International Journal on Food, Agriculture, and Natural Resources
Volume 06, Issue 03, Page 39-45
ISSN: 2722-4066
http://www.fanres.org

Original Paper

Growth and Production of Kailan (Brassica oleraceae L.) with Application of Banana Waste Liquid Organic Fertilizer and Cow Manure

Arya Alfa Rizky[1], Adinda Nurul Huda Manurung[1], Tubagus Kiki Kawakibi Azmi[1], Silvina Malasari[1]*

1) *Study Program of Agrotechnology, Faculty of Industrial Technology, Gunadarma University, Jl. Margonda Raya No. 100, Depok Indonesia 16424*

*) *Corresponding Author: adinda.nhm@gmail.com*

Received: 14 March 2025; Revised: 25 June 2025; Accepted: 22 September 2025
DOI: https://doi.org/10.46676/ij-fanres.v6i3.508

***Abstract*— Kailan (Brassica olerace L.) is one of the popular vegetables in Indonesia. Vegetable cultivation should use environmentally friendly fertilizers, such as cow manure and banana waste liquid organic fertilizer (BWLOF). This study aims to analyze kailan's growth and production responses with differences in concentration and dose in liquid organic fertilizers from banana waste and cow manure, respectively. This study used a factorial Randomized Complete Block Design (RCBD) consisting of 2 factors, namely banana waste liquid organic fertilizer (BWLOF) with concentrations of 0, 20, and 40 ml L^{-1} and cow manure (K) with doses of 0, 127, and 200 g polybag-1. The results of the orthogonal polynomial test showed that the optimum concentration of BWLOF for kailan was 12.4 ml L^{-1}, and the results of the DMRT test showed that a dose of 200 g $polybag^{-1}$ of manure was the best treatment to increase the growth of kailan. The conclusion of this study showed that the provision of BWLOF significantly increased the root length and total dry weight of kailan plants. The provision of cow manure significantly increased plant height, number of leaves, stem diameter, leaf area, root length, and fresh and dry weight in the crown and roots, including the root crown ratio. However, there was no interaction between BWLOF and cow manure, which suggests that their combined use may not necessarily lead to synergistic effects.**

***Keywords*— Horticulture, Nemo variety, Nutrition**

I. INTRODUCTION

Kailan (Brassica oleraceae L.) is a popular vegetables in Indonesia. This plant belongs to the Brassicaceae family and has oval-shaped leaves with soft stems. Kailan is known for its high nutritional content, including fiber, vitamins, and minerals, so it is widely consumed as part of a healthy diet for the Indonesian people. The nutritional content and delicious taste make kailan one of the agricultural products favored by the community, so it has high potential and commercial value [1].

Organic farming is a significant concern for many developed and developing countries, including Indonesia. In recent years, Indonesian farmers and agribusiness entrepreneurs have begun to explore their market share in this field. One key requirement in organic farming is using organic fertilizers as an alternative nutrient solution. According to [12], natural fertilizers, or organic fertilizers, are made from metabolic waste or remains of living organisms and contain essential nutrients for plants. Using organic fertilizers is crucial for maintaining the sustainability of organic soil while also providing necessary nutrients for plants. As a result, organic fertilizers are the primary choice for environmentally friendly agricultural practices.

Banana Waste Liquid Organic Fertilizer (BWLOF) is a type of organic fertilizer that can potentially improve soil quality and plant growth. Banana waste contains nutrients such as potassium, phosphorus, and nitrogen, which benefit plant growth. According to [17], providing BWLOF can increase the productivity of vegetable plants by providing the necessary nutrients. In addition, BWLOF and cow manure have the advantage of being a source of organic nutrients that are rich in nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), as well as beneficial soil microbes. According to [33], regular application of cow manure can increase soil fertility and soil microbial activity and ultimately increase vegetable crop yields, including kailan.

Providing a combination of BWLOF and cow manure simultaneously in kailan cultivation has become the research focus. [6] shows that combining these two types of organic fertilizers can significantly increase the growth of kailan plants. The mixture of nutrients derived from banana waste enriches the soil. Cow manure provides the necessary nutrients and increases soil microbial activity, increasing kale plants' productivity and quality overall. This study aimed to analyze kale plants' growth response and production results in addition of BWLOF and cow manure to find the optimal concentration and dose to obtain maximum growth and production.

II. MATERIAL AND METHOD

A. Time and Place

This research was conducted at UG Technopark, Mande District, Cianjur, West Java, 392 meters above sea level, in April-July 2024. Soil analysis was conducted at the Soil and Fertilizer Instrument Standard Testing Center, Bogor, Indonesia.

B. Tools and Materials

This study used drip irrigation, drums, digital electric timers, water pumps, parallel cables, ovens, and polybags. The materials used in this study were kailan's variety of Nemo, rice husks charcoal, cocopeat, banana waste liquid organic fertilizer (BWLOF) (N 5%, P_2O_5 0.01%, K_2O 0.58%, C-organic 1.08%), and cow manure.

C. Method

This study used a factorial randomized complete block design of 2 factors studied, i.e., banana waste liquid organic fertilizer (BWLOF) and cow manure. The provision of banana waste liquid organic fertilizer (BWLOF) consists of 3 levels, namely P0 = 0 ml L^{-1} (Control), P1 = 20 ml L^{-1}, and P2 = 40 ml L^{-1}. The cow manure provision factor consists of 3 levels, namely K0 = 0 g (Control), K1 = 127 g $polybag^{-1}$, and K2 = 200 g $polybag^{-1}$. There were nine treatment combinations. The treatments were repeated with five replications, with 45 experimental units. The experimental units consisted of three plant samples, totaling 135 plants.

D. Research Procedure

1) Sowing of kailan

Kailan sows using rice husk charcoal media on a tray with a thickness of media around ± 4 cm. The trays with sowed seeds are then placed in a shady place so they are not directly exposed to wind and rainwater. The trays with sowed seeds are covered with soil and let sit for 2-3 days. Seedlings are transplanted into polybags when they are 7-14 days old. Watering is done in the afternoon to maintain the humidity of the seeding media and prevent the seedlings from drying out.

2) Planting media preparation

The planting media used was mixed with soil, cocopeat, and rice husk charcoal with a ratio of 2:1:1 respectively (Handayani et al., 2020). Before mixing the media, the soil was checked using a pH meter, and it was found that the soil used had an acidic pH level, so liming with dolomite was needed until the pH became neutral (the soil analysis results can be seen in Appendix 4). Liming was carried out on the media with a dose of 17.3 g polybag-1; the media was then incubated for 2 weeks. Using the previous ratio, The soil was mixed until homogenized with cocopeat and rice husk charcoal. The homogenized media was then put into a 35 cm x 35 cm polybag. Planting media preparation

3) Sowing of kailan

The seedlings can be transplanted after reaching an adequate size with 2-4 leaves. Transplanting the seedlings was conducted about ten days after sowing. After transplanting, planted polybags were placed at a distance between 20 x 20 cm plants. Transplanting was done in the afternoon [13].

4) Maintenance

The maintenance activities included automatic watering, monitoring automatic drip irrigation, replanting dead seedlings, weeding, and controlling pests and diseases. Watering was done automatically with a schedule every morning from 08.00 to 10.00 AM and in the afternoon from 04.00 to 06.00 PM. Watering is carried out from the beginning of planting until harvesting. Drip irrigation was monitored daily to ensure the installation was running optimally. When the drip irrigation hose was blocked, cleaning was done by blowing or replacing the nozzle. Fertilization is carried out at seven days old after planting (DAP) at intervals once a week. The fertilization method was carried out by pouring BWLOF on the surface of planting media with a predetermined dose. Replanting was conducted to polybags with the dead plants for 2 weeks after transplanting. Weeding was performed within the polybag area while loosening the planting media. Pest and disease control using neem oil spraying daily began 7 DAP until the harvest stage.

5) Harvesting

Kailan plants harvested 35 DAP. Harvesting performed by pull out the plants along with their roots. Then, the roots were cleaned from the planting media attached. After that, weighing to record the fresh weight of plant biomass.

E. Data Analysis

The data obtained analyzed in The SAS System for Windows 9.4 program for data normality, then continued with the analysis of variance or Analysis of Variance (ANOVA) with a level of $\alpha = 5\%$. Suppose the analysis results show a significantly different on the treatments at $\alpha = 5\%$, it would be continued with Duncan Multiple Range Test (DMRT) and Orthogonal Polynomial Test. Duncan Multiple Range Test was used on BWLOF and Cow Manure to determine the best treatment. Polynomial Orthogonal Test obtained fertilizer recommendations from observation data that significant with a quadratic pattern. The optimal fertilizer concentration can be determined using a quadratic regression model: $R = a + bx - cx^2$, with R = relative value of the plant; X = fertilizer concentration; a, b, c = constants.

III. Result and Discussion

A. Abbreviations and Acronyms

Microclimatology conditions on the research area at Gunadarma University Technopark (UG-TechnoPark), Jamali Village, Mande District, Cianjur Regency, West Java (Table 1).

TABLE I. Microclimatology Of Research Area

Month	Temperature (°C)	Relative Humidity (%)	Light Intensity (Cd)
April	29.9	83	85400
May	31.9	80	88492
June	33.9	73	94253
July	33.5	76	92158

Source: Microclimatology observations of research area

The soil analysis results on the research land at UG Technopark obtained the soil nutrient content of N 0.04%, P_2O_5 0.2 ppm, K_2O 52 ppm, soil pH 4.1, and CEC value of 15.11 cmol(+)/kg.

B. Results and Data Analysis

1) Plant Height

The results of data analysis by DMRT test at 5% significant level showed that BWLOF and cow manure significantly differed in the plant height in W2 - W5. The height of kale plants in the BWLOF and cow manure treatments can be seen in Table II.

TABLE II. EFFECT OF BANANA WASTE LIQUID ORGANIC FERTILIZER (BWLOF) AND COW MANURE TREATMENTS ON THE HEIGHT OF KAILAN (CM)

Treatment	Plant Height (cm)				
	W1	W2	W3	W4	W5
BWLOF					
P0 (0 ml L^{-1})	6.05	7.88b	11.75	13.38ab	15.18ab
P1 (20 ml L^{-1})	6.48	8.65a	12.08	13.99a	15.74a
P2 (40 ml L^{-1})	6.27	8.04ab	11.31	12.89b	14.68b
Cow manure					
K0 (0 g $polybag^{-1}$)	6.16	7.60b	10.03c	11.19c	12.36c
K1 (127 g $polybag^{-1}$)	6.24	8.23a	11.87b	13.89b	15.84b
K2 (200 g $polybag^{-1}$)	6.40	8.82a	13.07a	15.19a	17.4a

Description: Numbers followed by the same letter in the same column are not significantly different in the DMRT test at $\alpha = 5\%$.

Table 2 shows that the best plant height from BWLOF treatment was in the P1 (20 ml L^{-1}) and the lowest in the P0 (0 ml L-1). Cow manure treatment resulted the highest value of height at K2 (200 g $polybag^{-1}$), and the lowest was K0 (0 g/polybag). The BWLOF treatment had a significant effect on plant height because the availability of macro and micronutrients for the growth of kailan plants. That result was also supported by other research conducted by [31], which stated that the BWLOF had significant effect on the height of kailan plants. Nutrients are essential factor for plant height growth, including N (nitrogen) that used to form proteins with sufficient growth needs [18]. Plant height growth is not only influenced by N (nitrogen) element but also by P (phosphorus) and K (potassium) elements. According to [19], phosphorus (P) is an element that forms cells in the growing root, shoots tissues, and strengthens the stem. Potassium (K) is a mobile element in plants in cells, tissues, xylem, and phloem.

Cow manure had significant effect on increasing plant height. This condition was also supported from research conducted by [34], which states that cow manure had significant effect on the growth of kailan. It because is an organic fertilizer that easily absorbed by roots and has the advantage of containing various soil microorganisms and being able to improve soil structure. Research conducted by [13] also stated that cow manure has a significant effect on the growth of kailan. Cow manure has considerably high nutrient content suitable for optimal plant growth. According to [20], Cow manure has an average value of C-organic 14.78%, N = 1.53%, P = 1.18%, K = 1.30%, C/N ratio of 14.32 and water content of 28.73%.

2) Number of Leaves

The results of data analysis by DMRT test at α=5% showed that only cow manure was significantly different in the number of leaves. The number of kailan's leaves in the BWLOF and cow manure treatments can be seen in Table III.

TABLE III. EFFECT OF BANANA WASTE LIQUID ORGANIC FERTILIZER (BWLOF) AND COW MANURE TREATMENTS ON THE NUMBER OF KAILAN'S LEAVES

Treatment	Number of leaves (leaves)				
	W1	W2	W3	W4	W5
Liquid Organic Fertilizer (LOF)					
P0 (0 ml L^{-1})	4.24	4.42	4.78	4.40	4.80
P1 (20 ml L^{-1})	4.40	4.47	4.76	4.56	4.67
P2 (40 ml L^{-1})	4.29	4.33	4.51	4.29	4.64
Cow manure					
K0 (0 g $polybag^{-1}$)	4.2b	4.07b	4.09b	3.78c	4.11b
K1 (127 g $polybag^{-1}$)	4.29ab	4.24b	4.78a	4.49b	4.91a
K2 (200 g $polybag^{-1}$)	4.44a	4.91a	5.18a	4.98a	5.09a

Description: Numbers that are followed by the same letter in the same column are not significantly different in the DMRT test at a significance level of 5%.

The treatment of BWLOF did not significantly affect the number of kailan's leaves. This condition suspected that BWLOF takes more time to decompose than observation periode of kailan in this research. The same result also reported by [37]' which stated that BWLOF treatment did not significantly affect the number of kailan's leaves. The nutrients contained in BWLOF was unavailable untill it can finally decomposed in the soil. The availability of plant nutrients dramatically influences the amount of kailan's leaves that can be absorbed which needed for plant growth. Another factor that can affect the number of leaves is the process of photosynthesis to produce photosynthate for the growth of plant organs [14]. The provision of cow manure significantly affects the number of kailan's leaves, it possibly because of leaves require more nitrogen than other parts of the plant. When nitrogen needs are met, leaf growth becomes more optimal, and photosynthesis runs more effectively. Research by [19] also shows that cow manure significantly affects the number of kailan's leaves. According to [2], the decomposition of organic matter in the soil enhances the availability of essential elements such as N, P, K, Ca, and Mg needed by plants and changes N and P into minerals available in the soil for plant, while K, Ca, and Mg decompose as nutrients reserves. Leaf growth and

photosynthesis processes able to proceed well with sufficient macro and micronutrients.

3) Stem Diameter

The results of stem diameter data analysis by DMRT test at α = 5% showed that the BWLOF showed no significant difference, while cow manure indicated significant different results started in second week after transplanting to the end of observation periode. (Table IV).

TABLE IV. EFFECT OF BANANA WASTE LIQUID ORGANIC FERTILIZER (BWLOF) AND COW MANURE TREATMENTS ON THE NUMBER OF KAILAN'S LEAVES

Treatment	Stem diameter (mm)				
	W1	W2	W3	W4	W5
Liquid Organic Fertilizer (LOF)					
P0 (0 ml L^{-1})	1.70	1.78	2.12	2.59	3.42
P1 (20 ml L^{-1})	1.73	1.81	2.25	2.64	3.46
P2 (40 ml L^{-1})	1.77	1.82	2.07	2.46	3.20
Cow manure					
K0 (0 g $polybag^{-1}$)	1.69	1.74b	1.98b	2.16c	2.60c
K1 (127 g $polybag^{-1}$)	1.73	1.8ab	2.13b	2.6b	3.41b
K2 (200 g $polybag^{-1}$)	1.78	1.87a	2.32a	2.93a	4.06a

Description: Numbers that are followed by the same letter in the same column are not significantly different in the DMRT test at a significance level of 5%.

Banana waste liquid organic fertilizer was not significantly affect the diameter of kailan stem diameter. [22] explained that stem formation occurs in the meristematic tissue at the stem growth point and root tip, where when cell division occurs, carbohydrates produced are transferred to the stem growth point, causing an increase in the stem diameter. In this cell division process, plants need nutrients to support the process. One of the essential elements needed is nitrogen (N), which is also crucial for formation of plant leaves. According to [36], organic fertilizers have a mineralization process. Organic compounds in organic fertilizers must first decomposed by soil microorganisms so that plants can absorb nutrients. The mineralization process depends on many factors, such as temperature, availability of water and oxygen, and the types and number of microorganisms in the soil. Therefore, duration of mineralization varies greatly depending on these factors. The mineralization rate can range from several days to months to years. Cow manure has a significant effect on stem diameter because the micro and macro nutrients needed for stem growth are sufficient. These results are also supported by research conducted by [19], which states that cow manure had significant effect on stem diameter. Cow manure contains organic materials that can increase the levels of N, P, K, Ca, and Mg that plants need for stem growth. According to [2], these nutrients also convert N and P elements into mineral forms that plants can absorb, while K, Ca, and Mg break down into nutrient reserves in the soil.

4) Leaf Area, Root Length, Root Crown Ratio

The results of data analysis using the DMRT at the 5% level showed that the BWLOF did not significantly affect the leaf area and root crown ratio parameters, but it did show a significant difference in the root length parameter. In contrast, the cow manure treatment showed significantly different results for all three parameters, indicating its potential as a comprehensive organic fertilizer (Table V).

TABLE V. EFFECT OF BWLOF AND COW MANURE ON LEAF AREA, ROOT LENGTH, AND SHOOT/ROOT RATIO OF KAILAN

Treatment	Leaf area (cm^2)	Root length (cm)	Shoot/Root Ratio
Liquid Organic Fertilizer (LOF)			
P0 (0 ml L^{-1})	5.28	25.54a	1.55
P1 (20 ml L^{-1})	5.10	25.76a	1.61
P2 (40 ml L^{-1})	4.85	20.72b	1.76
Cow manure			
K0 (0 g $polybag^{-1}$)	3.97c	20.71b	1.44b
K1 (127 g $polybag^{-1}$)	5.17b	25.57a	1.65a
K2 (200 g $polybag^{-1}$)	6.08a	25.74a	1.81a

Description: Numbers that are followed by the same letter in the same column are not significantly different in the DMRT test at a significance level of 5%.

Banana waste liquid fertilizer was not significantly differ in kailan's leaf area and shoot/root ratio. There is a mineralization process where soil microorganisms will decompose organic compounds in organic fertilizers so that plants can absorb these nutrients, if the mineralization process is not complete, the nutrients in the fertilizer cannot be absorbed by plants [36]. [29] state that nitrogen nutrients enhance leaf growth related to photosynthesis, enabling plants to produce enough carbohydrates for their vegetative growth. In the process of photosynthesis, the chlorophyll content shows the assimilation ability and photosynthesis capacity, so higher chlorophyll content is better photosynthesis process occur [26]. In the root length, significantly different results were obtained in BWLOF, phosphorus (P) nutrients mainly influenced root growth. These results also supported by [23], which stated that BWLOF gave results that had very significant effect on kailan. Roots are essential in plant growth to absorb soil nutrients and plant metabolism. Factors that affect root development include nutrient availability. The higher ratio of shoot to root, more photosynthate is transferred to the shoot, thereby increasing plant production, especially in the shoot section [31].

The results obtained in the cow manure treatment were significantly different regarding leaf area, root length, and shoot/root ratio of kailan. This condition could be caused by nitrogen content in cow manure. The nitrogen (N) is essential in the formation of leaves during the photosynthesis process.

Nitrogen also plays an essential role in the composition of chlorophyll (Bachtiar, 2018). In addition to nitrogen (N), iron (Fe) is essential for plant leaf growth. Iron plays a role in the synthesis of chlorophyll, which is essential for photosynthesis and respiration, as well as in the formation of chlorophyll, enzymes, and proteins [10]. According to [8], plants with sufficient chlorophyll in the leaves will increase sunlight's absorption, so the photosynthesis process runs smoothly. Manure also has the function of loosening the soil, and it can also improve soil structure. According to [9], manure can increase soil aggregates, aeration and water retention capacity so that nutrient absorption is more comprehensive than soil. According to [23], increased nutrient absorption can impact the shoot-to-root ratio of plants. This ratio is linked to the plant's ability to absorb water, which tends to increase as a mechanism to maintain high water potential.

5) Fresh Weight

The results of fresh weight data analysis by DMRT tests at α = 5% from BWLOF treatment showed no significant differences in shoot, root, and its total fresh weight. The treatment of cow manure showed significantly different results in both fresh weight of shoot and its total fresh weight. It can be seen in (Table VI) as follows.

TABLE VI. EFFECT OF BWLOF AND COW MANURE ON LEAF AREA, ROOT LENGTH, AND SHOOT/ROOT RATIO OF KAILAN

Treatment	Fresh weight (g)		
	Shoot	Root	Total
Liquid Organic Fertilizer (LOF)			
P0 (0 ml L^{-1})	7.16	1.65	10.44
P1 (20 ml L^{-1})	7.84	1.54	10.80
P2 (40 ml L^{-1})	6.10	1.40	8.39
Cow manure			
K0 (0 g $polybag^{-1}$)	3.22c	1.69	5.02b
K1 (127 g $polybag^{-1}$)	7.66b	1.65	10.84a
K2 (200 g $polybag^{-1}$)	10.22a	1.26	13.78a

Description: Numbers that are followed by the same letter in the same column are not significantly different in the DMRT test at a significance level of 5%.

Banana waste liquid fertilizer did not indicate significant different results on the fresh weight kailan, which was estimated because the growth of kailan requires nitrogen (N) as its primary nutrient. If the plant cannot absorb these nutrients due to the incomplete nutrient decomposition process, kailan growth will be inhibited [36]. This study's results align with research conducted by [30], which stated that BWLOF treatment did not significantly affect the fresh weight of plants. The fresh weight of plants indicates the amount of water content in plant tissue, which is the accumulation of photosynthate weight in the form of plant biomass and water content in leaves [27]. In the process of photosynthesis, nitrogen are needed as a chlorophyll former, which plays an essential role in the photosynthesis process, with increasing amounts of chlorophyll, the rate of photosynthesis also increases so that plant growth will be more optimal [24]. Other factors that affect the fresh weight of plants are plant height and leaf area, more extensive leaf area would be impact to higher of plant fresh weight [25]. Cow manure gave significantly different results in the fresh weight of shoot and its total fresh weight of the plant, while the fresh weight of the roots was not significantly different. This condition was caused by the fact that vegetable plants slowly absorb the nutrients from cow manure. Therefore, fresh weight of the roots shows similar results. According to research by [13], cow manure significantly affects the fresh weight of kailan.

Meanwhile, according to research by [19], cow manure treatment had no significant effect on the fresh weight of plants. Cow manure can act as a provider of nutrients, in addition, cow manure also supports moisture availability in the soil. Moisture availability in the soil plays a crucial role in dissolving and transporting nutrients, which in turn increases the activity of soil microorganisms [12]. Additionally, cow manure typically promotes the growth of the plant's upper parts, or shoots, because its nutrient content—particularly nitrogen, phosphorus, and potassium—is rapidly utilized for photosynthesis and biomass production in the leaves and stems [7].

6) Dry Weight

The results of dry weight data test by DMRT at α = 5% showed that BWLOF showed no significant difference in dry weight of shoot, root, and its total. In contrast, orthogonal polynomial test was carried out for the total dry weight, and the results obtained were significantly different in quadratic response. The cow manure treatment showed significantly different results for all variables observed, namely shoot, root, and it dry weight total. The result can be seen in (Table VII) as follows.

TABLE VII. EFFECT OF BWLOF AND COW MANURE ON DRY WEIGHT OF KAILAN (G)

Treatment	Dry weight (g)		
	Shoot	Root	Total
Liquid Organic Fertilizer (LOF)			
P0 (0 ml L^{-1})	0.96	0.63	1.48
P1 (20 ml L^{-1})	1.01	0.67	1.59
P2 (40 ml L^{-1})	0.91	0.56	0.83
Cow manure			
K0 (0 g $polybag^{-1}$)	0.67c	0.48b	0.75b
K1 (127 g $polybag^{-1}$)	1.00b	0.64a	1.20b
K2 (200 g $polybag^{-1}$)	1.22a	0.74a	1.95a

Description: Numbers that are followed by the same letter in the same column are not significantly different in the DMRT test at a significance level of 5%.

Banana waste liquid fertilizer on dry weight of shoot, root, and its total were not significantly different, while cow manure yield significant different in three of the variables observed. These results align with the study done by [31], which stated that the BWLOF treatment significantly affected kailan dry weight. According to [16], plant's dry weight indicates the results of the photosynthate assimilation process, which is transferred from the roots to all parts of the plant. Banana waste liquid fertilizer gave the highest average dry weight results. This can happen because optimal and stable amount of nutrients are needed in the photosynthesis process to support plant growth [11]. The treatment of cow manure on the dry weight variable obtained very significantly different results in shoot, root, and its total dry weight. These results align with the study by [15], which stated that manure was significantly different in the dry weight of plants, which was influenced by nitrogen (N), phosphorus (P), and potassium (K) available in cow manure can be well absorbed by plants, therefore plant growth can continue to increase. Sutedjo (2008) stated that increasing vegetative plant growth can affect plant metabolism. The results of metabolism in protein and carbohydrates are quickly distributed to all parts of the plant to stimulate vegetative growth, such as the formation of roots, stems, and leaves.

Optimization of fertilization using multiple linear regression on dry weight showed quadratic response pattern. The results of this optimization can be function as a tool to determine optimum dose of fertilizer [38]. Total dry weight was measured after harvesting, and drying process was carried out on the harvested plant at 5 weeks after transplanting. Based on analysis with orthogonal polynomials, it was found that observations of total dry weight showed a quadratic response. The quadratic curve is shown in Figure 3. From this curve, the BWLOF optimization equation was obtained: $y = -0.0011x^2 + 0.0273x + 1.48$, showing that the optimum BWLOF concentration was 12.4 ml L^{-1}.

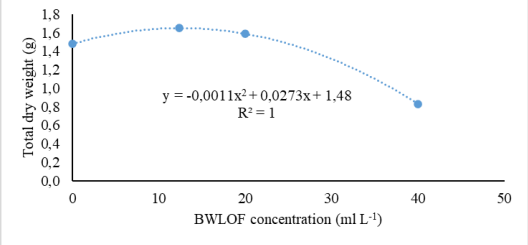

Fig. 1. Banana waste liquid organic fertilizer dose optimization curve on the observation of total dry weight of kailan

After using orthogonal polynomial regression to analyze the data, the optimal concentration for the total dry weight parameter was determined to be 12.4 ml L^{-1}. These findings can be applied to establish the ideal concentration of BWLOF for Kailan. This result contrasts with the study conducted by [31], which found that the best dry weight results occurred at a concentration of 20 ml L^{-1}. This discrepancy may be attributed to differences in nutrient absorption by the plant's roots. According to [3], the nutrients that plants absorb through their roots significantly contribute to their dry weight. Additionally, [5] highlighted that plant growth is influenced by two main factors: genetic and environmental. Environmental factors consist of various conditions and external influences that affect the life and development of an organism.

IV. CONCLUSION

The conclusion of this study indicates that banana waste liquid organic fertilizer significantly increased the root length and total dry weight of kailan (Chinese broccoli). In contrast, cow manure had a notable effect on various growth parameters, significantly increasing plant height, number of leaves, stem diameter, leaf area, root length, and both fresh and dry weight of the shoot and root. This also included improvements in the shoot-to-root ratio. It is important to note that there was no interaction observed between the banana waste liquid organic fertilizer and cow manure. The optimal concentrations determined for kailan were 12.4 ml of banana waste liquid organic fertilizer per liter and 200 grams of cow manure per polybag.

REFERENCES

[1] Abror, M., dan Harjo, R, P. (2018). Efektifitas Pupuk Organik Cair Limbah Ikan dan Trichoderma sp. Terhadap Pertumbuhan dan Hasil Tanaman Kailan (Brassica Oleraceae sp.). Jurnal Agrosains dan Teknologi, 3(1) : 1-12.

[2] Agustina, L. (2011). Teknologi Hijau dalam Pertanian Organik Menuju Pertanian Berlanjut. UB Press. Malang. pp 25- 59.

[3] Ariyani, I., dan Musbik. (2018). Pengaruh Takaran Pupuk Organik Cair Terhadap Pertumbuhan Tanaman Sawi Caisim (Brassica juncea L.) di Polibag. Prospek Agroteknologi, 7(1) : 60-68.

[4] Bachtiar, B. (2018). The Role of Planting Media and Compost Fertilizer on The Growth of Red Jabon Anthocepalus macrophyllus in Nursery. Jurnal Biologi Makasar. 3(2) : 10-1

[5] Damanik, B. M. M., Bachtiar, E. H., Fauzi., Sarifuddin., Hamidah, H. (2011). Kesuburan Tanah dan Pemupukan. USU Press, Medan. Hal 20-25.

[6] Fitriani, R. (2021). Combination Effect of Banana Peel Liquid Organic Fertilizer and Cow Manure on Growth and Production of Mustard Green (Brassica juncea L.). Agriculture and Agricultural Science Procedia, 22(3) : 93-98.

[7] Fathin, S. L., Purbajanti, E. D., dan Fuskhah, E. (2019). Growth and yield of Kale (Brassica oleracea var.Alboglabra) on several dosesof goat manure and nitrogen fertilizing frequency. Jurnal Pertanian Tropik, 6(3), 438–447.

[8] Hidayat, F. dan Tyasmoro, Y. S. (2019). The Effect of NPK fertilizer and Biofertilizer on the Growth and Yield of Shallots (Allium ascalonicum L). Jurnal Produksi Tanaman. 7 (11) : 2152-2160.

[9] Indria, A.T. (2005). Pengaruh Sistem Pengolahan Lahan dan Pemberian Macam Organik Terhadap Pertumbuhan dan Hasil Kacang Tanah (Arachis hypogaea L.). Skripsi. Fakultas Pertanian Universitas Sebelas Maret. Surakarta.

[10] Irwansyah, D., Basyaruddin, dan Lubis, R, M. (2020). Respon Pertumbuhan dan Hasil Tanaman Sawi Hijau (Brassica juncea L.Var. Tosakan) Dengan Perbedaan Media Tanam Organik dan Penambahan Pupuk Organik Limbah SludgeKertas di Dataran Rendah. Jurnal Ilmu Pertanian. 8 (2) : 121-127.

[11] Jumawati, R., A. T. Sakya dan M. Rahayu. 2014. Growth of Tomato on a Different Watering Frequency. Agrosains. Vol. 16 (1): 13- 18.

[12] Kasanah, A. Z., Munandar, D. E., Sari, V. K., Agronomi, P. S., Pertanian, F., dan Jember, U. (2024). Growth and Yield Responses of Three Varieties of Green Mustard (Brassica juncea L .) to The Addition of Cow Dung Manure . 8(1), 62–67.

[13] Krestiani V., Supriyo, H., Umam, K. (2022). Kajian Dosis Pupuk Kandang Sapi dan Konsentrasi LOF Urin Kambing Terhadap Pertumbuhan dan Hasil Tanaman Kailan (Brassica oleracea). Muria Jurnal Agroteknologi, 1(2) : 28-33.

[14] Kristianto, H. A., Prihatmo, G., & Madyaningrana, K. (2023). Pupuk Organik Cair Kulit Pisang Kepok terhadap Pertumbuhan Kailan dalam Sistem Hidroponik. Jurnal Biologi Dan Pembelajaran Biologi, .v8i1(p-ISSN 2527 –7111), 1–15. https://doi.org/10.32528/bioma.v8i1.301.

[15] Lathifah, A., dan Jazilah, S. (2019). The Effect of Light Intensity And Kinds of Manure on The Growth and Production of Chinese Cabbage (Brassica pekinensia L). Biofarm : Jurnal Ilmiah Pertanian, 14(1), 1–8.

[16] Maryani. T. A, (2012). Pengaruh Volume Pemberian Air Terhadap Pertumbuhan Bibit Kelapa Sawit Di Pembibitan Utama. Skripsi. Program Studi Agroekoteknologi, Fakultas Pertanian Universitas Jambi.

[17] Misran, A. (2019). Effect of Banana Peel Liquid Organic Fertilizer on The Growth of Red Spinach (Amaranthus tricolor L.) in Ultisol Soil. Indonesian Journal of Agricultural Science, 20(2) : 80-86.

[18] Mukti, M. S., Wardiyati, T., dan Islami, T. (2017). Time of Manure Application and Urea Dosage on Growth and Content of Nitrogen on Kailan (Brassica oleraceae L . var . Nova). Jurnal Produksi Tanaman, 5(2), 224–231.

[19] Noverensi., Yetti, H., Yulia, A, E. (2019). Pengaruh Pemberian Hasil Fermentasi Limbah pisang Sebagai Pupuk Organik Terhadap Pertumbuhan Tanaman Mawar (Rosa sp.). JOM FAPERTA, 6 (1) : 1-11.

[20] Novitasari, D., dan Caroline, J. (2021). Kajian Efektivitas Pupuk Dari Berbagai Kotoran Sapi, Kambing, dan Ayam. Seminar Teknologi Perencanaan, Perancangan, Lingkungan, Dan Infrastruktur II FTSP ITATS - Surabaya, 2003, 442–447.

[21] Nugroho, P. (2013). Panduan Membuat Pupuk Kompos Cair. Pustaka Baru Press. Yogyakarta.

[22] Nurwasila, N., Syam, N., dan Hidrawati, H. (2024). The Effect of Giving NPK And POC Fertilizer on The Growth and Results of Kailan (Brassica oleracea L.). AGrotekMAS Jurnal Indonesia: Jurnal Ilmu Peranian, 4(3), 403–413.

[23] Palupi, E. R., Dedywiryanto, Y. (2008). A Study on Characteristics Related to Drought Resistance in Four Genotypes of Oil Palm (Elaeis guineensis Jacq.) Seedling. Bul Agron 36(1): 24-32.

[24] Pramitasari, H. E., Wardiyati, T., dan Nawawi, M. (2016). The Influence of Nitrogen Fertilizer Dosage and Plant Density Level to Growth and Yield of

[25] Kailan Plants (Brassica juncea L.). Jurnal Produksi Tanaman, 4(1), 49–56.

[26] Prasetya, B., S. Kurniawan, dan M. Febrianingsih. (2009). (Brassica juncea L.) pada Entisol. Jurnal Agritek 17 (5) : 1022-1029.

[27] Rahayu, Y. S., Wardiyati, T., Maghfoer, M. D. (2021). The Effect of Monoculture And Intercropping System Between Vegetables Crop and Crotalaria juncea L. on Pb accumulation, biomass, and yield. Agromix, 12(2) : 111-118.

[28] Rahma, M. (2021). Respon Pertumbuhan dan Hasil Tanaman Caisim (Brassica juncea L.) dengan Berbagai Konsentrasi Pupuk Organik Cair. Skripsi. Fakultas Pertanian. Universitas Pembangunan Nasional "Veteran". Yogyakarta.

[29] Rasmito, A., Hutomo, A., Hartono, A, P. (2019). Pembuatan Pupuk Organik Cair dengan Cara Fermentasi Limbah Cair Tahu, Starter Filtrat Limbah pisang dan Kubis, dan Bioaktivator EM4. Jurnal IPTEK, 23(1) : 55-62.

[30] Rositawati, R., Rahayu, Y. S., dan Hadija, Y. (2024). Pemanfaatan Pupuk Organik Cair Limbah Buah-Buahan dengan Metode Tetes terhadap Pertumbuhan Tanaman Kailan. Jurnal Folium 8(2), 58–69.

[31] Rudiyanto, O. C., Sugiono, D., Agustini, R. Y., Singaperbangasa, U., dan Abstract, K. (2023). Respon Pertumbuhan dan Produksi Tanaman Kailan (Brassica oleraceae L.) Varietas New Veg-Gin Akibat Pemberian Limbah Baglog dan Pupuk. Jurnal Ilmiah Wahana Pendidikan, 9(11), 517–528.

[32] Santosa, S. G., Kalsum, U., dan Pribadi, E. M. (2023). Response of Growth and Production of Kailan to Automation of Variations in Drip Irrigation Watering Frequency and banana waste liquid organic fertilizer. Jurnal Pertanian Presisi (Journal of Precision Agriculture), 7(2), 155–167.

[33] Sepriani , Y., Jamaluddin., Hernosa, S, P. (2016). Pengaruh Pemberian LOF Limbah pisang Kepok Terhadap Pertumbuhan dan Produksi Tanaman Sawi Pahit (Brassica juncea L). Jurnal Agroplasma (STIPER) Labuhanbatu, 3(1) : 16-23.

[34] Suryadi, A. (2020). The Effect of Cow Manure Fertilizer and Inorganic Fertilizer on the Growth of Chilli Plants (Capsicum annuum L.) in Alluvial Soil. IOP Conference Series: Earth and Environmental Science, 46(1) : 1-14.

[35] Susilowati, M. I., Purwanti, S., dan Kautsar, V. (2023). Pengaruh Takaran Pupuk Kandang Sapi terhadap Pertumbuhan dan Hasil Tanaman Kailan pada Media Topsoil dan Subsoil (Brassica Oleracea). Agroforetech, 1(1), 109–112.

[36] Sutedjo, M. M. (2008). Pupuk dan Cara Pemupukan. Rineka Cipta. PT Bumi Aksara. Jakarta.

[37] Taiz, E., dan Zeiger, E. (2002). 3rd edn. Plant Physiology. Sunderland: Sinauer Associates.

[38] Wahyuningtyas, M. D., Zubaidah, S., Kulu, I. P. (2022). Pertumbuhan dan Hasil Kailan (Brassica oleraceae Var Alboglabra L. H. Bailey) Pada Pemberian Pupuk Organik Cair Limbah Kulit Buah di Tanah Gambut. Jurnal Penelitian UPR : Kaharati, 2(1) : 41-52.

[39] Webb, M. J. (2009). A Conceptual Framework for Determining Economically Optimal Fertiliser Use In Oil Palm Plantations With Factorial Fertiliser Trials. Nutr Cycl Agroecosyst. 83(2) : 163-178.