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*Research Article*

# Response of Cabbage (Brassica Oleracea Var. KK Cross) to Liquid Organic Fertilizer Derived from Tofu Industry Wastewater

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***Abstract -*** *Cabbage (Brassica oleracea var. KK Cross) is a widely consumed vegetable due to its high nutritional value, including vitamins A, B, and C, as well as essential minerals, carbohydrates, and proteins. The utilization of tofu wastewater as a source of organic nutrients presents a sustainable alternative to chemical fertilizers in agriculture. This study aimed to evaluate the effects of various concentrations of liquid organic fertilizer (LOF) derived from tofu wastewater on the growth and yield of cabbage plants. The experiment was conducted from July to October 2022 in Rarampadende Village, West Dolo District, Donggala Regency, Central Sulawesi, Indonesia, using a Randomized Group Design (RGD). Treatments included five LOF concentrations: P0 = control (no LOF), P1 = 5 ml/L, P2 = 10 ml/L, P3 = 15 ml/L, and P4 = 20 ml/L, each replicated three times for a total of 15 plots. Data were analyzed using ANOVA, and significant effects were further tested using the Honest Significant Difference (HSD) test at the 5% level. Results showed that tofu wastewater LOF significantly affected leaf width at 28 days after planting (DAP) and fresh weight at harvest. The best growth performance was observed in the P4 treatment (20 ml/L).*

***Keywords -*** *Cabbage, Liquid Organic Fertilizer (LOF), and Tofu Wastewater.*

## I. INTRODUCTION

Cabbage (Brassica oleracea L.) is a widely consumed vegetable due to its numerous health benefits. It is recognized as a rich source of vitamins A, B, and C, as well as minerals, carbohydrates, and protein. Similar to other types of vegetables, cabbage is highly perishable, has a seasonal production cycle, and possesses limited storage longevity. Its susceptibility to damage is primarily attributed to its tender leaves and high water content, which make it vulnerable to mechanical injury, pests, and plant diseases (Herminanto, 2004). Central Statistics Agency data indicate that cabbage production in Central Sulawesi reached 36.74 tons in 2021, then dropped to 27.03 tons in 2022 and 27.61 tons in 2023. (Badan Pusat Statistik, 2024).

Plant production and quality are influenced by various factors, one of which is nutrient availability. Low soil fertility indicates a deficiency in essential nutrients, including potassium a macronutrient that plays a vital role in plant growth. Potassium is considered the third most important nutrient after nitrogen (N) and phosphorus (P). One approach to enhancing soil N, P, and K content is the application of organic materials. The use of organic amendments not only improves soil nutrient levels but also helps reduce the reliance on high doses of inorganic N, P, and K fertilizers, thereby increasing their efficiency (Isrun, 2009). Liquid waste from the tofu industry is predominantly composed of proteins and fats. These organic compounds contain the elements carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), and sulfur (S), which can serve as potential nutrient sources for plants. However, the organic substances in tofu liquid waste cannot be directly absorbed by plants; they must first undergo degradation into simpler, more accessible forms (Pranoto, 2010). The characteristics of tofu wastewater include nitrogen (N) levels of 69.28 mg/L, phosphorus (P) levels of 39.84 mg/L, and potassium

(K) levels of 616 mg/L. Tofu liquid waste is therefore considered a potential alternative to conventional fertilizers, offering beneficial effects on plant growth (Siswono & Herman, 2017).

Tofu liquid waste contains organic materials, consisting of approximately 60% protein, 25%–50% carbohydrates, and 10% fat. These components decompose rapidly in the environment, potentially forming derivative compounds that may contribute to environmental pollution (Asmoro, 2008). Analytical studies have shown that tofu liquid waste also contains carbohydrates, proteins, fats, and essential nutrient elements such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and iron (Fe) (Indahwati, 2008). Based on the description above, it is necessary to conduct research to determine the appropriate concentration of tofu liquid waste that optimally supports the growth and yield of cabbage plants.

## II. MATERIALS AND METHODS

This research was conducted from July to October 2022 in Rarampadende Village, West Dolo Subdistrict, Donggala Regency, Central Sulawesi Province. The tools used in this study included a hoe, spade, writing instruments, bucket, sieve, measuring tape or ruler, hand sprayer, weighing scale, and camera. The materials utilized consisted of cabbage seeds of the KK Cross variety and organic fertilizer derived from tofu liquid waste. This research employed a Randomized Block Design (RBD) with treatments consisting of various concentrations of liquid organic fertilizer (LOF) from tofu wastewater at five levels:

- P0 = No application of LOF from tofu wastewater (control)
- P1 = 5 ml tofu wastewater per liter of water
- P2 = 10 ml tofu wastewater per liter of water
- P3 = 15 ml tofu wastewater per liter of water
- P4 = 20 ml tofu wastewater per liter of water

Each treatment consisted of 3 replications so there were 15 experimental beds. Each experimental bed unit is provided with 20 plants so that 300 plants are needed and in each bed unit 6 experimental samples are required so that there are 90 samples in carrying out the research.

## III. RESULTS AND DISCUSSION

### *A. Number of Leaves*

The number of leaves observed in cabbage plants at 14, 28, 42, and 56 days after planting showed no significant effect. The average number of leaves in cabbage plants at 14, 28, 42, and 56 DAT is illustrated in Figure 1.

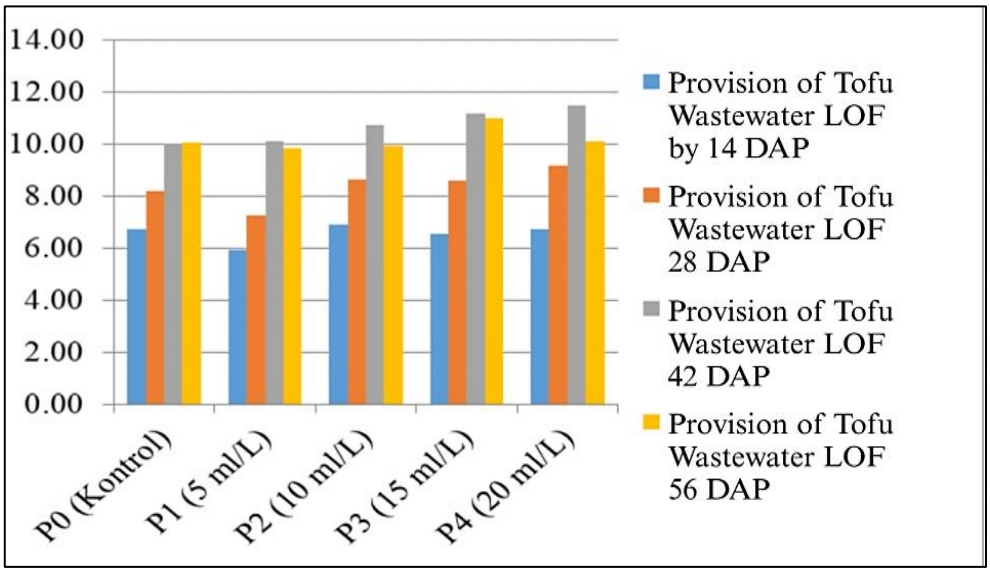


***Figure 1. Average Number of Leaves of Cabbage Plants at the Age of 14, 28, 42 and 56 DAT, When Given LOF from Tofu Water Waste***

Figure 1 illustrates that at 14 days after transplanting (DAT), the highest number of leaves was observed in the P0 and P4 treatments, both with an average of 6.72 leaves. At 28 and 42 DAT, the P4 treatment produced the highest number of leaves, with averages of 9.17 and 11.50, respectively. By 56 DAT, the highest number of leaves was recorded in the P3 treatment, with an average of 11.00 leaves.

***B. Leaf Length (cm)***

The left length observed in cabbage plants at 14, 28, 42, and 56 days after planting showed no significant effect. The average number of leaves in cabbage plants at 14, 28, 42, and 56 DAT is illustrated in Figure 2.

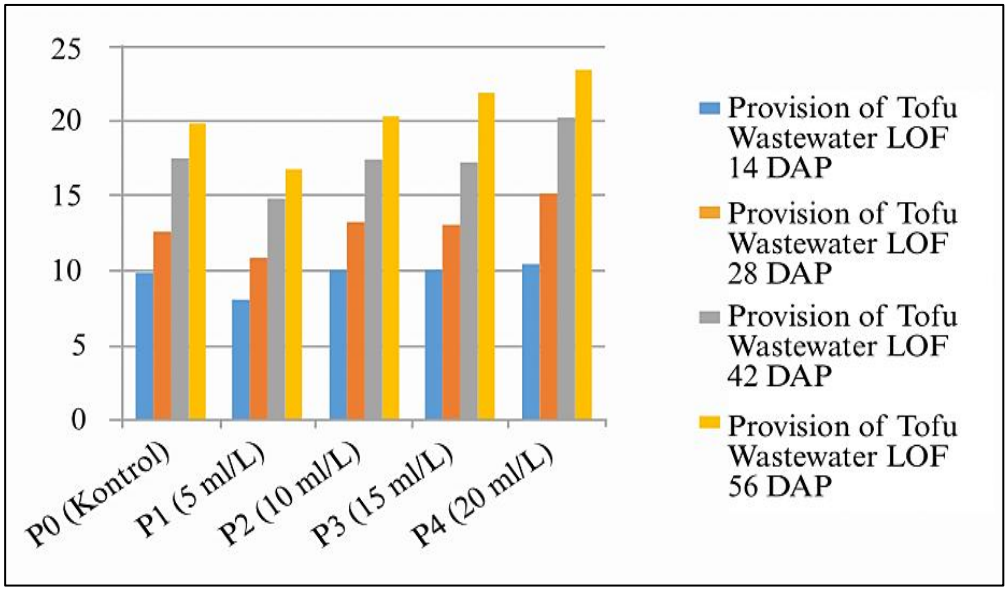


***Figure 2. Average Leaf Length of Cabbage Plants at the Age of 14, 28, 42 and 56 DAT, When Given LOF from Tofu Water Waste***

Figure 2 shows that the application of various concentrations of liquid organic fertilizer (LOF) derived from tofu wastewater at 14, 28, 42, and 56 days after transplanting (DAT) tended to result in greater leaf length in the P4 treatment. The average leaf lengths observed in the P4 treatment were 10.49 cm at 14 DAT, 15.20 cm at 28 DAT, 20.24 cm at 42 DAT, and 23.49 cm at 56 DAT.

***C. Wide Leaves (cm)***

Analysis of variance for leaf width observations at 20 days after planting indicated that the application of liquid organic fertilizer derived from tofu wastewater had a significant effect.

**Table 1. Average leaf width of cabbage plants at the age of 28 DAT when given LOF from tofu water waste**

| Treatment | Leaf Width (cm) | HSD 5% |
|---|---|---|
| | 20 DAP | |
| P0 (Control) | 10.35 [a] | 1.70 |
| P1 (5 ml/L) | 8.93 [a] | |
| P2 (10 ml/L) | 10.15 [a] | |
| P3 (15 ml/L) | 10.13 [a] | |
| P4 (20 ml/L) | 12.25 [b] | |

**Note**: Numbers followed by the same letter do not differ at the HSD test level α = 0.05

Based on the results of the 5% HSD test in Table 1, it shows that the P4 treatment produces the widest leaf width with an average value of 12.25. This treatment is significantly different from the other treatments.

***D. Volume Crop (ml)***

The analysis of variance revealed that applying liquid organic fertilizer derived from tofu wastewater had no significant effect on crop volume measurements at harvest. The average value of crop volume (ml) is presented in Figure 3.

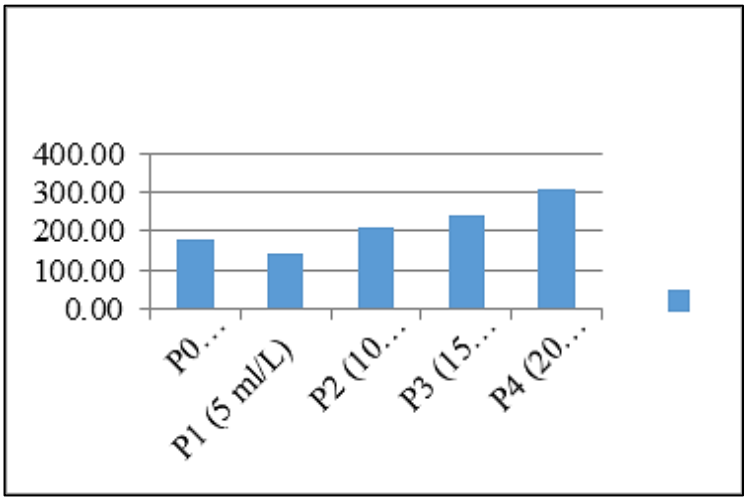


***Figure 3. Average Crop Volume of Cabbage Plants at the Age of 14, 42 and 56 DAT, When Given LOF from Tofu Water Waste***

Figure 3 shows that administering various LOF concentrations of tofu water waste at harvest time resulted in the heaviest crop volume in the P4 treatment, namely with an average value of 310.55 (ml).

***E. Fresh Crop Weight (g)***

The analysis of variance indicated that the application of liquid organic fertilizer derived from tofu wastewater had a highly significant effect on fresh crop weight at harvest. The average value of fresh weight is presented in Table 2.

**Table 2. Average fresh weight of cabbage plants at harvest time with Tofu water waste LOF application**

| Treatment | Fresh Weight (g) | HSD 5% |
|---|---|---|
| P0 (Control) | 199.50 $^{ab}$ | 87.74 |
| P1 (5 ml/L) | 182.83 $^{a}$ | |
| P2 (10 ml/L) | 271.61 $^{bc}$ | |
| P3 (15 ml/L) | 291.94 $^{c}$ | |
| P4 (20 ml/L) | 389.78 $^{d}$ | |

Note: Numbers followed by the same letter do not differ at the HSD test level α = 0.05

Based on the results of the 5% HSD test presented in Table 2, the P4 treatment yielded the highest fresh weight, with an average of 389.78 grams. This treatment differed significantly from the other treatments. The findings indicate that the application of tofu wastewater liquid organic fertilizer (LOF) at a concentration of 20 ml per liter of water (P4) had a significant effect on leaf width and fresh weight parameters. These values were higher compared to the control treatment (P0), which did not receive any tofu wastewater LOF.

The increase in plant growth and yield is likely due to the improved nutrient availability in the soil. A higher concentration of organic fertilizer enhances the nutrient supply, particularly as the organic matter decomposes and releases essential elements into the soil. Fertilization contributes to plant physiological processes, which in turn promotes better growth (Fajrin et al., 2020). This is consistent with the findings of Junita Puji Astuti (2012), who stated that liquid tofu waste contains protein, calories, fat, and carbohydrates. These organic materials can be decomposed by soil microbes, providing potential nutrients that support plant growth and yield. The KK

Cross cabbage variety used in this study is known for its high productivity and adaptability to lowland environments. According to Simatupang (1997), as cited in Hanny et al. (2015), varietal height is influenced by the plant's ability to adapt to its growing environment.

Tofu wastewater fertilizer is classified as an organic liquid fertilizer rich in nutrients such as phosphate and nitrate, both of which are essential for plant development and can accelerate the growth of cabbage (Aprilia & Nugroho, 2021). This aligns with Susanto (2003), who stated that organic fertilizer enhances the physical, chemical, and biological properties of soil, making it more fertile. The increased nutrient availability due to the application of tofu wastewater improves plant growth by supplying nutrients required during various growth stages.

According to Natalia (2021), broader leaves are the result of sufficient nutrient availability, which supports vegetative growth. Kholifah (2018) further explained that cell division driven by the breakdown of photosynthate and energy production through respiration contributes to leaf expansion. Larger leaves contain more chlorophyll, thus enhancing the rate of photosynthesis. The number of leaves is influenced by nitrogen (N), an essential element for amino acid synthesis, which supports plant metabolic processes and promotes leaf development. An increase in leaf number correlates with a higher photosynthesis rate, leading to greater photosynthate production. These assimilates not only support leaf development but also contribute to other vegetative growth aspects, such as plant height. Taller plants typically have more leaves, as leaves are formed at the nodes along the stem. This observation is in agreement with Raga and Bullu (2018), who reported that the application of NPK compound fertilizer provides a balanced supply of nitrogen, phosphorus, and potassium, thereby supporting plant growth. Similarly, tofu wastewater contains high levels of organic compounds carbohydrates, proteins, fats, iron, phosphorus, and water. These compounds can be decomposed by soil microbes, making nitrogen available for plant uptake. Nitrogen is a crucial nutrient for plant growth, particularly in leaf development.

The application of tofu wastewater LOF at 20 ml per liter (P4) resulted in higher values for parameters such as number of leaves, leaf length, and plant volume compared to the control, although not all differences were statistically significant. This outcome may also be influenced by favorable environmental conditions, such as climate and soil properties. Cabbage thrives in relatively cool and humid environments, with optimal humidity levels of 80%-90%, temperatures ranging from 15°C to 20°C, and adequate sunlight.

It is also important to note that plants absorb nutrients from the growing medium based on their physiological needs. Even if the medium contains high nutrient levels, plants will only absorb the amount necessary for their development. According to Prawitasari (2003), as cited in Erwin et al. (2015), plant growth and yield development are influenced by internal enzymatic activity and external environmental factors. Photosynthesis plays a central role in organ development, and optimal photosynthetic activity supported by favorable nutrient, temperature, and air conditions will enhance plant growth and yield. As noted by Willy (1998), in Erwin et al. (2015), the expansion of plant organs and cell growth are key indicators of productive physiological processes.

## IV. CONCLUSION

The results of this research concluded that the concentration of LOF in tofu waste water on the growth and yield of cabbage plants had a real effect on the parameters of leaf width and fresh weight. LOF concentration treatment of tofu wastewater provides better growth, namely LOF of tofu liquid waste 20 ml / l (P4).

## Conflicts of Interest

The authors declare no conflict of interest.

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