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Response of Local Garlic on Solid and Liquid Vermicompost and The Impact to Financial Yield

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ABSTRACT

Converting solid Vermicompost into liquid form is an alternative for garlic cultivation in the *Dibawah Lake* Solok region, and the cost is cheaper. A preliminary study evaluated the impact of applying solid Vermicompost (0, 5, 10, and 15 t/ha) on garlic growth and yield. A subsequent study examined the effect of applying solid Vermicompost in liquid form using a chitosan solution and identified effective NPK fertilizer doses to optimize local garlic growth and yield. The experimental design was a randomized factorial with NPK doses of 0, 100, and 200 kg/ha and Vermicompost concentrations of 0, 30, 60, or 90 g/L chitosan solution. The preliminary study demonstrated that applying 10 to 15 tons per hectare of solid Vermicompost combined with 100 kilograms per hectare of NPK fertilizer significantly increased garlic yield compared to no solid Vermicompost application. A subsequent study found that varying NPK doses from 0 to 200 kilograms per hectare and Vermicompost from 0 to 90 grams produced similar effects on local garlic growth and yield. However, yields remained lower than those achieved with 15 tons per hectare of solid Vermicompost. In contrast, substituting solid with liquid Vermicompost at all tested concentrations resulted in higher profitability than the 15 tons per hectare solid Vermicompost treatment, particularly for 100 NPK and 60 grams of Vermicompost in chitosan solution. That treatment was more cost-effective for farmers because it increased income by 63% and was more environmentally friendly than the solid form application in the *Dibawah Lake* Solok region.

1. Introduction

Garlic (*Allium sativum*) is one of the important vegetable commodities in Indonesia that is a natural source of many bioactive molecules, such as polysaccharides, saponins, tannins, linalool, geraniol, phellandrene, β-phellandrene, ajoene, alliin, and S-allyl-mercapto cysteine. Sulfur-based compounds like allicin and ajoene have been shown to provide anticancer, antidiabetic, anti-inflammatory, antioxidant, antimicrobial, immunomodulatory, and cardioprotective effects. Garlic shows broad therapeutic potential and may help develop new drugs for various human diseases (El-Saadony *et al*., 2024).

One of the areas in West Sumatra where Garlic is expanded is Nagari Kampung Batu, Dibawah Lake, Solok Regency. This area is a hilly area that surrounds the lake. A lot of garlic land in this area is cleared on steep, hilly slopes with an average land slope above 25%. It is

feared that it will accelerate the rate of land erosion, especially when it is only a few meters from the edge of the lake, which results in an increased risk of landslides and sedimentation in the lake (Sadtim *et al*., 2020). Meteorological data from 2002 to 2005 indicate that the Bukit Barisan Mountains in this region have a very wet climate with rainfall between 2500 and 3000 mm/year, with 140-170 rainy days/year, and a hyper-humid climate with rainfall > 3000 mm/year, with 180-220 rainy days/year (Nontji, 2016). The climate conditions of that area also exacerbate the soil conditions. Firmawini (2018) shows evidence of the effect of climate conditions on soil properties of one area of Kampuang Batu where the Corg is low (1.86%), other soil properties such as Ktot (0.32 me/100 g) is low, Ca (0.39 me/100 g) and SO42--S (5.43 ppm).

On the other hand, farmers try to solve the problem of soil conditions by using solid organic matter and chemical fertilizers. However, soil and water erosion will carry organic and inorganic materials from agricultural areas and settle on the bottom of the water. The more organic and inorganic matter that settles, the more oxygen is needed for biological and chemical oxidation processes. Microorganisms will break down organic matter in the water, and they need oxygen to do that. This process causes low DO (dissolved oxygen) (Sugianti & Astuti, 2018). DO concentration influenced by like atmospheric exchange, respiration, photosynthesis, pollution and some physical factors like salinity and temperature (Ali, Anushka, & Mishra, 2022). Continued land use intensification has contributed to increasing pollution in the lake, increasing the frequency and duration of low dissolved oxygen events, and increasing the risk of adverse effects on fish communities (Franklin, 2014). Reducing the use of chemical fertilizers and solid organic matter is essential for the sustainability of the lake ecosystem. Appropriate garlic cultivation techniques, which are environmentally friendly but do not harm farmers in Kampung Batu Village, Solok Regency, are needed.

Solid vermicompost is an effective biofertilizer and offers farmers an alternative cultivation method. Converting it to a liquid form can further benefit the health of the Kembar Lakes. Vermiculture transforms various biodegradable wastes, including farm, kitchen, and market wastes, into nutrient-rich vermicompost, which enhances soil health and nutrient content. Liquid vermicompost provides essential macro and micronutrients, such as nitrogen, phosphorus, potassium, iron, copper, and zinc, as well as plant growth regulators like auxins, cytokinins, and gibberellins (Chaulagain *et al*, 2017). Dosem *et al*. (2018) published a dose of Vermicompost fertilizer at 50 g/polybag, which better affected the fresh weight of the lettuce canopy compared to 0, 30, and 40 g. Cultivation of plants in vermiponic nutrient media is reported to increase growth, nutrient content, chlorophyll, protein, starch and sugar content of Amaranthus viridis (Deepthi *et al*., 2021).

Dissolving Vermicompost with 4 ml of chitosan in 1 L of water is expected to strengthen the effect of Vermicompost liquid fertilizer, and at the same time reduce production cost because solid Vermicompost is too expensive. Chitosan is an organic molecule made from shrimp shells that contain chitin compounds. It is easy and cheaper, biodegradable, biocompatible, nontoxic, contains hormones, antimicrobial activity, and can reduce plant stress. This material has been used as a growth stimulant in various plant species with good results. The application of chitosan-based nanoparticles can be a part of sustainable farming (González-García *et al*., 2022). Besides that, no studies have been done on the combination of NPK and liquid Vermicompost on local garlic until now. Therefore, this study aimed to investigate the effect of Vermicompost in chitosan composite liquid as a biofertilizer for local garlic as one effort to substitute chemical fertilizers and organic matter for lake rescue

2. Methodology

2.1 The Site and The Condition of The Field

This research has been carried out in the village of Kampung Batu, Danau Kembar District, Solok Regency, which has a height (altitude) of 1462 masl, and the air temperature is around 18 °C during the day. However, at 5 am, it can reach 12oC. Analysis of soil shows pH is slightly acidic (6.02), Ntot is medium (0.33%) and P2O5 is very high (72.26 ppm), Ktot (0.32 me/100 g) is low, Ca (0.39 me/100 g) and SO42--S (5.43 ppm) are very low. The experimental area is shown in Figure 1.

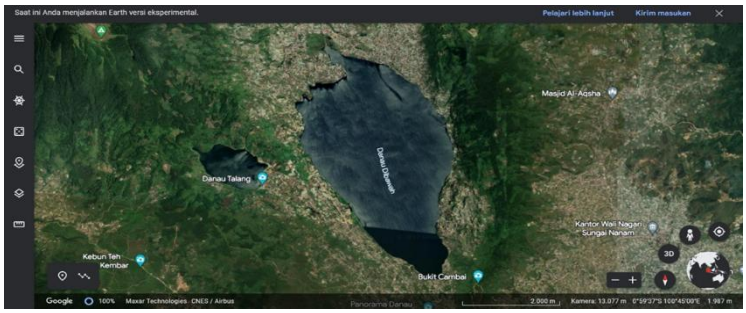

Figure 1. The map of the village of Kampung Batu, Danau Kembar District, Solok Regency

2.2 Experimental Design and Data Analysis

This research has two studies. The first study is a one-factor experiment consisting of 0, 5, 10 and 15 t/ha solid Vermicompost. The study's second phase was two-factor experiment using a completely randomized design (CRD). The first factor is the treatment dose of NPK (15%N:15%P:15%K), which consists of 0, 100, and 200 kg/ha NPK. The second factor was the concentration of Vermicompost 0, 30, 60, and 90 g in 1 L of chitosan solution. Analysis of data was done by STAR software. If the Pr>F was least from 0.05, it means the effect of treatment was significantly different; it would be continued with the DNMRT 5%.

2.3 Experimental Procedure

The Vermicompost fertilizer was weighed according to the treatment and dissolved in 1 L of chitosan solution, which was prepared by dissolving 4 mL of chitosan in 1 L of water. Vermicompost/chitosan liquid fertilizer is sprayed onto the leaves until the entire leaf surface is wet. Spraying started two weeks after planting and continued once a week until the age of 10 WAP (Week After Planting). The dosage of Vermicompost in chitosan solution that one plant needs until the harvest is 100 mL, as for NPK, fertilizer was given with the dose-appropriate treatment three weeks after planting. Lumbu Hijau seed tubers were obtained from the propagation of farmers who originally came from one of the farmer groups in Danau Kembar District, and had a storage period of 85 days. The cloves are 1 cm in diameter, healthy, and not deformed. Using calipers, plant height was measured using a roller, stem, and tuber diameter. The income value is obtained by subtracting revenue from fertilization costs, excluding other costs. To compute fertilization costs, first calculate the Vermicompost and NPK fertilizer requirements per plant and convert them to a per-hectare basis. With a planting distance of 20 x 20, there are approximately 250,000 plants per hectare. The price

of 1 kg of solid Vermicompost is IDR10,000, chitosan is IDR50,000 per liter, and NPK is IDR10,000 per kg. The selling price of garlic is IDR20,000/kg.

3. Results and Discussion

3.1 First Study was Solid Vermicompost on 100 kg/ha NPK

Table 1 shows that 100 kg/ha NPK on 10-15 ton/ha solid Vermicompost gave the best growth and yield of garlic. Without solid vermicompost the performance of garlic is not satisfactory.

Table 1. Effect of Liquid Vermicompost Fertilizer and NPK on Plant Height, Number of Leaves, Bulb Diameter, Weight of Fresh Bulb per Plant (g) and Weight of Wind Dry Bulbs per Plant of Garlic at 9 WAP

Treatment NPK (kg/ha) and Solid Vermicompost (tones/ha)	Plant Height (cm)	Number of leaves	Bulb Diameter (cm	Weight of fresh bulb per plant (g/plant)	Yield (ton/ha)
100 - 0	48.57 b	10.12 c	3.88 b	26.56 b	6.64 b
100 - 5	50.95 ab	10.77 bc	4.52 ab	30.22 b	7.55 b
100 - 10	55.27 a	11.14 ab	4.63 a	35.90 a	8.97 a
100 - 15	56.08 a	11.90 a	4.86 a	39.05 a	9.76 a
CV%	1.60%	1.25%	2.30%	2.06%	2.06%

Remarks: The numbers on each column are followed by the same lowercase letters were not significantly different according to Duncan's test (P>0.05)

3.2 Factors Internal and External Affecting the Development of Kurma Park Agrotourism

3.2.1 *Plant growth from 2 to 9 weeks after planting*

We changed solid Vermicompost to liquid Vermicompost, and we found there was no difference in plant height since 2 WAP-9 WAP at all NPK doses and Vermicompost, including the treatment without NPK (Figure 2) and without Vermicompost (Figure 3).

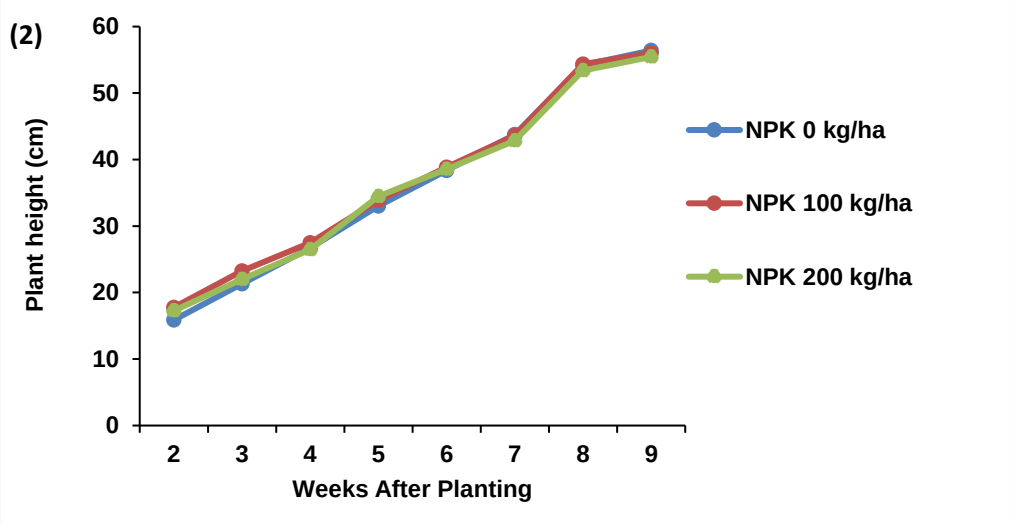

Figure 2. Plant Height by Giving Several Doses of NPK

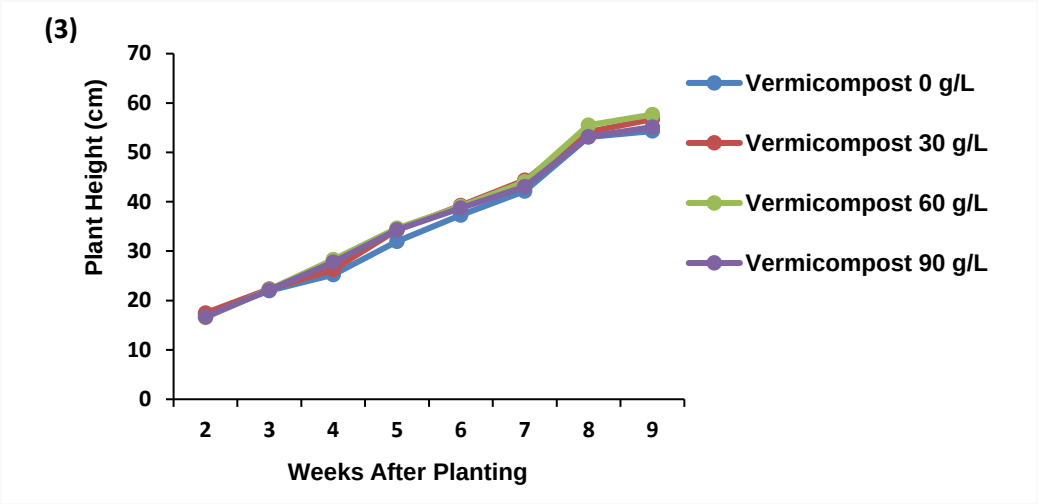

Figure 3. Plant Height by Giving Several Concentrations of Vermicompost

The observed plant growth demonstrates that garlic plants can thrive in the experimental soil. The soil pH is nearly neutral, with moderate total nitrogen and a high concentration of available phosphorus. The roles of these nutrients are critical for plant development. Nitrogen is a fundamental component of amino acids, the building blocks of proteins and enzymes responsible for most biological processes. Nitrogen is also present in nucleic acids, which store genetic information, and chlorophyll, which is essential for photosynthesis. An adequate nitrogen supply promotes root growth, plant development, and the uptake of other nutrients (Weil & Brady, 2017). Similarly, phosphorus is an essential element in photosynthesis, respiration, and the synthesis of nucleic acids and cellular membranes (P. Marschner, 2012). Phosphorus also plays a crucial role in the regulation of many enzymes (Xu, *et al*., 2019).

3.2.2 *Vegetative parameters*

The data analysis results showed no effect of Vermicompost and NPK on the number of leaves, stem diameter, or fresh weight of the plant. Table 2 also shows that the number of leaves produced ranged from 11.00 to 12.31 strands. In this experiment, applying NPK fertilizer at 0 t/ha and Vermicompost at 0 g/L meaning only chitosan solution was used resulted in about 12 leaves. For the Lumbu Hijau variety planted in the same area, the NPK treatment of 100 kg/ha and solid Vermicompost of 15 t/ha produced 11.90 strands, which was not different from all liquid Vermicompost treatments. In contrast, Samadi (2005) reported that Lumbu Hijau typically has only 7 to 9 leaves. This change in genetic potential is probably caused by long-term selection and adaptation of the Lumbu Hijau variety around Danau Kembar.

Table 2. Effect of Liquid Vermicompost Fertilizer and NPK on The Height and Number of Leaves of Garlic Plants at 9 WAP

Treatment NPK(kg/ha) and Vermicompost in Chitosan solution (g/L)	Number of leaves	Stem diameter (mm)	Fresh weight of the plant (g)
0-0	12.00	5.86	33.19
0-30	12.00	6.37	38.00
0-60	12.23	5.99	40.41
0-90	11.00	5.78	34.72
100-0	12.00	5.51	32.36
100-30	11.83	6.02	38.33
100-60	12.31	7.34	47.33
100-90	12.00	6.81	35.66
200-0	11.39	5.47	30.48
200-30	12.00	5.81	36.50
200-60	11.66	6.07	30.50
200-90	12.00	6.20	30.69
CV%	3.37%	14.02%	18.02%

Remarks: The numbers on each column were not significantly different according to ANOVA α = 5%.

Garlic grows in clumps and stands upright, reaching 30-75 cm. Ishthifaiyyah and Sobir (2018) tested seven garlic genotypes and found that the pseudo stem diameter ranged from 2.4 to 7.7 mm. In this experiment, the average pseudo stem diameter was 5.47 to 7.34 mm, which is relatively large. Even, 0 NPK and the 0 Vermicompost treatment, the stem diameter remains within the potential threshold. Another possible explanation is the presence of chitosan. Sajid *et al*., (2020) reported that foliar spraying of 1% chitosan significantly enhanced fruit weight, volume, yield per tree, firmness, titratable acidity, and ascorbic acid concentration, while notably reducing total soluble solids, juice pH, and the incidence of peach fruit diseases. Likewise, applying chitosan 50 days after full bloom resulted in greater fruit weight, volume, yield per tree, firmness, titratable acidity, and ascorbic acid levels, accompanied by lower fruit number per kilogram, soluble solids, juice pH, and disease incidence compared with other application periods. Anusuya & Sathiyabama (2016) found that chitosan (0.1%, w/v) produces high-yielding and curcumin content turmeric plants.

3.2.3 *Yield component*

The result in Table 3 shows that the treatment without NPK has no significant difference with using NPK on fresh yield of Garlic.

The growth and yield of Garlic are not only influenced by how much chemical fertilizer is applied, but are also closely related to the nutrient content of the soil. Although dolomite and organic fertilizer were not given in the second study, because the pH is slightly acidic, N is medium, and very high P, it supports garlic growth. The size of the bulb diameter ranging from 3.32 to 3.74 cm. It is no significant different with Samadi (2005) the bulb diameter of Lumbu Hijau was 3.30 – 3.90 cm and Kristina, Yusniwati, Warnita, & Resigia (2023) was getting bulb diameter of Lumbu Hijau 3.28 cm on 300-900 kg/ha NPK.

Table 3. Effect of Liquid Vermicompost Fertilizer and NPK on Weight of Fresh Bulb, Bulb Diameter, Wind Dry Weight of Bulbs per Plant and Hectare of Garlic at 9 WAP

Treatment NPK(kg/ha) and Vermicompost in Chitosan solution (g/L)	Weight of fresh bulb per plant (g)	Bulb diameters (cm)	Yield (ton/ha)
0-0	22.49	3.36	5.62
0-30	25.17	3.55	6.29
0-60	27.32	3.58	6.83
0-90	23.98	3.41	5.99
100-0	23.47	3.51	5.87
100-30	25.89	3.46	6.47
100-60	29.76	3.74	7.44
100-90	23.39	3.44	5.85
200-0	21.66	3.32	5.41
200-30	24.51	3.51	6.13
200-60	23.42	3.41	5.85
200-90	23.74	3.54	5.93
CV%	17.99%	6.56%	6.56%

Remarks: The numbers on each column were not significantly different according to ANOVA α = 5%.

Table 3 also shows that each treatment of NPK-liquid Vermicompost had no significant effect on the yield of garlic bulbs. Although on 100 NPK and 60 g/l liquid Vermicompost fertilizers, the yield of garlic reaches 7.44 t/ha. Table 1 shows that adding solid organic matter, Vermicompost 15 t/ha at 100 kg/ha NPK, significantly increased the yield of garlic bulbs of the Lumbu Hijau variety to 9.76 t/ha. This means that the organic matter content in soil is significant for garlic. Garlic is not tolerant of drought because it has shallow fibrous roots. Loose soil will encourage the development of bulbs. A sound drainage system is needed for waterlogged or muddy soil (Titisari, *et al*., 2019). The best soil condition for plant growth is fertile, loose, well-aerated, porous, and has good drainage. This condition can be formed by giving organic matter.

The treatment with 100 NPK and 60 g/L liquid Vermicompost tended to have a higher value than other treatments (stem diameter 7.34 mm). Vermicompost contains auxins, cytokinins, and the flowering hormone gibberellin secreted by earthworms (Rehman, 2023), which can promote growth. Unfortunately, the application of organic matter such as solid Vermicompost in large quantities causes pollution to the Dibawah Lake.

3.3 Financial Analysis of Solid and Liquid Vermicompost Garlic Farming

From an economic point of view, we know from Table 4 that changing solid Vermicompost into liquid is very profitable for farmers because liquid Vermicompost is cheaper than solid Vermicompost. For the examples, we calculate the income from treatment 100 NPK and 60 g Vermicompost in chitosan solution. The price of solid Vermicompost is very expensive, IDR10,000/kg. The Vermicompost solution that needed by one plant until the harvest is 100 ml. If there are 60 g of Vermicompost in one Liter of solution, it takes about 6 g of solid Vermicompost to get 100 ml of chitosan Vermicompost solution. If there are 250,000

garlic plants in one hectare at a spacing of 20 x 20 cm, then the Vermicompost required is 6 g x 250,000 plants/ha, which is 1500 kg/ha, equivalent to IDR15,000,000. The needed chitosan per 100 mL Vermicompost solution is 0.4 mL, so it takes 0.4 mL x 250,000 plant/ha = 100,000 mL (100 L chitosan solution). The cost for chitosan is 100 L x IDR50,000 = IDR 5,000,000. 100 kg NPK (@ IDR10,000) is IDR1,000,000. The total cost per hectare for NPK plus liquid fertilizer is IDR 21,000,000. If it is assumed that the price of Garlic per kg is at least IDR20,000, then the revenue per hectare of 7.44 tons/ha is IDR148,800,000, which means that the income, excluding the cost of seed, tillage, and poison, is around IDR127,800,000. The percentage increase in income compared to income on 100 kg/ha NPK -10 t/ha solid Vermicompost treatment is highest, reaches 63%. The contra condition if only using chitosan (100 NPK - 0 Vermicompost), we only pay chitosan solution IDR5,000,000, plus NPK IDR1,000,000. But, the revenue per hectare for a 5.87 tons/ha yield is only IDR117,400,000. Which means that the income, excluding the cost of tillage and poison, is only around IDR111,400,000. The percentage increase in income compared to income on 100 kg/ha NPK -0 Vermicompost treatment is only reaches 42.09%.

Table 4. Financial Analysis of Garlic by Different Treatment

Treatment NPK(kg/ha) and Vermicompost in Chitosan solution (g/L)	Yield (t/ha)	Revenue (IDR ha^{-1})	Cost (IDR ha^{-1})	Income (IDR ha^{-1})	Percentage Increase in Income (%)*
0 - 0	5.62	112,400.000	5,000,000	107,400,000	36.99
0 - 30	6.29	125,800,000	12,500,000	113,300,000	44.51
0 - 60	6.83	136,600,000	20,000,000	116,000,000	47.96
0 - 90	5.99	119,800,000	27,500,000	92,300,000	17.72
100 - 0	5.87	117,400,000	6,000,000	111,400,000	42.09
100 - 30	6.47	129,400,000	13,500,000	115,900,000	47.83
100 - 60	7.44	148,800,000	21,000,000	127,800,000	63.00
100 - 90	5.85	117,000,000	28,500,000	88,500,000	12.88
200 – 0	5.41	108,200,000	7,000,000	101,200,000	29.08
200 – 30	6.13	122,600,000	14,500,000	108,100,000	37.88
200 - 60	5.85	117,000,000	22,000,000	95,000,000	21.17
200 - 90	5.93	118,600,000	29,500,000	89,100,000	13.65
100 kg/ha NPK -10 t/ha solid Vermicompost	8.97	179,400,000	101,000,000	78,400,000	
100 kg/ha NPK-15 t/ha solid Vermicompost	9.76	195,200,000	156,000,000	39,200,000	

* Shows percentage increase in income compared to income on 100 kg/ha NPK -10 t/ha solid Vermicompost treatment.

Application of 100 kg per hectare NPK combined with 15 tons per hectare solid Vermicompost resulted in a higher tuber dry weight yield of 9.76 tons per hectare. At a market price of IDR20,000 per kilogram, the estimated revenue is IDR195,200,000. The total cost for

solid Vermicompost fertilizer and NPK is IDR156,000,000, resulting in a net profit of IDR 39,200,000. In contrast, treatment 100 NPK, which utilized 60 grams per liter of Vermicompost in chitosan solution, generated higher profit and required less chemical fertilizer. Therefore, this treatment is more economically advantageous and reduces nutrient pollution in Dibawah Lake by decreasing solid organic fertilizers.

4. Conclusion

The preliminary study demonstrated that applying solid Vermicompost at rates of 10 to 15 tons per hectare, combined with 100 kilograms per hectare of NPK fertilizer, resulted in the highest garlic yield compared to the control treatment without Vermicompost. In a subsequent study, liquid Vermicompost concentrations ranging from 0 to 90 grams per liter, applied with NPK fertilizer rates of 0 to 200 kilograms per hectare, produced no different effects on garlic growth and yield. Although the highest yield was observed with 15 tons per hectare of solid Vermicompost, liquid Vermicompost at a concentration of 60 grams per liter was more cost-effective for farmers because it increased until 63% income and was more environmentally friendly than the solid form application, particularly when used with 100 NPK.

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