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The Effect of Green Fertilizer Application Apu-Apu (Pistia Stratiotes) and Plant Growth Regulators on the Growth and Production of Lettuce (*Lactuca Sativa* L.)

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Abstract
This study aims to determine the effect of green fertiliser apu-apu and plant growth regulators on the growth and production of lettuce (Lactuca sativa L.). This study used a randomised block design (RAK) with two factors. The first factor is green fertiliser Apu-Apu with the symbol (K) consisting of 3 levels: K1 = 1 kg/plot, K2 = 1.5 kg/plot, and K3 = 2 kg/plot. The second factor is plant growth regulators with the symbol (P) consisting of 4 levels: P0 = control (no treatment), P1 = 2 cc/l water, P2 = 4 cc/l water, and P3 = 6 cc/l water. The results showed that green fertiliser apu-apu up to a dose of 2 kg/plot significantly increased the height of fresh weight per plant, wet weight per plot, and root weight per plot but did not affect plant height. The provision of plant growth regulators significantly increased plant height, wet weight per plant, wet weight per plot, and root weight per plot. The administration of growth regulators up to a concentration of 6 cc/l of water resulted in the highest wet weight per plant and wet weight per plot. The interaction between apu-apu green manure and growth regulators did not significantly affect plant height, number of leaves, wet weight per plant, wet weight per plot, and root weight per plot.

Keywords—: *Green Fertilizer, Plant Growth Regulators and Lettuce*

Introduction

Lettuce is a type of vegetable plant that is consumed for its leaves. The market absorption prospects for lettuce commodities will continue to increase in line with the population, community education, community income and welfare, and community preferences for lettuce. (Hammado, 2019)

Lettuce (Lactuca sativa L.) is a horticultural commodity with good prospects and commercial value. Lettuce (Lactuca sativa L.) is included in the group of leafy vegetable plants known in the community. This type of vegetable contains nutrients, especially vitamins and minerals, that are complete to meet the community's nutritional needs.(Manullang et al., 2019)(Nurza & Venesia, 2020). Lettuce is a source of vitamin K. Rich in mineral salts with alkaline elements dominating. This helps keep the blood clean and the mind and body healthy. Leaf lettuce is rich in lutein and beta-carotene and supplies vitamins C and K, calcium, fiber, folate, and iron (Faisal, 2020)(Abdillah, 2024). Vitamin K functions to help blood clotting. Other nutrients are vitamins A and B6, folate, lycopene, potassium, and zeaxanthin. Lettuce contains alkaloids that are responsible for the therapeutic effects. The nutritional content in 100 g of lettuce includes 15.00 calories, 1.2 g protein, 0.2 g fat, 2.9 g carbohydrates, 22 mg Ca, 25 mg P, 0.5 g Fe, 1.2 mg vitamin A, 0.04 mg vitamin B, 8.0 mg vitamin C, and 94.80 mg water.(Zulia et al., 2017).

The increasing demand for vegetables must be balanced with increasing vegetable

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productivity. Several types of vegetables have high production potential, so they are worth developing. One type is leaf lettuce, which can yield 12 tons/ha. Since the 1980s, domestic demand for lettuce has increased, especially in supermarkets, restaurants, and starred hotels that foreigners often visit. Meeting these needs has caused Indonesia to import other commodities. Lettuce (Lactuca sativa L.) is a leaf vegetable that in West Java is known as seladah, selada bokor (Sundanese), and Javanese people generally call it selada or sladah (Javanese). Lettuce originates from Asia Minor or the Middle East and has been better known as a vegetable and ingredient since 4500 BC.(Prabowo et al., 2022).

Lettuce is a group of leafy vegetable plants known in the community. This type of vegetable contains nutrients, especially vitamins and minerals, that are complete to meet the community's nutritional needs. Lettuce as a food ingredient can be consumed fresh as a salad eaten with other foods. (Rizki et al., 2024; Septiani, 2024).

The importance of this vegetable for health, both in terms of its nutritional content and fiber, encourages people to increasingly like vegetables, especially lettuce. The demand continues to increase in line with population growth, so efforts need to be made to develop technology in lettuce cultivation.(Dewi et al., 2021; Setyawati & Andayani, 2021). Considering its various uses in everyday life, lettuce is very easy to market. Lettuce farming can be successful if farmers have extensive knowledge of all aspects of lettuce plants, starting from its benefits and uses, varieties, seed quality, cultivation techniques, planting environmental conditions, harvest handling, and pests and diseases that attack lettuce itself.(Satriawan & Aprillia, 2019)(Azhari, 2019).

Green manure is fertilizer made from plants or harvest residues buried in the soil when still green or after being composted. Its purpose is to increase the content of organic matter and nutrients in the soil, improving its physical, chemical, and biological properties, ultimately impacting productivity and soil resistance to erosion(Tyasmoro, 2023).

Plants with high levels of N often found are Azolla piñata, kiambang, kapu-kapu and other plants.Green manure must be used properly so that the soil and main plants are not harmed by the large amount of material that has not experienced decomposition. The decomposition process will be faster in soil with high humidity, so the benefits obtained will be faster.(Wardana et al., 2016).

Modern agriculture relies heavily on chemical fertilizers, pesticides, and synthetic plant growth regulators (PGRs) to increase crop yields. The use of these chemicals has proven its results. Developments in technology have encouraged the development of environmentally friendly alternative products. Agricultural development that utilizes local components to increase production and is environmentally friendly needs to be supported and applied at the farmer level. One of these components is using organic plant growth regulators (PGRs) to regulate plant growth.(Lestari & Hariyanto, 2024).

Based on the description, the author is interested in researching the effect of apu-apu leaf fertilizer and growth regulators on the growth and production of lettuce plants.

Literature Review

Lactobacillus is the only genus of Lactuca that has been domesticated and cultivated as a vegetable plant. Lettuce originates around the Mediterranean, including Asia Minor, Transcaucasia, Iran, and Turkistan. First, lettuce was cultivated as a medicinal plant, such as a sleeping pill, and starting in 4,500 BC, this plant was used as food(Arianandaet al., 2020).

Lettuce (Lactuca sativa L.) is one of the plants that has an essential meaning in the community's economy. This is because the selling value of lettuce vegetables is quite promising, in line with the increasing public awareness of the importance of the nutritional value contained

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in lettuce plants; lettuce. Lettuce plants function as body-building substances, with a relatively high content of nutrients and vitamins that are good for public health(Novitasari, 2018).

This plant is very close to farmers; its spread is swift, especially in watery places; it does not rely on soil as a source of life. This plant is categorized as a weed by farmers because when it grows in the rice fields, it will absorb and compete for food sources with rice plants, so newly planted rice may interfere with the growth of farmers' rice plants. To reduce the adverse effects, farmers spray anti-weeds or use herbicides, but the best thing is to bury it in the soil because it can function as a green fertilizer when this plant dies in the soil.(Setyawati & Andayani, 2021). Green manure is an organic fertilizer from plants or vegetation or in the form of harvest residue. Material from these plants can be buried while still green or immediately after being composted.(Purnamasari et al., 2020).

The purpose of providing green fertilizer is to increase the content of organic materials, elements, and nutrients in the soil, improving its physical, chemical, and biological properties. This ultimately impacts soil productivity and resistance to erosion. The content of apu-apu leaves (Pistia Stratiotes) contains N 3.5 - 4.0%, P 0.35 - 0.38%, K 3.5 - 4.1%, Ca 0.59%, and Mg 0.27%(Rachman et al., 2006).

Plant growth regulators play an essential role in the growth and development of plant survival. Without plant growth regulators, there is no plant growth. Plant growth regulators are organic compounds that are not nutrients, where in small amounts they can stimulate and in large amounts they can inhibit the physiological processes of plants.(Sitinjak et al., 2022). Plant growth regulators can generally accelerate the physiological process in the plant body, as a stimulant, affect the work of enzymes, and act as catalysts to stimulate cell division and development of tissue in the plant body. Atonik works biochemically by directly absorbing the leaves, roots, and flower buds, affecting the plasma flow process in cells and providing vital strength to stimulate growth. (Lidar, 2008). Plant growth regulators are synthetic hormones added from outside the plant body; these substances stimulate growth, such as in root growth, shoot growth, germination processes, etc. (Setiawan, 2023).

Research Method

This research was conducted in Jl. Bunga Herba 5, Medan Selayang District, North Sumatra, with an altitude of ± 30 meters above sea level. This study used a randomized block design (RAK) with two factors. The first factor is Apu-Apu green fertilizer with the symbol (K) consisting of 3 levels: K1 = 1 kg/plot, K2 = 1.5 kg/plot, and K3 = 2 kg/plot. The second factor is a plant growth regulator with the symbol (P) consisting of 4 levels, namely: P0 = control (no treatment), P1 = 2 cc / l of water, P2 = 4 cc / l of water and P3 = 6 cc / l of water. The observation variables of this study are plant height, wet weight per plant, wet weight per plot, and root weight per plot. To test mean differences between treatments, honestly, significant difference tests, regression, and correlation were carried out at a test level of 5%.

Results and Discussion

Research result

1 Plant Height

The analysis of variance showed that the apu-apu green fertilizer treatment had no significant effect on the Height of lettuce plants at the ages of 1, 2, 3, and 4 weeks after planting. Meanwhile, the provision of growth regulators had no significant effect on the Height of lettuce plants at ages 1, 2, and 3 but had a significant effect at age 4 weeks after planting. Table 1 presents the average Height of lettuce plants and Duncan's distance difference test at ages 1, 2, 3, and 4 weeks after planting due to the influence of apu-apu green fertilizer and growth regulator

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treatments.

Table 1. Average Height of Lettuce Plants Due to Treatment of Apu-apu Green Fertilizer and Plant Growth Regulators at Ages 1, 2, 3 and 4 Weeks After Planting (cm)

Treatment	Plant Height (cm)			
	1 mst	2 mst	3 mst	4 mst
K1	3.89	5.66	7.69	8.95
K2	3.97	5.68	7.53	9.17
K3	3.81	5.46	7.54	9.65
P0	3.97	5.74	7.56	8.68a
P1	3.89	5.29	7.02	8.72ab
P2	3.75	5.58	7.68	9.61ab
P3	3.96	5.78	8.09	10.02b
K1P0	3.64	5.66	7.50	8.35
K1P1	4.31	5.78	7.53	8.79
K1P2	4.02	5.94	8.12	9.27
K1P3	3.61	5.27	7.60	9.40
K2P0	4.21	5.76	7.46	8.87
K2P1	3.97	5.51	7.05	8.26
K2P2	3.67	5.60	7.59	9.38
K2P3	4.01	5.84	8.02	10.18
K3P0	4.07	5.80	7.71	8.82
K3P1	3.37	4.57	6.46	9.11
K3P2	3.55	5.21	7.33	10.18
K3P3	4.26	6.24	8.64	10.48

Information: Numbers followed by the same letter in the same column mean they are not significantly different in the 5% BNJ test.

In Table 1, the apu-apu green fertilizer treatment had no significant effect on plant height, but plant height tended to increase with increasing doses of green fertilizer.

In Table 1, it can also be seen that in the growth regulators treatment at 4 MST, the tallest plants were in the P treatment. 3 was significantly different from P0 but not significantly different from P1 and P2. Plant height in treatments P0, P1, and P2 was not significantly different.

The relationship between the concentration of plant growth regulators and the Height of lettuce plants at 4 weeks of agemst is shown in Figure 1.

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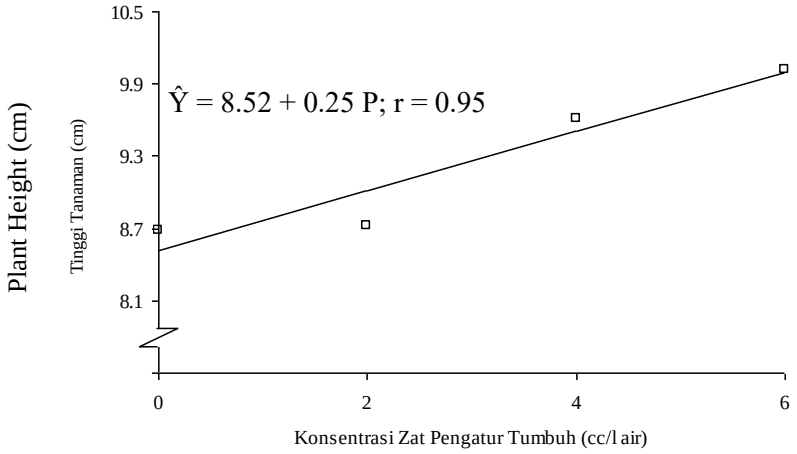

Figure 1. The Effect of Plant Growth Regulator Concentration on Lettuce Plant Height at 4 Weeks After Planting

Figure 1 shows Growth Regulator Concentration (Cc/L Water) egulators, the higher the Height of lettuce plants following a positive linear regression curve.

2. Wet Weight per Plant

The analysis of variance showed that the treatment of apu-apu green fertilizer and growth regulators had a significant effect on the wet weight per plant. In contrast, the interaction between the treatment of apu-apu green fertilizer and growth regulators had no significant effect on the wet weight per plant. Table 2 presents the differences in the average wet weight per plant due to the treatment of apu-apu green fertilizer and plant growth regulators.

Table 2. Average Wet Weight per Plant Due to Green Fertilizer and Plant Growth Regulator Treatment (g)

Treatment	Wet Weight per Plant (g)
K1	24.21a
K2	30.82ab
K3	35.67b
P0	22.34a
P1	26.86ab
P2	36.90b
P3	34.84b
K1P0	18.89
K1P1	22.29
K1P2	28.90
K1P3	26.76
K2P0	20.33
K2P1	24.43
K2P2	43.10
K2P3	35.43
K3P0	27.79
K3P1	33.85

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K3P2	38.72
K3P3	42.33

Information: Numbers followed by the same letter in the same column mean they are not significantly different in the 5% BNJ test.

Table 2 shows that in the apu-apu green fertilizer treatment, the heaviest wet weight per lettuce plant was in the K3 treatment, which was significantly different from K1 but not significantly different from K2. The wet weight per lettuce plant in the K2 treatment was not significantly different from K1.

The relationship between the dose of green fertilizer apu-apu and the wet weight per plant is shown in Figure 2.

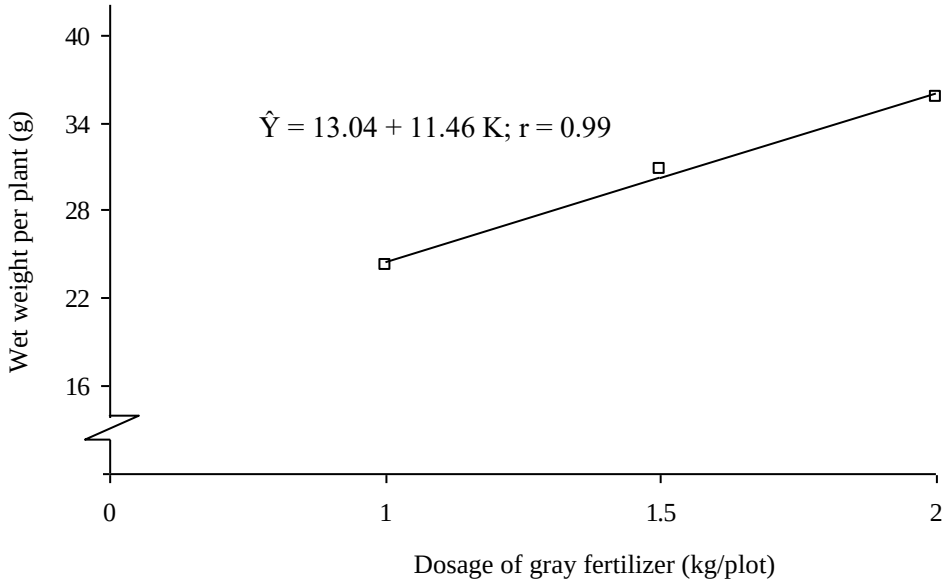

Figure 2. The Effect of Apu-apu Green Fertilizer Dosage on Wet Weight per Plant

Figure 3 shows that the higher the dose of apu-apu green fertilizer, the more the wet weight per lettuce plant increases following a positive linear regression curve.

In Table 3, it can also be seen that in the growth regulator treatment, the heaviest wet weight per lettuce plant was in the P treatment. 3 was significantly different from P0 but not significantly different from P1 and P2. The wet weight per lettuce plant in treatment P2 differed significantly from P0 but not significantly from P1. The wet weight per lettuce plant in treatment P1 was not significantly different from P0.

The relationship between the concentration of growth regulators and the wet weight per plant is shown in Figure 3.

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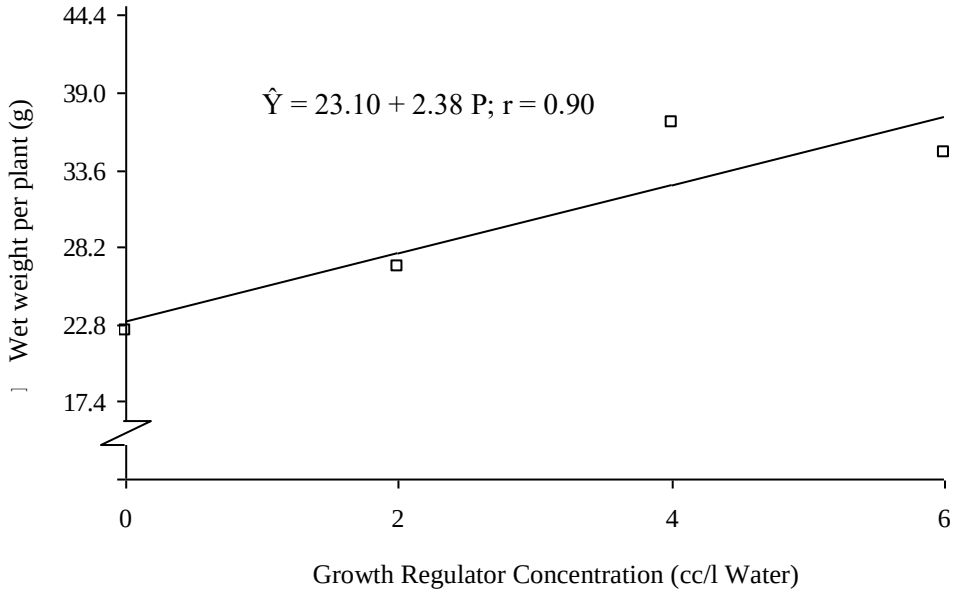

Figure 4. The Effect of Plant Growth Regulator Concentration on Wet Weight per Plant

Figure 4 shows that the higher the concentration of growth regulators, the more the wet weight per lettuce plant increases following a positive linear regression curve.

3. Wet Weight per Plot

The analysis of variance showed that the treatment of apu-apu green fertilizer and growth regulators significantly affected the wet weight per plot. In contrast, the interaction between the treatment of apu-apu green fertilizer and growth regulators had no significant effect on the wet weight per plot. Table 3 presents the test of differences in the average wet weight per plot due to the treatment of apu-apu green fertilizer and plant growth regulators.

Table 3. Average Wet Weight per Plot Due to Green Manure and Plant Growth Regulator Treatment (g)

Treatment	Wet Weight per Plot (g)
K1	94.95a
K2	113.10ab
K3	137.68b
P0	84.36a
P1	102.98ab
P2	132.06bc
P3	141.58c
K1P0	67.99
K1P1	89.17
K1P2	115.59
K1P3	107.05
K2P0	73.94
K2P1	97.71
K2P2	139.05

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K2P3	141.72
K3P0	111.15
K3P1	122.05
K3P2	141.53
K3P3	175.97

Information: Numbers followed by the same letter in the same column mean they are not significantly different in the 5% BNJ test.

Table 3 3 shows that in the apu-apu green fertilizer treatment, the wet weight per plot of lettuce plants was the heaviest in the K3 treatment, significantly different from K1 but not significantly different from K2. The wet weight per plot of lettuce plants in the K2 treatment was not significantly different from K1.

The relationship between the dose of green manure apu-apu and the wet weight per plot is shown in Figure 5.

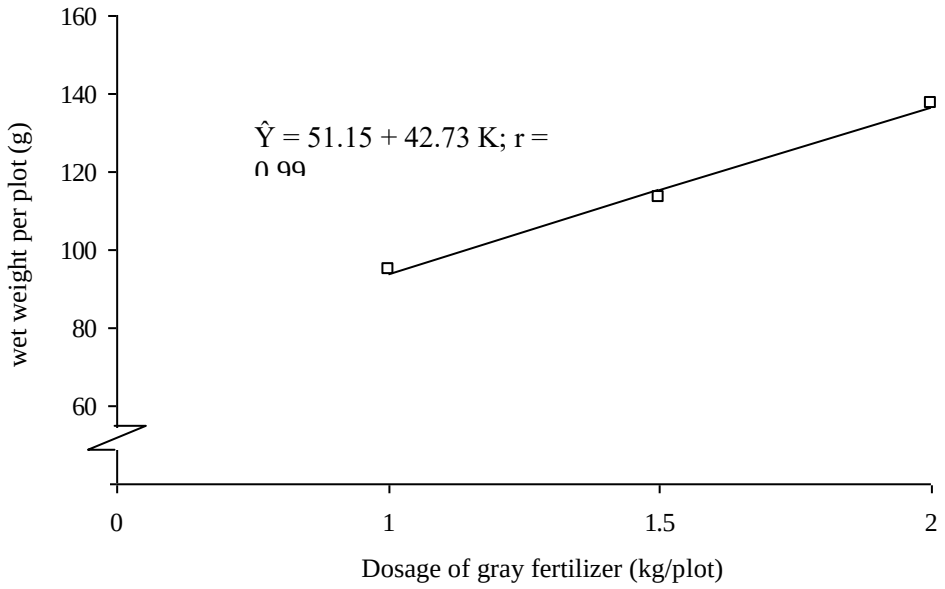

Figure 5. Effect of Apu-apu Green Fertilizer Dosage on Wet Weight per Lettuce Plant Plot

Figure 5 shows that the higher the dose of apu-apu green fertilizer, the higher the wet weight per lettuce plant plot increases following a positive linear regression curve.

Table 3 also shows that in the growth regulators treatment, the wet weight per plot of the heaviest lettuce plants was in the P3 treatment, which was significantly different from P0 and P1 but not significantly different from P2. The wet weight per plot of lettuce plants in the P2 treatment differed significantly from P0 but not significantly from P1. The wet weight per plot of lettuce plants in the P1 treatment was not significantly different from P0.

Figure 6 shows the relationship between the concentration of plant growth regulators and the wet weight per plot.

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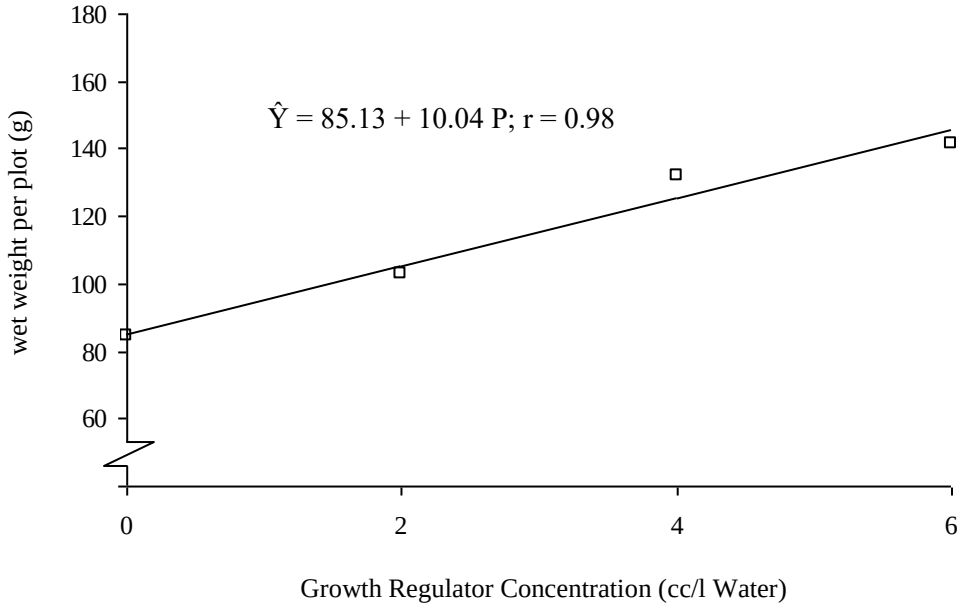

Figure 6. Effect of Plant Growth Regulator Concentration on Wet Weight per Plot

Figure 6 shows that the higher the concentration of plant growth regulators, the more the wet weight per plot of lettuce plants increases following a positive linear regression curve.

4. Root Weight per Plot

The analysis of variance showed that the treatment of apu-apu green manure and growth regulators significantly affected the wet weight of roots per plot. In contrast, the interaction between the treatments had no significant effect.

Table 4 tests the difference in the average wet weight of roots per plot due to the treatment of green manure and plant growth regulators.

Table 4.Average Wet Root Weight per Plot Due to Green Manure and Plant Growth Regulator Treatment (g)

Treatment	Root Wet Weight per Plot (g)
K1	24.05a
K2	24.69ab
K3	31.80b
P0	18.77a
P1	24.32ab
P2	31.76bc
P3	32.54c
K1P0	14.28
K1P1	25.67
K1P2	30.55
K1P3	25.68
K2P0	17.66
K2P1	20.64

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K2P2	26.15
K2P3	34.33
K3P0	24.38
K3P1	26.64
K3P2	38.58
K3P3	37.61

Information: Numbers followed by the same letter in the same column mean they are not significantly different in the 5% BNJ test.

Table 4 shows that in the apu-apu green fertilizer treatment, the heaviest root wet weight per plot was in the K3 treatment, which was significantly different from K1 but not significantly different from K2. The root wet weight per plot in the K2 treatment was not significantly different from K1.

Figure 7 shows the relationship between the dose of apu-apu green fertilizer and the wet weight of roots per plot.

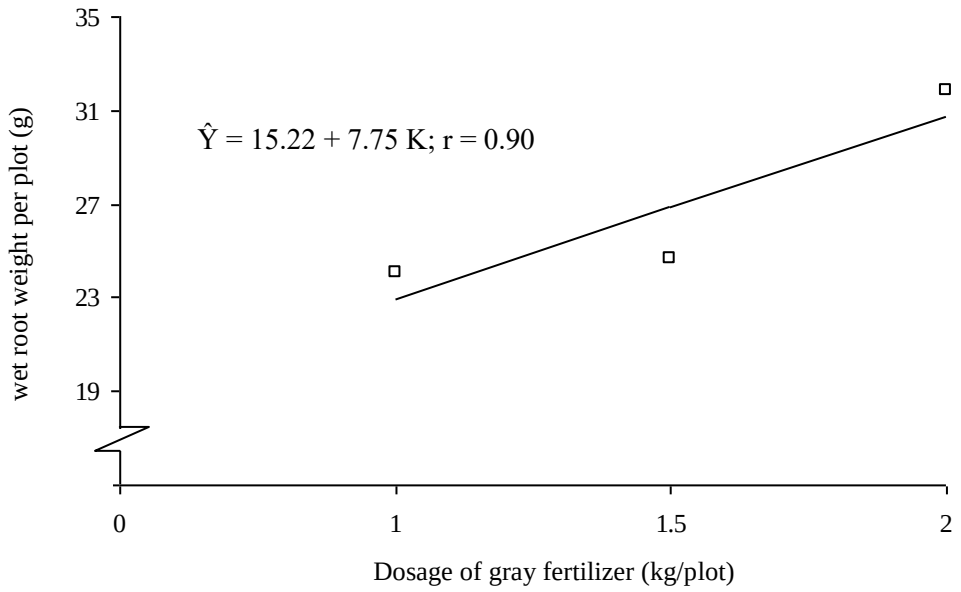

Figure 7. Effect of Apu-apu Green Fertilizer Dosage on Root Wet Weight per Lettuce Plant Plot

Figure 7 shows that the higher the dose of apu-apu green fertilizer, the more the wet root weight per lettuce plant plot increases following a positive linear regression curve.

In Table 5, it can also be seen that in the growth regulator treatment, the heaviest wet root weight per plot was in the P treatment. 3 significantly different from P0 and P1 but not significantly different from P2. The wet weight of roots per plot in treatment P2 differed significantly from P0 but not significantly from P1. The wet weight of roots per plot in treatment P1 was not significantly different from P0.

Figure 8 shows the relationship between the concentration of plant growth regulators and the wet weight per plot.

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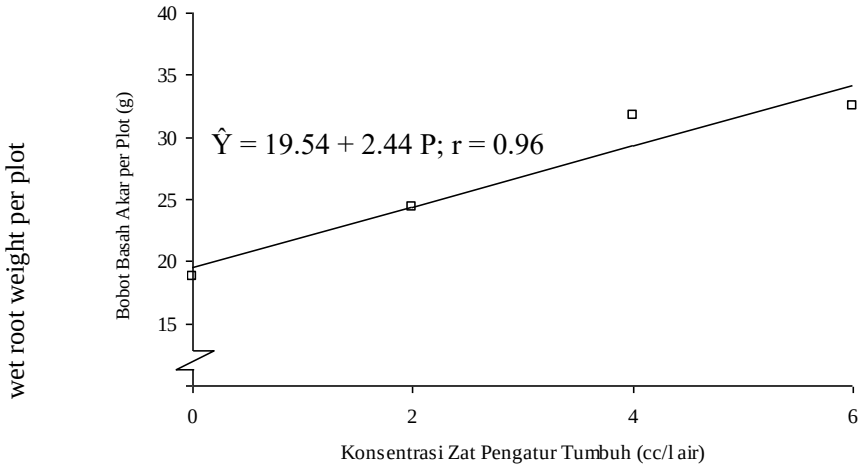

Figure 8. Effect of Plant Growth Regulator Concentration on Root Wet Weight per Plot

Figure 8 shows that th Growth Regulator Concentration (cc/l Water) lators, the more the wet root weight per plot increases following a positive linear regression curve.

Discussion

1. The Effect of Apu-apu Green Fertilizer on Lettuce Growth and Production

The analysis of the variance test showed that apu-apu green fertilizer up to 2 kg/plot significantly increased the wet weight per plant, wet weight per plot, and wet weight of roots per plot but had no significant effect on plant height and number of leaves.

The study results showed that Apu-apu green fertilizer did not affect plant height and number of leaves. This is thought to be caused by the Apu-apu green fertilizer not being able to be directly absorbed by the plants after treatment. Green fertilizer still needs time for the mineralization process in the soil. Since lettuce is a short-lived plant, its effect is likely only to be seen at the end of the study, namely on lettuce production parameters(Yusuf, 2019).

Green manure application can increase wet weight per plant, wet weight per plot, and wet weight of roots per plot. This is because the provision of Apu-apu green fertilizer can improve the condition of the soil biologically, chemically, and physically. Providing green fertilizers with different doses and types affects soil fertility differently. This is because each type of green fertilizer that has organic C, organic N, C/N ratio, lignin, and polyphenol content will determine the decomposition and mineralization process of the organic material, which in turn is an increase in the content of soil organic matter identified from soil organic C. Increasing the efficiency of fertilizer or nutrient utilization is indicated by the CEC value, soil reaction with soil pH. The contribution of N nutrients with the identification of total soil N and soil looseness with soil bulk density. Green fertilizers can improve the physical and chemical properties of the soil, increase pH, increase CEC, increase P absorption, and reduce AL in the soil. Green-green fertilizers can increase soil fertility in planting patterns and increase biomass and food crop production(Nugroho et al., 2013).

According to(Nugroho et al., 2013), providing green fertilizer with a dose of 15 tons.ha-1 provides a higher contribution of N nutrients, growth, and lettuce plant yield than Cromolaena.

The provision of green manure can also increase the highest KTK value compared to other treatments. This is because this organic material is slow to decompose, so it can increase the organic matter content of the soil, which in turn will increase the KTK. In addition to the type

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and amount of clay, the organic matter content of the soil(Nugroho et al., 2013).

The green fertilizer treatment will increase soil organic colloids of C, O, and H, which have a higher cation absorption capacity than clay. An increase in CEC indicates an increase in the soil's ability to bind and provide better plant nutrients. A high soil CEC will protect the nutrients in the soil solution from leaching due to water percolation. The nutrients in the colloid absorption complex are not readily leached into deeper soil layers. Green manure can reduce the highest soil weight. This is because the content of weather-resistant materials is higher, so organic materials are slower to decompose and have a longer residence time in the soil.

2. The Effect of Plant Growth Regulators on Lettuce Growth and Production

The analysis of the variance test showed that the treatment of growth regulators significantly affected plant height, root wet weight per plant, root wet weight per plot, and root weight per plot.

Treating growth regulator concentrations of up to 6 cc/l of water can increase the growth and production of lettuce plants. It is suspected that at this concentration, the active ingredients in the growth regulator are in an optimum state to stimulate the auxin to work more actively. Providing auxin to a plant tissue will support the synthesis of new RNA and the formation of proteins. The function of auxin in this process is to free Histone (an essential protein material consisting of DNA), which is converted into a color, eventually becoming a protein where the mRNA will help form new enzymes, which can result in plasticity and widening of the cell wall.(Adinata et al., 2019).

At a concentration of growth regulators of 2 cc/l of water, the growth and production of lettuce plants could be more optimal. This is because, at this concentration, there are still more active ingredients of growth regulators, so they play less of a role in the growth of lettuce plants. Providing growth regulators in optimum amounts will stimulate auxin activity and cell division in meristematic tissue, which will affect growth. The main processes auxin stimulates in vegetative growth are cell division, cell enlargement, and cell differentiation, including root formation (Muharram et al., 2022).

According to (Mulyadi and Ananda, 2021), Plant growth regulators affect plants' physiological and biochemical processes. Plant growth regulators are compounds consisting of aromatic and acidic compounds. In administering them, the concentration must be considered; if the concentration is too high, it can result in stunted growth or even death for plants. Increased plant growth occurs with increasing concentrations of plant growth regulators. This is because plant growth regulators affect cell division, cell elongation, and cell enlargement, which causes an increase in overall plant growth. This is the increase in fresh weight as a measure of the effect of auxin on stimulating cell division, and auxin can increase the formation of chloroplasts in leaves so that the leaves become younger and fresher. Leaves are where photosynthesis occurs, producing glucose products, then translocated to cells that need to activate plant growth and development. If photosynthate is available in sufficient quantities, the activity of the meristem tissue to divide and enlarge cells is faster, resulting in more incredible plant growth. Some carbohydrates and proteins are translocated to the growing point area and used for cell division, cell elongation, and cell thickening, which causes increased plant growth.

3. Interaction between Apu-apu Green Fertilizer and Plant Growth Regulators on Lettuce Growth and Production

The variance analysis showed that the interaction between apu-apu green manure and growth regulators had no significant effect on plant height, number of leaves, wet weight per plant, wet weight per plot, and root weight per plot. It is suspected that growth regulators can react

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quickly to increasing plant growth, while green manure is a fertilizer that plants slowly use. This causes no interaction between the two treatments in increasing the growth and production of lettuce plants.

Conclusion

Green manure apu-apu up to a dose of 2 kg/plot significantly increased the Height of fresh weight per plant, fresh weight per plot, and root weight per plot but did not affect plant height. The application of growth regulators significantly increased plant height, fresh weight per plant, fresh weight per plot, and root weight per plot. Application of growth regulators that increased up to 6 cc/l of water could increase fresh weight per plant and fresh weight per plot. The interaction between green manure apu-apu and growth regulators had no significant effect on plant height, number of leaves, fresh weight per plant, fresh weight per plot, and root weight per plot. Suggestion: To obtain the optimum application of green manure apu-apu and growth regulators, further research is needed by increasing the application of green manure apu-apu above 2 kg/plot and the concentration of growth regulators above six cc/l of water.

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