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THE EFFECT OF LIQUID TOFU WASTE AND GROWING MEDIA ON THE GROWTH AND YIELD OF LONG BEANS (*Vigna sinensis* L.)

Pengaruh Limbah Cair Tahu dan Media Tanam terhadap Pertumbuhan dan Hasil Panen Tanaman Kacang Panjang (*Vigna sinensis* L.)

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ABSTRACT
Long bean is a leguminous plant that has the potential to be developed into productive plants. Tofu liquid waste organic fertilizer and planting media are needed to meet nutrient needs, improve the physical and chemical properties of the soil. This study aims to understand the effect of liquid tofu waste, growing media, and their combined interaction on the growth and yield of long beans. This study used a factorial randomized block design (RBD) with 3 replications, 3 treatments of liquid tofu waste of 0 mL (T_0), 150 mL (T_1), and 300 mL (T_2), and 3 planting media, namely cow manure compost + rice husk charcoal (M_1), cow manure compost + cocopeat (M_2), and cow manure compost + chopped fern (M_3). If they had a significant effect, a Tukey's test at a 5% probability level would be performed. The parameters observed included the chlorophyll a and b, net assimilation rate, relative growth rate, height, number of flowers, pod length, and wet fruit weight of long beans. The results showed that the T_1 and M_3 treatments significantly affected chlorophyll a and b, height, number of flower, and pod length. The T_1 and M_2 treatments significantly affected the wet fruit weight of long beans.The T_2 and M_2 treatments significantly affected the net assimilation rate. Finally, the T_2 and M_3 treatments significantly affected the relative growth rate. There was no interaction effect found between liquid tofu waste and growing media on all research parameters.

Keywords: *Growing media, growth and production, liquid organic fertilizer, liquid tofu waste, long beans*

ABSTRAK
Kacang panjang adalah tanaman polong-polongan yang memiliki potensi untuk dikembangkan menjadi tanaman produktif. Diperlukan pupuk organik limbah cair tahu dan media tanam untuk memenuhi kebutuhan unsur hara, memperbaiki sifat fisik dan kimia tanah. Penelitian ini bertujuan mengetahui pengaruh pemberian limbah cair tahu, media tanam dan juga interaksi kombinasi terhadap pertumbuhan dan hasil tanaman kacang panjang. Penelitian menggunakan rancangan acak kelompok (RAK) faktorial dengan 3 ulangan, 3 perlakuan limbah cair tahu 0 mL (T_0), 150 mL (T_1), 300 mL (T_2), dan terdiri dari 3 media tanam yaitu kompos kotoran sapi + arang sekam padi (M_1), kompos kotoran sapi + cocopeat (M_2), kompos kotoran sapi + pakis cacah (M_3). Parameter yang diamati yaitu klorofil a, b, laju asimilasi bersih, laju pertumbuhan relatif, tinggi tanaman, jumlah bunga, panjang buah, dan bobot basah buah. Hasil penelitian menunjukkan perlakuan T_1 dan M_3 berpengaruh sangat nyata terhadap klorofil a, b, tinggi tanaman, jumlah bunga dan panjang buah. Perlakuan T_1 dan M_2 berpengaruh sangat nyata terhadap bobot basah buah. Sedangkan perlakuan T_2 dan M_2 berpengaruh sangat nyata terhadap laju asimilasi bersih. Sedangkan perlakuan T_2 dan M_3 berpengaruh sangat nyata terhadap laju pertumbuhan relatif. Tidak ada pengaruh interaksi antara limbah cair tahu dan media tanam terhadap seluruh parameter penelitian.

Kata Kunci: Media tanam, pertumbuhan dan produksi, pupuk organik cair, limbah cair tahu,kacang panjang

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INTRODUCTION

Long beans (*Vigna sinensis* L.) are legumes with good development value after peanuts and soybeans (Ardian et al. 2016). The product of this plant is usually eaten fresh as fresh vegetables or to improve community nutrition (Hadi and Evita 2020). Unripe long beans have properties as processed food and as medicine, namely anemia medicine (Nurjanah et al. 2020), as well as a source of protein and antioxidants and as a high natural fiber source (Gunawan et al. 2022).

According to data from the Statistics Indonesia (2022), long bean productivity increased from 2013-2018, ranging from 92,520 to 321,066 kg/ha with an average increase of 38,094 kg/ha.However, there was instability in production from 2019-2021, rangingfrom 293,128 to 2,640 kg/ha. In 2021, a very rapid production decline from 2020 of 420 kg/ha. It can be concluded that innovations need to be made to increase long bean production and is by community expectations. One way that can be done to achieve this goal is with fertilization and media to support growth and production yields to obtain varieties that have superior characteristics with high production.

Figure 1. Long bean plants

Figure 2. Liquid tofu waste

In the biological aspect, organic fertilizer is the most important energy producer for the activity of soil microorganisms. The application of organic fertilizers stimulates the proliferation of microorganisms and increases nutrients for plants (Zainuddin et al. 2022).

According to Poerwanto et al. (2022), there are more organic compounds in liquid tofu waste than inorganic compounds. Liquid tofu waste contains 40-60% protein, carbohydrates 25%-50%, and fat 10%. Liquid tofu waste formed from protein residues that do not clot and other dissolved substances in water through a precipitation process (Marian and Tuhuteru 2019).

Tofu liquid waste is waste from the tofu processing industry, which so far has barely been used except as animal feed or thrown away (Buololo et al. 2022). In general, tofu solid waste can be used for animal feed. Meanwhile, tofu waste in the form of liquid is disposed of into the waters resulting in a negative impact on water quality, which results in a foul odor in the river or places around the disposal of the tofu liquid waste (Yudhistira et al. 2016).

Tofu liquid waste is obtained free of charge from the tofu industry which does not process the waste, so it is only disposed of for nothing. The content of tofu liquid waste obtained in this study was 0.40% N, 0.21% P, and 147 mg/L K, while the pineapple liquid waste studied by Sutanto and Qurniani (2015) obtained at 0.02% N, 0.03% P, and 134.08 mg/L K. Compared to the content of pineapple liquid waste, the content of tofu liquid waste is higher in nutrients. The nutritional content of tofu waste can be used

as liquid organic fertilizer for plants so that it can reduce the impact of environmental pollution (Aliyenah et al. 2015).Moreover the tofu liquid waste contained the nutrient needed by plants, such as N, P, and K (Saenab et al. 2018).

Asmuliani and Ria (2021) said that the growth response of lettuce with 100 mL liquid tofu waste treatment was the bestforthe plant height, fresh weight, and leaf size, while the leaves number, plant height, and fresh weight were best achieved by soil + cow manure + cocopeat treatment. According to the research results from Rahmawati et al. (2018), 300 mL liquid tofu waste treatment significantly affects the leave counts and height of celery.

Planting media is one of the supporting factors for plant breeding for growth and maintaining plants. Good characteristics of growing media are influenced by several factors, including pH, light, air, water, temperature, nutrients, humidity, and soil. A good growing media must meet several criteria, such as free of weeds and pests, have lots of nutrients (loose and fertile), can accommodate and drain excess water, is easy to obtain, etc (Bui et al. 2016).

Cow manure compost contains high levels of nutrients and energy, which can be used for biogas and organic fertilizers. The nutrients content in cow manure compost includes 0.40% N, 0.20% P, and 0.10% K (Sucipto et al. 2020). The nutrients content in rice husk were easily available to plants and can increase soil pH. The nutrients content of husk charcoal were 0.18% N, 0.08% P, and 0.3% K (Tarigan et al. 2015). The advantage of cocopeat as a breeding ground is its ability to withstand and good aeration, making it suitable in hot areas. Cocopeat contains several main nutrients, including0.37% N, 0.44% P, and 0.20% K (Sari et al. 2013). Chopped fern was also used for growing media because it holds water, has good aeration, absorbs water, as well as smooth texture to facilitate plant root penetration (Mariana 2017).This study aims to determine the effect of liquid tofu waste, growing media, and their interaction of the combination treatments on the growth and yield of long beans.

MATERIALS AND METHODS

Location and time

This study was carried out in Huta I Bandar Siantar Village, Gunung Malela Subdistrict, Simalungun District (3°01'42.8"N 99°10'47.1"E), at 170 m above sea level with an average temperature of 23-32ºC. The study was conducted in August-October 2022.

Tools and Materials

The tools utilized in this study included 35×35 cm polybags, shovel or hoe, label paper, digital scales, laptops, cameras, digital soil meters 3 in 1, and stationery. The materials used included cow manure compost, rice husk charcoal, cocopeat, chopped ferns, liquid tofu waste and Canton Tavi long bean seeds (*V. sinensis* L.).This variety was chosen because it is rarely used by farmers due to the low productivityof fruit produced, the specialty of this variety is that it is resistant to Gemini virus, resistant to Fusarium wilt and bacterial wilt, and can adapt well to the lowlands with an altitude of 50 – 300 m above sea level. The seeds were purchased from agriculture shop at Bandar Siantar, Simalungun Regency.

Methods

This study used a factorial randomized block design (RBD) with 3 treatments, 3 growing media, and 3 replications. The liquid tofu waste treatment was applied at 3 levels for each type of media, namely:

T_0 = 0 mL
T_1 = 150 mL
T_2 = 300 mL

The growing media used include:

M_1 = Compost of cow manure + rice husk charcoal (1:1)
M_2 = Compost of cow manure + cocopeat (1:1)
M_3 = Compost of cow manure + chopped fern (1:1)

Research Procedures

Provision of materials: the materials used in this study included liquid tofu waste of 24,300 mL for watering 6 times until harvest with a watering interval of 7 days, as well as seeds, cocopeat, rice husk charcoal, and chopped ferns. The cow manure compost was obtained from several farms in

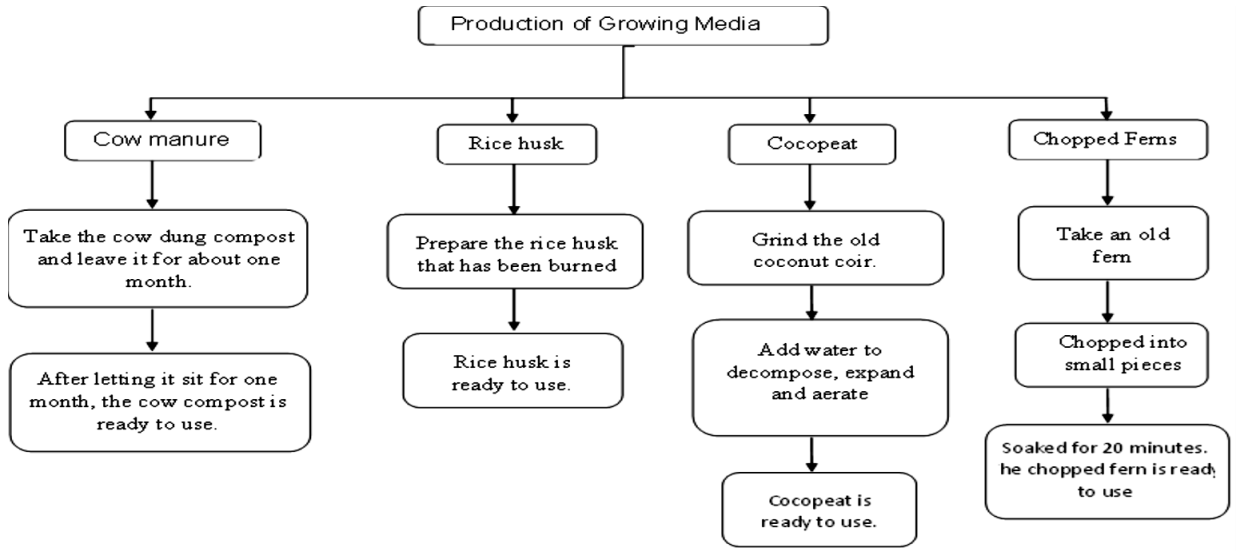

Figure 3. Production of planting media

several residents in Huta I Bandar Siantar, Gunung Malela Subdistrict.

Production of liquid organic fertilizer from liquid tofu waste: liquid tofu waste is fermented in closed jerry cans without the addition of microbes and without oxygen for 15 days before watering time. The fermented waste can be used according to the treatment level and then used as fertilizer. The content of N, P, and K was tested using the SNI 6989.69-2009 method. Production of growing media: the following is a flowchart for making growing media (Figure 3).

Planting and Harvest

Long bean seeds were planted in polybags, with as many as 2 long bean seeds in each polybag. After planting, then watering was conducted to maintain soil moisture. Watering was done every morning and afternoon. Weeding is done when the polybag starts to grow weeds. Watering with liquid tofu waste was carried out 6 times at 7 days after planting (DAP) intervals in the afternoon, which were 7, 14, 21, 28, 35, and 45 DAP. Harvesting was done at 50 DAP by picking the pods on each plant, followed by weighing.

Observation Variables

Data collection was carried out by measuring several parameters on long bean plants (*V. sinensis* L.), which were:

a. Chlorophyll content

The chlorophyll content was measured at 30 DAP. The leaves to be tested were taken from the leaves in the middle, and the chlorophyll a and b content was measured using a spectrometer.

b. Net assimilation rate (g/cm^2/week)

The net assimilation rate was measured by observing plant dry weight and leaf area of plants aged 21 and 28 DAP. The leaves analyzed came from the middle leaves. With the following formula (Zulkifli et al. 2020).

$$\mathrm{NAR} = \frac{\mathrm{Log\ A2} - \mathrm{Log\ A1}}{\mathrm{A2} - \mathrm{A1}} - \frac{\mathrm{Log\ W2} - \mathrm{Log\ W1}}{\mathrm{t2} - \mathrm{t1}}$$

Note:
NAR = net assimilation rate
A1 = leaf wide measurement 1
A2 = leaf wide measurement 2
W1 = dry weight measurement 1
W2 = dry weight measurement 2

c. Relative growth rate

The relative growth rate was calculated at 21–28 DAP using the following formula (Zulkifli et al. 2020):

$$\mathrm{RGR} = \frac{\mathrm{Log\ W2} - \mathrm{Log\ W1}}{\mathrm{t2} - \mathrm{t1}}$$

Note:
RGR = relative growth rate
W1 = dry weight measurement 1
W2 = dry weight measurement 2
t1 = time 1
t2 = time 2

d. Plant height (cm)

The plant height was measured from the stem's surface to the plant's tip. Plant height was measured at 14, 21, 28, 35, and 45 DAP.

e. Number of flower

The number of flower that have bloomed at the age of 33 DAP were calculated.

f. Pod length (cm)

Pod length was measured with a cloth meter on each sample plant at harvest.

g. Fresh weight of planted fruit (grams).

The wet fruit weight was calculated by weighing fresh fruit at harvest (grams).

Data Analysis

The data were analyzed with SPSS version 25 using the univariate ANOVA (analysis of variance) test at a 5% probability level. If it had a significant effect, a Tukey's test at a 5% honestly significant difference (HSD) would be performed.

RESULTS AND DISCUSSION

The nutrient content of liquid tofu waste after being fermented for 15 days resulted in a standard pH of 5.71, N-Total of 0.40%, phosphorus of 0.21%, and potassium of 147 mg/L. The N, P and K elements met the quality standard of liquid fertilizer of the Ministry of Agriculture Number: 28/Permentan/SR.130/5/2009.

Table 1. Theaverage content of chlorophyll a and b at 30 DAP

Parameters	Average	
	Chlorophyll a (645nm)	**Chlorophyll b (663nm)**
Liquid Tofu Waste		
0 mL (T_0)	6.66a	4.73a
150 mL (T_1)	7.81ab	5.79ab
300 mL (T_2)	8.48b	5.57b
Planting Media		
Cow Compost + Rice Husk Charcoal (M_1)	5.92a	4.20a
Cow Compost + Cocopeat (M_2)	7.66b	5.28b
Cow Compost + Chopped Fern (M_3)	9.37c	6.61c
Interaction	0.996 (-)	0.652 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction

Chlorophyll Content

The content of chlorophyll in the leaves affected the photosynthetic reaction. The small amount of chlorophyll resulted in not maximal photosynthetic reactions and could not produce maximum carbohydrate compounds (Nurcahyani et al. 2020).

The analysis of the various measurements of the content of chlorophyll a and b at 30 DAP showed that tofu liquid waste and planting media had a very significant effect (Table 1). The chlorophyll a showed that applying 150 mL of liquid tofu waste (T_1) with an average of 7.81 $mg.g^{-1}$, and cow manure compost + chopped fern (M_3) with an average of 9.37 $mg.g^{-1}$ had a very significant effect. In chlorophyll b, 150 mL liquid tofu waste (T1) with an average of 5.79 $mg.g^{-1}$, and cow manure compost + chopped fern (M3) with an average of 6.61 $mg.g^{-1}$ had a very significant effect. Thus, chlorophyll a is higher than chlorophyll b, because chlorophyll absorbs the most energy in blue and red light so that it becomes the main pigment in the process of photosynthesis.

High-level plants have two kinds of chlorophyll: chlorophyll a with a dark green color and chlorophyll b with a light green color. Chlorophyll a and chlorophyll b can absorb light at most in the red part (600-700 nm) and at least absorb green light (500-600 nm) (Amelia and Kurniawan 2021).

Water deficit affects all aspects of plant growth, including physiological, biochemical, anatomical, and morphological processes. One of the physiological responses of plants to water deficit is a decrease in chlorophyll content in leaves, which may be caused by inhibited chlorophyll formation, reduced Rubisco enzymes, and inhibited absorption of nutrients, especially nitrogen. Magnesium plays an important role in the synthesis of chlorophyll. Leaf chlorophyll content can be used as a reliable indicator to assess the metabolic imbalance between photosynthesis and yield during periods of water deficit. Chlorophyll content can be used as a reliable indicator to assess metabolic imbalance between

photosynthesis and yield during periods of water deficit (Putri et al. 2022).

Net Assimilation Rate

Net assimilation rate is the ability of photosynthesis to produce plant dry matter. Safitri et al. (2018) stated that leaf size correlates to the net assimilation rate. The assimilation rate increases as the leaves expand, but the cover decrease the net assimilation rate if the leaves are too wide.

The results of analysis of the various measurements of the net assimilation rate at 21-28 DAP showed that liquid tofu waste at a dose of 300 mL (T_2) with an average of 2.50 g/cm^2 and cow manure compost + cocopeat (M_2) with an average of 2.48 g/cm^2 had a very significant effect on the net assimilation rate (Table 2).

Table 2. Average net assimilation rate of long beans at 21-28 DAP

Treatment	Average
Liquid TofuWaste	
0 ml (T_0)	2.33a
150 ml (T_1)	2.47a
300 ml (T_2)	2.50b
Planting Media	
Cow manureCompost + Rice Husk Charcoal (M_1)	2.37a
Cow manureCompost + Cocopeat (M_2)	2.48b
Cow manureCompost + Chopped Fern (M_3)	2.45ab
Interaction	0.803 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction.

Table 3. Average relative growth rate of long bean plants at 21 and 28 DAP

Treatments	Average
Liquid Tofu Waste	
0 mL (T_0)	0.11ab
150 mL (T_1)	0.08a
300 mL (T_2)	0.19b
Planting Media	
Cow Compost + Rice Husk Charcoal (M_1)	0.05a
Cow Compost + Cocopeat (M_2)	0.10a
Cow Compost + Chopped Fern (M_3)	0.23b
Interaction	0.694 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction.

The net assimilation rate increase in line with the increase in the leaf area ratio, up to a certain point then it decrease because in a canopy with a high leaf area ratio, young leaves can absorb the lightest, have a high photosynthetic rate, and translocate most of the photosynthates to other parts of the plant, others include the lower leaves (Mahmudi et al. 2022).

Relative Growth Rate

Relative Growth Rate is the increase in dry weight in a time interval related to the fresh weight of the fruit (Ajlouni et al. 2020).The results of the analysis of variance in the measurement of relative growth rates at 21-28 DAP indicated that 300 mL (T_2) liquid tofu waste of 0.19 grams and cow manure compost + chopped fern (M_3) with an average of 0.23 grams had a significant effect on the relative growth rate (Table 3).

Andrew (2016) stated that 2 factors affect plant growth: external and internal. External factors include light, water, air, and soil. Internal factors are obtained from the plant itself (gene factors). If one of the availability factors is insufficient, it will disrupt plant growth.

The relative growth rate shows the ability of plants to produce organic matter to be accumulated in plants. FormationPlant biomass is sourced from nutrient uptake, photosynthesis, nutrient uptake, and water that is processed in the biosynthesis process (Syahputra 2019).

Plant Height

The stems is a part of a plant organ that play a role in storing the results of plant assimilation so that measurements of plant height are observed to determine various plant structures that have an effect as a source of dry matter in plants. When the plant is in the vegetative period, cell division occurs in the stem far from the tip of the stem (Darmawan 2015).

The results of the analysis of the variance of plant height measurements at 14, 21, 28, 35, and 45 DAP showed that 150 mL (T_1) liquid tofu waste and cow manure compost + chopped fern (M_3) had a very significant effect on the height of long beans.

Table 4. Average height of long beans at 14, 21, 28, 35, and 45 DAP

Treatments	Average				
	14 DAP	**21 DAP**	**28 DAP**	**35 DAP**	**45 DAP**
Liquid Tofu Waste					
0 mL (T_0)	25,33a	104,77a	132,55a	195,44a	236,33a
150 mL (T_1)	27,22ab	111,00ab	151,55b	203,44b	249,22ab
300 mL (T_2)	28,88b	115,11b	153,44b	205,55b	258,55b
Planting Media					
Cow manureCompost + Rice Husk Charcoal (M_1)	19,22a	87,22a	125,22a	171,66a	214,44a
Cow manureCompost + Cocopeat (M_2)	27,22b	113,11b	148,44b	196,67b	256,33b
Cow manureCompost + Chopped Fern (M_3)	35,00c	130,55ac	163,88c	236,11c	273,33c
Interaction	0.115 (-)	0.667 (-)	0.980 (-)	0.541 (-)	0.127 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction.

Table 5. Average number of flowerof long beansat 33 DAP

Parameters	Average
Liquid Waste Tofu	
0 mL (T_0)	19.33a
150 mL (T_1)	20.22ab
300 mL (T_2)	22.00b
Planting Media	
Cow manureCompost + Rice Husk Charcoal (M_1)	14.77a
Cow manureCompost + Cocopeat (M_2)	21.67b
Cow manureCompost + Chopped Fern (M_3)	25.11c
Interaction	0.615 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction.

Table 6. Average pod length of long beans at 50 DAP

Treatments	Average
Liquid Tofu Waste	
0 mL (T_0)	67.67a
150 mL (T_1)	69.00ab
300 mL (T_2)	72.44b
Planting Media	
Cow manureCompost + Rice Husk Charcoal (M_1)	66.44a
Cow manureCompost + Cocopeat (M_2)	69.78b
Cow manureCompost + Chopped Fern (M_3)	72.89c
Interaction	0.583 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction.

Based on Table 4, the best 150 mL liquid tofu waste (T_1) treatment was at 45 DAP, resulting in the height of 249.22 Cm. Meanwhile, the best cow manure + chopped

fern compost (M_3) treatment was at 45 DAP, resulting in the height of 273.33 Cm.

The number of flower

The analysis of the variety of the number of flower at 33 DAP indicated that 150 mL liquid tofu waste (T_1) resulted in an average the number of flower of 20.22, and cow manure compost + chopped fern (M_3) resulted in an average the number of flower of 25.11, which was very significant (Table 5). The nutrient phosphorus plays an important role in stimulating root growth, formation flowers, fruit and seeds. Phosphorus really helps the formation of proteins and minerals important for plants, stimulates the formation flowers, fruit and seeds. Even able to accelerate ripening the fruit and make the seeds heavier. If the lack of phosphorus nutrients in plants then resulted in plants not producing flowers and fruit (Hartanti and Yumadela 2018).

Pod Length

The analysis of pod length variance at 33 DAP showed that 150 mL liquid tofu waste (T_1) resulted in an average pod length of 69.00 Cm, and cow manure + chopped fern (M_3) resulted in an average pod length of 72.89 Cm (Table 6).The effect of giving tofu liquid waste and planting media had a significant effect on the length of the long bean fruit. This is due to the provision of nutrients which were absorbed well by plants, supported by good weather factors with low rainfall, so that the nutrient content is well absorbed.

Table 7. Average wet weight of long beansat 50 DAP

Treatment	Average
Liquid Tofu Waste	
0 mL (T_0)	204.89a
150 mL (T_1)	269.33b
300 mL (T_2)	257.56b
Planting Media	
Cow manure Compost + Rice Husk Charcoal (M_1)	185.33a
Cow manure Compost + Cocopeat (M_2)	277.00b
Cow manure Compost + Chopped Fern (M_3)	269.44b
Interaction	0.471 (-)

Note: The numbers followed by different letters on each line show significantly different based on the HSD test at 5% level, (-) = no interaction.

Wet Fruit Weight

The analysis of the variety of fresh fruit weight at 50 DAP indicated that 150 mL liquid tofu waste (T_1) resulted in an average fresh fruit weight of 269.33 grams, and cow manure compost + cocopeat (M_2) resulted in an average wet fruit weight of 277.00 grams (Table 7). Wet pod weight is closely related to pod filling, however not all pods are filled, which depended on the need for nutrients. The formation of filled pods depended on the level of humidity and the provision of nutrients, especially phosphorus and potassium for the fertilization and seed ripening processes (Hartanti and Yumadela 2018).

The benefits of this research for society and science are that the community can take advantage of the use of tofu liquid waste as liquid organic fertilizer so that the waste produced from the tofu industry does not pollute the environment and can also reduce the use of inorganic fertilizers which are relatively expensive and harmful to health, while the planting media can improve the physical, chemical and biological structure of the soil.

CONCLUSION

Liquid tofu waste significantly affected the chlorophyll a and b, height, number of flower, pod length, and fresh fruit weight of long beans. The application of 300 mL liquid tofu waste (T_2) significantly affected the net assimilation rate and relative growth rate. Cow manure compost + cocopeat (M_2) significantly affected the net assimilation rate and fresh fruit weight of long beans. Meanwhile, cow manure compost + chopped ferns (M_3) significantly affected the chlorophyll a and b, net assimilation rate, relative growth rate, height, number of flower, and pod length of long beans. There was no combination interaction of giving liquid tofu waste and growing media that significantly affected the growth and yield of long beans.

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