the amount of costs incurred. The indicators in the R/C analysis are if R/C > 1 means the farming is worth running, R/C = 1 means the farming is breaking even, and R/C < 1 means the farming is not worth running (Suratiyah, 2015).

Data were processed with analysis of variance. If the analysis of variance shows a significant effect of a treatment, the Duncan's Multiple Range Test (DMRT) was performed at the 5% significance level.

RESULTS AND DISCUSSION

Plant height

The results showed that the application of chicken manure resulted in the highest radish plants (Figure 1). Chicken manure, when used, decomposes rapidly, leading to a swift release of nutrients into the soil. This efficient process ensures that the nutrients are readily available for absorption by the plants. During the vegetative growth phase, plants particularly require nitrogen (N). This element is crucial for stimulating the vegetative growth of plants, including stems, roots, leaves, and branches (Hang et al., 2019). Chicken manure has the highest nitrogen content compared to other organic fertilizers. The content of chicken manure is 2.87% N, 1.56% P, and 1.68% K, while cow manure contains 1.50% N, 0.96% P, and 1.23% K (Geng et al., 2019). Additionally, Biratu et al. (2018) stated that chicken manure fertilizer could increase organic C content (26%), organic matter (45%), CEC (26 $cmol^{(+)}$ kg^{-1}), as well as macro and micronutrients such as N, P, K, Ca, Fe, Mn, Zn and Cu. Chicken manure also contains lignin and polyphenols and has a C/N ratio, which correlates with the speed of decomposition and mineralization of the organic material so that the fertilizer is quickly decomposed or available to plants (Tobing et al., 2023). In line with the research (Gyewali et al., 2020), applying chicken manure fertilizer at a dose of 30 tons ha^{-1} to radish resulted in a plant height of 22.5 cm at 42 DAP.

Leaf number

The application of goat manure resulted in the highest leaf numbers of radish, namely 19.7, which was very significantly different from the control but not significantly different from the application of chicken manure, cow manure, and ashes (Table 1). The availability of nutrients such as N, P, and K in goat, chicken, cow manure, and ashes can increase the leaf number of radish plants. Nitrogen has a role in cell division, cell enlargement, and protein synthesis. Phosphorus plays an essential role in ion transport and cell membrane development, while K plays a role in the osmotic regulation of plant cells. The positive response in plants for each fertilizer treatment from several animal wastes and ashes compared to the control indicates that the soil media has improved. Applying organic fertilizer significantly differs at all doses and can improve soil's physical properties, especially soil bulk weight, porosity, and permeability (Lawenga et al., 2015).

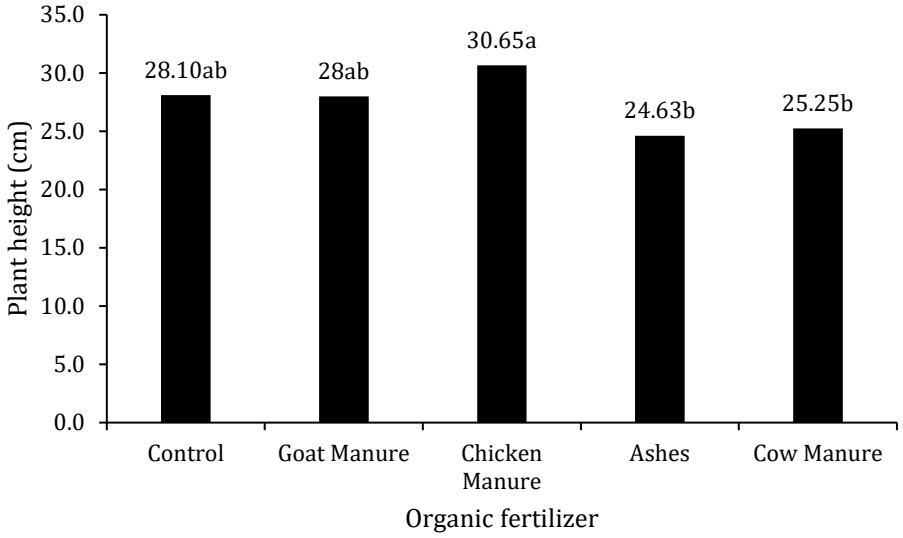


Figure 1. The effect of some organic fertilizers on the height of radish plants at 42 DAP.

Table 1. The leaf number, the bulb diameter, the bulb length, and the root length.

Treatment	Leaf number	Bulb diameter (cm)	Bulb length (cm)	Root length (cm)
Control	15.0b	2.63b	11.95b	9.15
Goat Manure	19.7a	3.80a	17.50a	6.10
Chicken Manure	17.7ab	3.55a	19.65a	6.60
Ashes	18.5a	3.62a	16.90a	8.85
Cow Manure	17.7ab	3.49a	17.40a	10.75

Note: Numbers followed by the same letter in the same column do not differ significantly according to the DMRT at the level of 5%.

Providing organic materials at optimal doses can increase photosynthetic assimilation so that the leaf number can increase (Debbarma et al., 2015). Increased CO_2 can increase the rate of photosynthesis and carbohydrate production and have a positive impact on the transportation and growth of food substances resulting from photosynthesis, from the leaves to the entire plant body so that leaf area directly affects the photosynthetic capacity of plants (Aluko et al., 2021). Atmaja et al. (2019) stated that if plants have sufficient N nutrients, this can be characterized by the progress of the photosynthesis process, greener leaf color, and better vegetative growth.

Bulb diameter

The application of goat manure also showed a larger diameter of radish tubers, namely 3.80 cm, as did the application of chicken and cow manure and ashes (Table 1). Research results (Pranata, 2017) show that goat manure consists of 67% solid and 33% liquid material; the nutrient composition is 0.70% N, 0.35% P, 25; 1.95% Ca, and 0.56% Mg. Goat manure is considered to have a higher percentage of potassium nutrients when compared to other fertilizers. The potassium content is 2.88% higher than the K element in cow manure (0.69%) and chicken manure (1.45%). Potassium is a catalyst in enzymatic reactions and plant tissue development. Apart from that, potassium speeds up the metabolism of nitrogen elements and increases carbohydrates in plants. There needs to be more than organic materials to support the growth and yield of radish plants. According to (Otieno et al., 2021), potassium is essential in growth, tuber development, and quality. In addition, K plays a vital role in several physiological processes, such as photosynthesis and photosynthate translocation, stomatal regulation and transpiration, and activation of plant enzymes. Potassium is needed to increase cambium activity in

roots that store starch and increase starch synthesis activity in tubers (Zierer et al., 2021). Harahap et al. (2015) also stated that potassium nutrients play a role in increasing stem diameter, especially in the translocation of potassium nutrients so that carbohydrate formation will run well with the availability of potassium nutrients. Its function in plants is to help form proteins and carbohydrates, increase resistance to disease attacks, and improve fruit quality (Rawat et al., 2022).

Healthy and optimally growing plants require sufficient nutrients because they will affect tuber formation through photosynthesis. Assimilates produced from photosynthesis in the leaves and distributed to the tubers are essential for tuber growth. The leaf number available increases the ability of photosynthesis to produce assimilates. Based on Table 1, the provision of goat manure gives the highest results in the leaf number and tuber diameter (Suryana, 2018).

Length of bulb and root

Chicken manure, a treatment that resulted in the most extended tuber length of 19.65 cm, also significantly increased the concentration of N, P, K, Ca, Mg, organic matter, pH, soil porosity, and water content (Adekiya, 2019). This increase in water content is particularly important for root growth, as it affects turgor and cell expansion, root elongation, and storage organs. Drought stress, on the other hand, can lead to a decrease in turgor in plant cells and a subsequent decrease in physiological processes, such as photosynthetic activity (Zhang et al., 2023).

The availability of nutrients N, P, and K is crucial for cell division and elongation, processes integral to plants' vegetative growth phase. These processes, in turn, require carbohydrates, which are formed in plants and combine with nitrogen compounds to form protoplasm at the growing points, thereby affecting the increase in plant height. The availability of carbohydrates is directly influenced by the availability of nutrients for the plant (Mardianto, 2014).

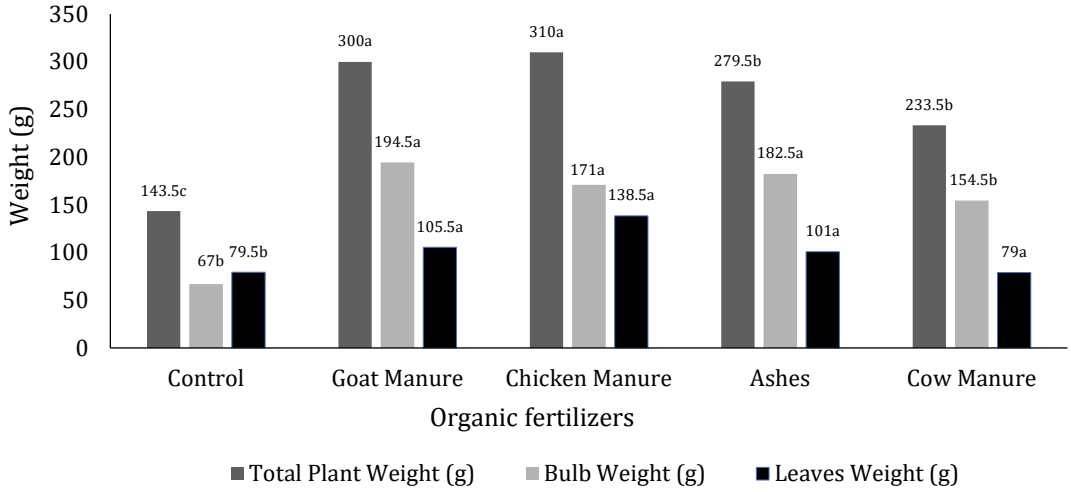
Chicken manure has a low C/N ratio but encourages faster decomposition and release of nutrients than other organic fertilizer sources. Plants can easily absorb nutrients in the soil, making them suitable for short-lived radish plants. Increasing porosity in the soil will reduce mechanical barriers to radish tuber growth, which can cause an increase in tuber length (Adekiya, 2019).

The root length in treatments with various organic material applications was not significantly different from the control. The highest result in the cow manure treatment was 10.75 cm, while the control was 9.15 cm. This shows that root length does not affect the nutrients absorbed by the soil for plant growth.

Plant weight

From the results of observations, applying chicken manure fertilizer provides fresh plant weight (weight of the entire plant). The roots absorb nutrients into the leaves to be processed into assimilates through photosynthesis, which is then distributed to all plant parts. The fresh weight of the plant shows the overall nutrient elements that can be distributed from the leaves to the tubers. According to Nafery et al. (2021), the availability of nutrients in sufficient conditions causes the biosynthesis process to run smoothly. This condition causes an increase in the fresh weight of the plant.

From the results of the DMRT test at the 5% level, the highest total plants and leaf weights were 310 g and 138.5 g (Figure 2). Chicken manure contains various nutrients and elements such as nitrogen, phosphorus, potassium, copper, zinc, calcium, cobalt, iron, selenium, molybdenum, manganese, and boron. Compared with other types of animal manure, chicken manure shows a higher content of 15 kg mg^{-1} of nitrogen, 15 kg mg^{-1} of phosphorus, and 24 kg mg^{-1} of calcium (Drozdz et al., 2020). These nutrients play a role in stimulating plant vegetative growth, encouraging root growth, and strengthening plants. Apart from that, nutrient availability is necessary for forming organic compounds such as carbohydrates, proteins, and lipids. These compounds also play a role in the formation of organs and cells in plants (Pagare et al., 2015).



Note: Means followed by the same letters in the same variable are not significantly different according to the DMRT at α=5%.

Figure 2. Weight of the harvest on the radish plant.

Tubers are the main product of the radish plant. The condition of the loose planting medium influences the development of radish tubers. According to Yan et al. (2021), organic material will improve soil structure and increase the soil's ability to hold nutrients. A loose soil structure supports radish tubers to develop well. The highest tuber weight when applying goat manure was 194.5 g (Figure 2). The availability of the potassium nutrient content in goat manure makes tuber formation more optimal. The potassium element in goat manure is the third most important element after nitrogen and phosphorus. Plants absorb potassium in large quantities, sometimes greater than nitrogen in root crops (Atmaja et al., 2019). Potassium maintains plant water status and cell turgor pressure, regulates stomata, and regulates the accumulation and translocation of newly formed carbohydrates, thus affecting the yield and quality of tubers (Johnson et al., 2022). The increase in radish growth and yield was due to improvements in the biological and physical properties of the soil, as well as increased micronutrient content in organic fertilizers (Afriyie & Amoabeng, 2017).

Yield per hectare

The provision of various organic materials can increase the yield of radish when compared to the control. The results showed that chicken manure had an average descriptive value of 15.50 tons ha^{-1}, with the highest production results per hectare (Figure 3). Chicken manure can affect important soil properties in vegetable production, such as pH, organic matter content, CEC, and salinity. Peng et al. (2018) reported the potential use of chicken manure fertilizer as a natural soil conditioner. In addition, chicken manure contains quite a lot of organic material, so it impacts soil pH. Rayne and Aula (2020), also stated that there is a real influence on plants because chicken manure contains nutrients that can loosen the soil and improve the structure of the soil; it has optimal water absorption capacity so that plants' water needs are met. In line with Setiyo et al. (2018), the function of chicken manure fertilizer is to increase water absorption and capacity so that the roots more easily absorb the nutrients contained in the soil.

Chicken manure contains macro and micronutrients consisting of N (1.72%), P (1.82%), K (2.18%), Ca (9.23%), and Mg (0.86%) (Tufaila et al., 2014). The availability of N P K in the soil is influenced by the mineralogical composition of the parent material and increased soil microbial activity, which increases soil nutrient availability (Sun et al., 2016). Increasing N P K available in the soil can increase biomass and plant yields. In line with research by Gondwe et al. (2020), increasing the nutrient N P K significantly increases tuber yield and potato yield variable at harvest. According to Baloch et al. (2014) increasing nitrogen nutrients positively affects all growth and yield variables of radishes.

Silvitri et al. (2023) stated that higher amounts of potassium are needed by radishes for the formation of radish tuber roots. Giving chicken manure fertilizer can also increase the concentration of microelements such as Mg, Fe, Al, Ca, and soil CEC Setiyo et al. (2018). Providing biological fertilizer and micronutrients significantly impacts plant growth, roots, yield, and quality of radish. Combining micronutrients and biological fertilizer can increase radish production (Ahamad et al., 2023).

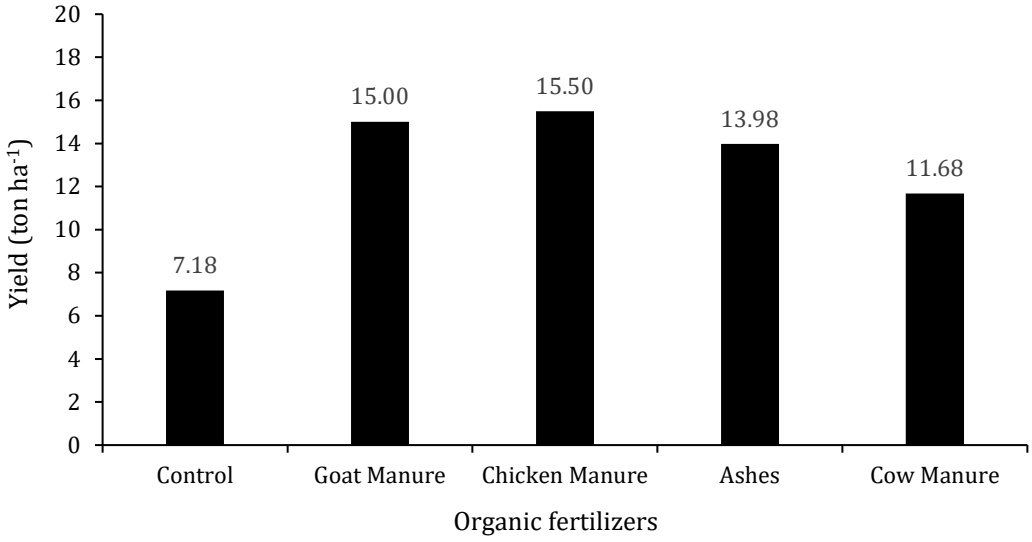


Figure 3. Radish production (tons ha^{-1}) on the supply of some organic fertilizer.

Financial analysis

The research results show that the average radish production ranges from 2.29-4.96 tons ha^{-1}, with a selling price of IDR. 12,000,- (farmer price). The high yield of radishes and promising market prices have made farmers enthusiastic about cultivating radish plants. With the proper cultivation techniques, plant productivity can be increased.

Table 2. Farm analysis on application of some organic fertilizers on radish plant.

Description	Organic fertilizer				
	Chicken (Rp.000)	Cow (Rp.000)	Goat (Rp.000)	Ashes (Rp.000)	Control (Rp.000)
Cost					
Labor (VC) (IDR)	16.500	16.500	16.500	16.500	16.500
Production inputs (VC) (IDR)	8.300	7.550	7.550	5.600	5.300
Tool depreciation (FC)(IDR)	15.00	15.00	15.00	15.00	15.00
Total cost (TC) (IDR)	24.815	24.065	24.065	22.115	21.815
Income (TR) (IDR)	59.520	44.832	57.600	53.664	27.552
Production (Y)(kg)	4.960	3.736	4.800	4.472	2.296
Price (Py)/ kg (IDR)	12	12	12	12	12
Profit (P)	34.705	20.767	33.535	31.549	5.737
B/C Ratio	1.40	0.86	1.39	1.43	0.26
R/C Ratio	2.40	1.86	2.39	2.43	1.26

Note: IDR: Indonesian Rupiah; VC: variable cost; FC: fix cost; TC: total cost; TR: total revenue; Y: yield; Py: price of yield; P: profit.

The farming analysis showed that using chicken manure on turnip plants provided greater profits, namely Rp. 34,705,000 per hectare. The R/C ratio value of ash use (2.43) is higher than that of chicken manure (2.40) because the cost of using ash is lower, but the production of turnips with chicken manure is the highest compared to other treatments. With an R/C value of 2.40 and a B/C ratio of 1.40. An R/C value of more than 1 explains that the radish cultivation business with chicken manure is feasible. The R/C value above 1 indicates the feasibility of the turnip cultivation business with chicken manure. The R/C

ratio, an analysis method that measures the return on business in implementing technology, is crucial in assessing business feasibility (Siadari et al., 2022).

CONCLUSIONS

The provision of chicken manure gave the highest results on radish plants. Chicken manure had a significant effect on the parameters of the plant height variable (30.65 cm), tuber length (19.65 cm), plant weight (310 g), and leaf weight (138.5 g). The highest root length variable in the cow manure treatment was 10.75 cm. Providing chicken manure fertilizer gave the highest yield, namely 15.50 tons ha^{-1}, with a profit of IDR. 34,705,000 per hectare. The R/C value is 2.40, and the B/C ratio is 1.40, so radish cultivation using chicken manure is feasible.

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