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Productivity and Cost Analysis of Chinese Cabbage (Brassica rapa) in Hydroponic Wick System Based on Formula

Nurkholis[1], Anas Tian[2], Adi Sutanto[3]

[1]Department of Agribusiness, Muhammadiyah University Malang, Indonesia
Email: rozaqzaqi33@gmail.com
[2]Department of Agribusiness, Muhammadiyah University Malang, Indonesia
Email: tugasmhswanta@gmail.com
[3]Department of Agribusiness, Muhammadiyah University Malang, Indonesia
Email: sutantoadi10@gmail.com

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***Abstract*—** *Organic fertilizers have emerged as a vital alternative to address the environmental and human health concerns associated with the use of inorganic fertilizers. This research aims to develop the right nutrient formula for cultivating Pak Choi (Chinese cabbage) using the Wick hydroponic system. Considering factors such as variety selection, cultivation system, and nutrient requirements, this study explores the productivity of Pak Choi plants and the cost structure of cultivation. The research methodology involves testing various nutrient formulas and observing post-harvest plant metrics like wet weight, leaf width, leaf count, and plant height. Descriptive analysis and ANOVA tests reveal significant differences among treatments in plant morphology. Furthermore, cost analysis highlights the efficiency and profitability of each treatment, with Treatment F3 emerging as a cost-effective option with low expenses and good gross profit. These findings offer practical guidance for farmers to enhance vegetable production economically and sustainably in hydroponic cultivation.*

***Keywords*— Productivity, Hydroponics, Formula.**

I. INTRODUCTION

Fertilizers play a crucial role in increasing agricultural production nowadays. However, long-term use of inorganic fertilizers can harm the environment and human health. The rising prices of chemical fertilizers have led to a decrease in purchasing power among communities, resulting in reluctance to cultivate vegetables, even though the government has subsidized inorganic fertilizers. The use of inorganic fertilizers is also increasing, while the raw materials for fertilizers are depleting (Utami Lestari et al., 2018). One example of an inorganic fertilizer is ABMix hydroponic fertilizer, suitable for both leafy and fruit vegetables. The need for fertilizers in hydroponic technology is crucial, especially since the medium used is water and nutrients. If the nutrient requirements are not met or the fertilizers are not applied properly, the plants cannot grow vigorously. Organic fertilizers provide a solution to the current fertilizer situation, as they can utilize green plants around us that contain the necessary elements for plants to grow vigorously, such as Moringa oleifera, Azolla Microphylla, Ananas comosus, fruit waste, and household waste. Liquid organic hydroponic nutrients are organic nutrients derived from natural or plant-based sources that can be used to combine with inorganic fertilizers to reduce costs.

Pakcoy (Brassica rapa) is a popular vegetable among Indonesian farmers because it is easy to grow conventionally, either in hydroponics or directly in soil (Putri et al., 2023). According to Kilmanun (2020), the highest revenue is obtained from Pak Choy vegetables, totaling Rp. 1,400,000 out of Rp. 4,385,000. The types of vegetables cultivated include green lettuce, sweet mustard greens, spinach, and water spinach, as Pak Choy is highly sought after by consumers due to its delicious taste. When producing hydroponic vegetables, it is necessary to consider the types of vegetables and tailor them to the preferences of consumers or customers. One of the popular agricultural cultivation methods in urban areas is hydroponic farming. Hydroponic cultivation not only requires the right nutrients but also requires selecting a system suitable for the characteristics and types of plants. One cost-effective hydroponic system is the wick system.

According to Putera T.D. (2015), the wick system is a static or passive hydroponic system that relies on the capillary principle of water through the use of a wick as a mediator. This hydroponic system is simple, as it does not require electricity or a water pump for nutrient distribution, resulting in cost efficiency. Referring to previous research, Sri Utami (2018) discussed the chemical elements using Azolla plants for leafy vegetable plants. The analysis of Azolla microphylla compost composition shows a total N of 2.57%, available P of 0.54%, and K of 0.03%. According to Fahmi et al. (2020), the treatment with various concentrations of ABMix nutrients and banana rhizome organic compound (POC) showed that the best nutrient concentration was ABMix 8.5 ml/L and POC 40 ml/L water, resulting in plants with a 35-day growth period (21.3 cm), leaf count (9 leaves), leaf area (3.14 cm), and fresh weight (22.14 g). In previous research, POC used was a single POC, so it is necessary to combine other ingredients to meet the macro and microelement contents required by vegetables, especially leafy vegetables such as Chinese cabbage. Based on the above facts, the author is interested in analyzing the appropriate organic fertilizer formula to increase the productivity of Chinese cabbage (Pakcoy) and minimize cultivation costs. The analysis process also considers factors that influence plant productivity, including selecting superior varieties, cultivation systems, and nutrient requirements such as nitrogen (N), phosphorus (P), and potassium (K), as well as several other micronutrients such as calcium (Ca), magnesium (Mg), and others. This research aims to: 1) Determine the optimal nutrient formula for Chinese cabbage growth in the wick hydroponic system. 2) Measure Chinese cabbage productivity (plant wet weight, leaf width, leaf count, and plant height) in the wick hydroponic system. 3) Analyze the cost structure of Chinese cabbage cultivation by applying various nutrient formulas in the wick hydroponic system. 4) Plan Chinese cabbage production using the wick hydroponic system. According to Dahlan et al. (2017), hydroponic vegetable cultivation has advantages and disadvantages. Its advantages include: (1) Easy renewal of plants without depending on land conditions and seasons, (2) Growth and harvest quality can be controlled, (3) Labor-saving, (4) Clean and more hygienic products, (5) Water and fertilizer savings (environmentally friendly), (6) Shorter cultivation period, (7) Low operational costs. However, its disadvantages include: (1) Higher initial investment costs, (2) Highly influenced by fertilizer composition and concentration, pH, and temperature. Dewi et al. (2020) conducted research on the effect of rice washing water waste on the growth of Pak Coy Chinese cabbage using the wick system. This research lasted for 27 days with three repetitions. Good Plant Nutrition Concentration and Rice Washing Water Waste factors became the RAL analysis factors in this study. The observed parameters included plant height, leaf count, wet weight, initial water pH, and final water pH. There was no significant relationship between good plant nutrition and rice washing water waste. The research results showed that rice washing water waste did not affect plant height, leaf count, wet weight, initial water pH, and final water pH; however, good plant nutrition affected the leaf count at twenty days after planting, but not the plant height at ten or thirty days after planting. Feni et al. (2017) investigated the costs and profits of vegetable farming in the Ratu Agung District, Bengkulu City. In that area, water spinach, mustard greens, and spinach are the most commonly cultivated vegetables. This study used proportional random sampling survey methods. Both primary and secondary data were used in this research. As a result of the study, vegetable farmers in the Ratu Agung District, Bengkulu City, have the potential to meet the demand for vegetables in Bengkulu City. The R/C value of the three types of vegetables is more than 1, indicating that this business is profitable. In addition, except for spinach vegetables with a B/C ratio of less than one, the Break Even Point (BEP) volume of production and BEP price for all types of vegetables have exceeded the break-even point. Arianto (2021) conducted research on pakcoy Chinese cabbage farming in the Medan Deli District, North Sumatra. The purposive sampling method, which means intentionally selecting samples according to the required sample criteria, was used in the sample determination process. Both primary and secondary data were used in this research. Analysis of revenue, income, average cost (AC), and Cost Revenue Ratio (R/C) are some of the data analyses conducted. The research results showed that pakcoy Chinese cabbage farming in the Medan Deli District, North Sumatra, has the following costs and profits: fixed costs amounted to Rp 87,472,000.50, variable costs amounted to Rp 272,747,000.00, with a total cost of Rp 360,219,002.50 and an average cost of Rp 12,007,300.08.

Revenue reached Rp 666,320,000.00, with an average revenue of Rp 22,210,666.67. Pakcoy Chinese cabbage farming in the Medan Deli District, North Sumatra, generated an average income of Rp 10,203,366.58, with a total income of Rp 306,100,997.50. Pakcoy cabbage farming has a Cost Revenue Ratio (R/C) of 1.8, meaning that every Rp 1 expenditure can generate Rp 1.8 in revenue. Since the R/C result is greater than 1, it can be concluded that pakcoy cabbage farming is profitable and worthy of development. Rizal's study (2017) was conducted from January to April 2017 at the Integrated Laboratory of PGRI University Palembang. This study investigated the effect of nutrients on the growth of pakcoy Chinese cabbage (Brassica rapa L.) cultivated hydroponically. This study used a Completely Randomized Design (CRD) with three treatments and nine replications. Additionally, the wick hydroponic system was used for cultivation. Three nutrient treatments were used in this study: AB mix (N1), liquid organic fertilizer (N2), and NPK+growmore (N3). The research results show how the fertilizer concentration given to hydroponically grown pakcoy Chinese cabbage affects its growth. Liquid organic hydroponic nutrients are natural or plant-based nutrients derived from organic sources through anaerobic or airtight fermentation processes, with the addition of bioactivators, namely decomposing bacteria, to accelerate the composting process. Bacteria contained in bioactivators include lactobacillus sp, Azotobacter sp, Rhizobium sp, Pseudomonas sp, T., as well as Tricoderma sp, Actinomycetes sp, pathogenicity, nitrogen fixers, and phosphorus solubilizers. For the composting process to run smoothly, food for these bacteria is needed, which can be sugar cane syrup or brown sugar. The elements contained in NHOC already include macro elements needed by plants for vigorous growth. The application of NHOC to plants ensures healthier vegetable quality and fewer chemical residue contents. The materials used for liquid organic hydroponic nutrients include Moringa, Azolla, Pineapple, and coffee grounds. According to Tjendapati (2017), POC nutrient application can be carried out during seedling or when vegetable seedlings are already in the hydroponic installation, with a ratio of 1:5, meaning that for every liter of POC, 5 liters of clean water are used, and 1 liter of POC is added every two days. POC nutrients can be used for various types of leafy vegetables. The growing medium used in the wick hydroponic system can be rockwool, rice husk charcoal, or sawdust. Sponge waste can be used as a substitute for rockwool. The medium used must be sterile to avoid contamination by pests and plant diseases, as this will affect the plant growth process in hydroponic vegetable seedlings.

II. LITERATURE REVIEW

2.1 Cost Theory

According to Novitasari D. (2020), investment cost is the amount of money used by business owners at the beginning of starting a business. Operational costs consist of fixed costs and variable costs. Fixed costs are expenses incurred for business operations that are not affected by the quantity and do not deplete within one production cycle. Variable costs are expenses whose amount is influenced by the quantity of production. The total cost incurred each year is the sum of total fixed and variable costs. According to Kilmanun J.C (2020), vegetable cultivation with hydroponic systems is considered exclusive because it requires significant expenses. The exclusive vegetable market has not been fully tapped yet, so the market opportunities remain wide open because hydroponic vegetables are needed by supermarkets, cafes, and hotels in big cities.

2.2 Moringa Plant

The moringa tree (Moringa oleifera) almost all parts of the plant can be a high-nutrient food source, ranging from leaves, stems, fruits, flowers, to young roots, moringa seed cake with its high mineral and protein content is excellent for use as organic fertilizer. Moringa leaves contain seven times the vitamin C of oranges, four times the calcium of milk, four times the vitamin A of carrots, twice the protein of milk, and three times the potassium of bananas (Suwahyono, 2008). Sources of organic fertilizer Waste extraction of oil and coagulant compounds from moringa seeds, in the form of seed cake, can be utilized as fertilizer because it contains a lot of protein, especially as a source of microelements needed by plants (Suwahyono, 2008). Moringa leaf extract as an effective fertilizer, moringa leaves contain active compounds like zeatin, categorized as plant hormones from the Cytokinin group, as leaf fertilizer and also functions as a protectant that makes plants resistant to pest attacks and diseases.

2.3 Azolla Plant

The Azolla plant can be cultivated and contains the nitrogen elements required by leafy vegetable plants. The parts of the Azolla plant can be used for organic nutrition in plant cultivation (Widodo, 2015). According to Kusumaningsih (2023), the combination of liquid organic fertilizer application from Azolla has an impact on the growth of plants in floating raft installations. Azolla plants, often referred to as "mosquito fern" or "water fern," are small aquatic plants that thrive in freshwater environments. They are known for their ability to fix nitrogen from the atmosphere, making them valuable contributors to soil fertility. Cultivating Azolla can provide a sustainable source of organic nitrogen for various crops, particularly leafy vegetables, which have high nitrogen requirements for vigorous growth.

Research conducted by Widodo in 2015 highlights the significance of Azolla as a source of organic nutrition in plant cultivation. The plant's nitrogen-rich composition makes it an ideal supplement for promoting the growth and development of leafy vegetables. Azolla can be incorporated into agricultural practices as a natural fertilizer, reducing the reliance on synthetic fertilizers and promoting environmentally friendly farming methods. Furthermore, recent findings by Kusumaningsih in 2023 emphasize the positive impact of applying liquid organic fertilizer derived from Azolla on plant growth, particularly in floating raft installations. This suggests that integrating Azolla-based fertilization techniques into hydroponic or aquaponic systems can enhance the overall productivity and sustainability of vegetable cultivation practices.

2.4 Pineapple Plant

When ripe, pineapples have a sweet taste, but when overly ripe, they can taste slightly tangy due to their high oxalate acid content. Within the fruit, there is bromelain, an enzyme that acts as a protein digestant (meat tenderizer). Pineapple waste is commonly used to produce liquid organic fertilizer (Sunarjono, 2010). Pineapples, known for their tropical flavor and juicy texture, undergo significant chemical changes as they ripen. Initially, the fruit's acidity gives it a refreshing tang, but as it matures, the sugars increase, leading to a sweeter taste profile. However, if left to ripen for too long, the fruit can develop an overly acidic taste due to the accumulation of oxalic acid.

Bromelain, found abundantly in pineapples, is a proteolytic enzyme that breaks down protein molecules. This enzyme's presence contributes to the tenderization of meat, making pineapple juice or extracts a popular choice for marinades or meat tenderizers in culinary applications. Additionally, pineapple waste, such as peels and cores, contains valuable nutrients and organic matter. Sunarjono's research in 2010 underscores the utilization of pineapple waste as a raw material for producing liquid organic fertilizer. This sustainable practice not only reduces waste but also harnesses the nutritional benefits of pineapple residues to enrich soil fertility, promoting healthier plant growth in agricultural settings.

2.5 Hydroponic Wick System

Hydroponic vegetable cultivation is a farming method that can be applied in limited land areas, typically in urban regions but also found in non-urban areas. There are various types of hydroponic systems, including the Wick System, NFT system, Drip System, Floating Raft System, Aeroponic System, Ebb and Flow System, Aquaponic System, and Deep System (Nugroho, 2016). Hydroponic systems that require minimal costs can utilize the Wick System. This system is cost-effective in installation and does not require a water pump, thus saving electricity costs and making it accessible to people of various ages.

In this system, the addition of a wick is used, which can be made of flannel cloth or recycled fabric that absorbs plant nutrients, ensuring adequate moisture conditions and nutrient supply without excessive use. The materials used in the installation can be recycled, and maintenance of the Wick System hydroponic installation is relatively easy and straightforward. Vegetables commonly cultivated in this system are leafy vegetables such as pak choi, Chinese cabbage, kale, spinach, and lettuce. Wick systems that use buckets or Dutch buckets can be used for fruiting vegetables such as chili, eggplant, tomato, cucumber, and others. The growing medium used in hydroponic wick systems can be rockwool, rice husk charcoal, or sawdust. Sponge waste can be used as a substitute for rockwool. The medium used must be sterile to avoid contamination by pests and plant diseases, as this will affect the plant growth process in hydroponic vegetable seedlings.

2.6 Production theory

Production is an activity aimed at increasing the value of a product by involving several factors of production together (Rahmadani, n.d., 2020), an activity conducted to transform inputs into outputs or to add value to the outputs. In a production process, inputs are required in the form of factors of production, which are tools or resources used in production activities. According to Rahmadani (n.d., 2021), factors of production include: (1) Natural resources, the earth and all its contents. (2) Labor, which involves individuals with skills and integrity. (3) Capital, encompassing all goods used to support the production process. (4) Management Organization, to manage activities within the business.

According to Harahap QH (2018), in hydroponic vegetable production, plants not only require a growing medium to support their growth and a suitable nutrient solution for plant growth and production but also require sufficient sunlight for the photosynthesis process. This proves that the height of the plant, number of leaves, leaf width, leaf color, and yield of pak choi plants are inseparable from the combination of treatments between the growing medium and the nutrient solution provided. The most influential type of nutrient on pak choi plant growth is the ABMIX fertilizer, while the growing medium that affects plant height, leaf area, leaf color, number of leaves, plant weight, and plot weight is using Rockwool.

According to Zahara VM (2021), the production function is a function or equation that shows the physical or technical relationship between the amount of production factors used and the amount of product produced per unit of time, without considering prices, both for production factor prices and product prices. The Production Function is the technical relationship between input (independent variable) and output (dependent variable). Basic assumptions about the nature of the production function are used in economic theory, where the problem is subject to the Law of Diminishing Returns (a law stating that the aim of production includes: (1) Maintaining business continuity by continuously increasing the production process, (2) Increasing business profits by minimizing production costs. (3) Increasing the quantity and quality of production. (4) Obtaining satisfaction from production activities. (4) Fulfilling the needs and interests of producers and consumers.

According to Ma'arif et al., (2022), production factors include land area, labor, seeds, nutrients, and medications. According to Kilmanun J.C (2020), the amount of production and price greatly affect revenue, with the average selling price of hydroponic vegetables being Rp. 5,000 per net pot. Increasing consumption of hydroponic vegetables provides significant opportunities for hydroponic vegetable production businesses. According to Harahap, Q.H (2018), the causes of decreased cabbage production are: 1) Decreasing interest of farmers in growing vegetables because it is considered unprofitable and many agricultural land areas are being converted, and there is currently a lot of imported vegetables. 2) Decreasing agricultural land conditions, while on the other hand, the fulfillment of food needs from agricultural products is increasing, if this condition is left unchecked, it is not impossible that in a few years we will experience a vegetable shortage.

Research on Production and Cost Analysis of pak choi based on ABMix and NHOC nutrients. This research system is an experimental type of research with a completely randomized design (CRD) single factorial method. A single-factor experiment is an experiment designed involving only one factor with several levels as treatments. The completely randomized design is used when the experimental units used are relatively homogeneous, such as experiments conducted in a laboratory. Factors: NHOC Treatment Moringa oliefera, Azolla microphylla, Ananas comosus L, and Coffee grounds. P0 = Non-formula (Negative control), P1 = Formula 1, P2 = Formula 2, P3 = Formula 3, P4 = Formula 4, P5 = ABMix 100% (Positive control). If these research factors are combined, it will result in 54 replications with 6 wick system installations, each installation differentiated according to the type of NHOC treatment. The determination of the number of replications refers to the formula for calculating a completely random calculation according to Tribudi (2020), as follows: $t(r-1) \geq 15$. Explanation: t = treatment (number of treatments), r = replication (number of replications), 15 = degrees of freedom. The number of treatments in this research is 6 (six), so the calculation of replications in this research is as follows: $t(r-1) > 15$; $6(r-1) > 15$; $6r - 6 > 15$; $6r > 15+6$; $6r > 21$; $r > 21/6$; $r > 3.5$ replications. r = 4 (replication/number of replications). Based on the calculation above, it is obtained that the minimum replication is 4 times replication in each treatment in the research. The replication used in this research is 9 times replication, so the total number of pak choi plants (Brassica rapa) is 54 plants.

Table.1: Experimental Design Treatment Formula

Treatment Fertilizer	**Replication**									**Mean**
	1	2	3	4	5	6	7	8	9	
P0	P01	P02	P03	P04	P05	P06	P07	P08	P09	
P1	P11	P12	P12	P14	P15	P16	P17	P18	P19	
P2	P21	P22	P23	P24	P25	P26	P27	P28	P20	
P3	P31	P32	P33	P34	P35	P36	P37	P38	P39	
P4	P41	P42	P43	P44	P45	P46	P47	P48	P49	
P5	P51	P52	P53	P54	P55	P56	P57	P58	P59	
Overal Mean										

2.7 Cost Design

According to Maarif (2022), the fixed costs in this study include equipment rental and depreciation, while the variable costs include seed costs, ABMix nutrients, NHOC, labor, and water.

Table.2: Cost Description

No.	Type of Cost	Description
1	Fixed Cost	1. Rental space
		2. Depreciation of Installation
		3. Depreciation of Netpots
		4. Depreciation of seedling trays
		5. Depreciation of supporting equipment (TDS and PH meters)
		6. Depreciation of Measuring cups
		7. Depreciation of Buckets
2	Variable Cost	1. Seeds
		2. Rockwool growing media
		3. ABmix nutrients
		4. NHOC nutrients
		5. Organic pesticides
		6. Water costs
		7. Flannel cloth
		8. Labor wages

III. RESEARCH METHOD

3.1 Research Time and Location

This research was conducted from August 23rd to November 23rd at the Agricultural Vocational School UPT. BLK Wonojati Malang. It involved the formulation, hydroponic seeding, construction of the Hydroponic Wick System installation, planting, plant maintenance, harvesting, and post-harvest activities, as well as the measurement of parameters for Pakchoy (Brassica rapa) plants in the Hydroponic Greenhouse.

3.2 Research Tools and Materials

The equipment used in this research includes seeding trays, hacksaw, Netpots, 1.5 cm hole puncher for PVC pipes, ruler, NHOC drums with locking lids, measuring cups, scale, water pass hose, bucket, ladle, blender, pestle, stirrer, labels, ruler, marker, water bottles, scissors, TDS meter, EC meter, pH meter, ice box, covers, flannel cloth, while the research materials include Moringa oleifera leaves, Azolla Microphylla, Ananas comosus, coffee grounds, Pak choi F1 seeds, sugarcane molasses, M21, coconut water, rice washing water, shallots, toothpicks, and rockwool.

3.3 Research Variables

This research utilizes several variables:

1. Independent variables, including P0 as the negative control (without nutrient), P1 Formula 1, P2 Formula 2, P3 Formula 3, P4 Formula 4, P5 using 100% ABMix at 5 ml/liter water (as the positive control).
2. Dependent variables in this study are the measurement of plant height, leaf width, leaf count, and wet weight of Brassica rapa L. plants grown in rockwool hydroponic wick systems.
3. Control variables in this study include the use of Brassica rapa L. seeds.

IV. RESULT AND DISCUSSION

4.1 Descriptive Statistics

The descriptive analysis focuses on the productivity and cost of Chinese cabbage in the Wick System hydroponic system. Variables such as plant wet weight, plant height, number of leaves, leaf width, nutrient concentration, acidity level of nutrient solution, and success rate in pest control are examined. Descriptive statistics are used to analyze each parameter, displaying the distribution of plant weight, growth, variation in leaf number and size, nutrient concentration, pH of the solution, and pest resistance level. The results will be presented in descriptive tables.

Table.3: Statistics Descriptive

Variable	Treatment	N	Mean	Deviation	Std. Error
Leaf Width	F0	9	1.11	0.22	0.07
	F1	9	9	1.22	0.41
	F2	9	7.56	0.53	0.18
	F3	9	7.22	0.44	0.15
	F4	9	4.78	0.83	0.28

	F5	9	8.22	0.97	0.32
	Total	54	6.32	2.79	0.38
Leaf Width	F0	9	7.17	0.43	0.14
	F1	9	25.44	2.46	0.82
	F2	9	23.11	1.05	0.35
	F3	9	22.67	0.71	0.24
	F4	9	14.89	2.09	0.7
	F5	9	24.67	1.73	0.58
	Total	54	19.66	6.79	0.92
Number of Leaves	F0	9	4.89	0.6	0.2
	F1	9	21.89	2.37	0.79
	F2	9	22.67	1	0.33
	F3	9	21.78	1.2	0.4
	F4	9	13.44	2.96	0.99
	F5	9	21.67	2.12	0.71
	Total	54	17.72	6.85	0.93
Root Length	F0	9	9	1.8	0.6
	F1	9	13.56	3.09	1.03
	F2	9	13.11	3.14	1.05
	F3	9	12.89	2.15	0.72
	F4	9	9	2.55	0.85
	F5	9	18.89	5.21	1.74
	Total	54	12.74	4.53	0.62
Wet Weight	F0	9	10	0	0
	F1	9	222.22	38.33	12.78
	F2	9	196.67	7.07	2.36
	F3	9	189.44	10.14	3.38
	F4	9	85.56	17.04	5.68
	F5	9	186.67	38.81	12.94
	Total	54	148.43	79.34	10.8

Table 3 presents the descriptive statistics of Chinese cabbage (Brassica rapa) in the Wick System hydroponic system, providing a comprehensive overview of its various characteristics. Leaf width, for example, shows variation across treatments, with F1 having the highest mean (9.00), followed by F5, F2, F3, F4, and F0. Similar patterns emerge for leaf length, where F1 also exhibits the highest mean (25.444), followed by F5, F2, F3, F4, and F0. The analysis also highlights leaf count, with F2 showing the highest mean (22.67), followed by F1, F3, F5, F4, and F0. Treatment F5 demonstrates the highest mean root length (18.89), while F1 exhibits the highest mean wet weight (222.22). Variability among treatments is evident from the differing means and standard deviations, reflecting variations in plant responses to the hydroponic system. This provides valuable insights into the growth of Chinese cabbage in the Wick System hydroponic environment.

4.2 ANOVA Test for Brassica Rapa in the Wick System Hydroponic System

Analysis of Variance (ANOVA) is a statistical technique used to compare means among three or more groups. In the context of Chinese cabbage (Brassica rapa) morphology in the Wick System hydroponic setup, ANOVA is employed to assess whether there are significant differences in plant morphology characteristics among various treatments. The dependent variables in the ANOVA test for Chinese cabbage morphology are these morphological characteristics, such as leaf width, leaf length, leaf count, root length, and wet weight. Treatments are the groups or conditions being tested, in this case, different growth conditions of Chinese cabbage plants in the Wick System hydroponic setup. Each treatment may involve differences in nutrient composition, light intensity, or other environmental factors affecting plant growth. Testing with ANOVA is conducted by forming hypotheses as follows:

$H_0: \mu 1 = \mu 2 = \mu 3 = \cdots = \mu k$

H_1: At least two groups have different means..

Table.4: ANOVA Test

Variables		Sum of Squares	df	Mean Square	F	Sig.
Leaf Width	Between Groups	383.87	5	76.774	125.869	0
	Within Groups	29.278	48	0.61		
	Total	413.148	53			
Leaf length	Between Groups	2324.912	5	464.982	183.697	0
	Within Groups	121.5	48	2.531		
	Total	2446.412	53			
Number of Leaf	Between Groups	2311.278	5	462.256	127.845	0
	Within Groups	173.556	48	3.616		
	Total	2484.833	53			
Root Length	Between Groups	599.481	5	119.896	11.82	0
	Within Groups	486.889	48	10.144		
	Total	1086.37	53			
Wet Weight	Between Groups	306291.2	5	61258.24	107.51	0
	Within Groups	27350	48	569.792		
	Total	333641.2	53			

The results of the ANOVA test in Table 4.3 indicate significant differences in the morphology of Brassica rapa plants in the Wick System hydroponic cultivation of Chinese cabbage. The observed parameters include leaf width, leaf length, leaf count, root length, and wet weight. There is significant variation among treatments for all parameters with $p < 0.05$, indicating a significant impact on plant morphology characteristics. These findings suggest that differences in treatments in the Wick System hydroponic setup significantly affect the morphology of Chinese cabbage plants. This insight provides valuable information for managing hydroponic growth environments and improving Chinese cabbage production.

4.3 Cost Analyze

In this subsection, the cost of the Wick System hydroponic system will be analyzed by investigating all factors influencing the investment and expenses associated with this cultivation method. The cost analysis picture is presented as follows:

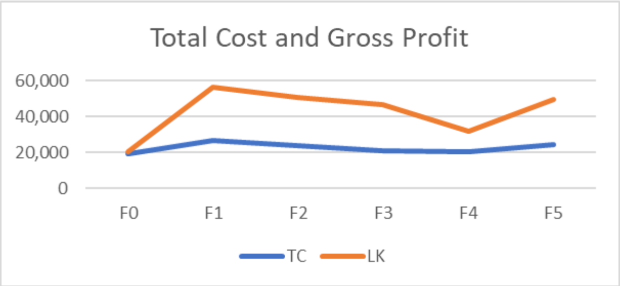

Fig.1: Graph Cost Analyze

Based from Figure 1 for each treatment, the total cost (TC) represents the overall expenditure incurred for that treatment, while the gross profit (GP) is the gross income generated from that treatment. Gross profit is obtained by subtracting the total cost from the gross income. Here is the cost analysis of the six treatments: Treatment F0 with Total Cost (TC): 19,184; Gross Profit (GP): 1,350, Treatment F1 with Total Cost (TC): 26,648.04; Gross Profit (GP): 30,000.00, Treatment F2 with Total Cost (TC): 23,903.54; Gross Profit (GP): 26,550.00, Treatment F3 with Total Cost (TC): 21,192.54; Gross Profit (GP): 25,575.00. Treatment F4 with Total Cost (TC): 20,150.04; Gross Profit (GP): 11,550.00. Treatment F5 with Total Cost (TC): 24,425.54; Gross Profit (GP): 25,200.00.

V. CONCLUSION

The results of the research and analysis highlight several key findings regarding the growth and cost of Pak Choi plants in the Wick System hydroponic system. It was found that various nutrient formulas have a significant impact on plant growth, with Formula 1 standing out as the most effective in increasing plant height, leaf width, and wet weight. Specific treatments, such as F1, F2, and F3, exhibited better growth compared to others. However, cost analysis revealed interesting variations, where certain treatments, despite having higher total costs, also yielded higher net profits. This underscores the importance of considering both costs and profits when selecting the most optimal formula for cultivating Pak Choi plants in hydroponic systems.

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