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Research

Dynamics of Yield and Chlorophyll Content of Four Kangkung (*Ipomea reptans* Poir) Sequences With Soilless Cultivation System Due to Direct and Residual Effects of Vermicompost Application

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ABSTRACT

The applications of organic fertilizers releasing nutrients slowly not only have a direct impact on the growing crop, but also, residual effects on the subsequent crops in the conventional crop cultivation systems. Studies on the residual effects of organic fertilizer in soilless crop cultivation are quite rare. The present study, which is a pot experiment conducted in a greenhouse, describes the dynamics of yield and chlorophyll content of kangkong as direct and residual effects of vermicompost for four consecutive plantings in soilless crop cultivation, further, compared with inorganic fertilizer treatment. The experimental design used was a randomized complete block design with different levels of vermicompost rates and a control treatment using inorganic fertilizer. The vermicompost was applied only in the first crop, while, inorganic fertilizer was supplemented in each crop. Fresh weight per plant per pot increases ~35 - 54% at the second planting compared with the first planting, thereafter, gradually decreases in subsequent planting. The content of chlorophyll A was found to be relatively constant, while the chlorophyll B content was highest in the first planting and, thereafter, subsequently decreased in further planting. The higher yields were found at 400 - 500 g pot^{-1} vermicompost fertilizer dose, insignificantly different from the inorganic fertilizers treatment.

Key words: Chlorophyll content, residual effect, soilless culture, vermicompost, yield

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INTRODUCTION

Research and development are going on to resolve problems faced by mankind such as in solar cells (Khadtare *et al*., 2014; Khadtare *et al*., 2019), catalysis (Sartale *et al*., 2013; Ansari *et al*., 2015a; 2015b; Ansari *et al*., 2016a), semiconductor (Ansari *et al*., 2016b; Lee *et al*., 2020; Choi *et al*., 2021), ALD (Ansari *et al*., 2020) 2D materials (Raya *et al*., 2020; Raya *et al*., 2021), CO_2 reduction (Ansari *et al*., 2021), and fuel cell (Ahmed *et al*., 2021; Ahmed *et al*., 2022a; 2022b; 2022c Wu *et al*., 2022). Besides these auxiliary needs the basic need food of mankind needs to be addressed which is becoming a serious issue. The agriculture sector facing issues due to the use of chemical fertilizers in conventional crop cultivation. Chemical-dependent cultivation in conventional agriculture hurts the environment due to the use of large quantities of chemical fertilizers, synthetic pesticides, and herbicides. Further, agricultural land is decreasing due to the excessive use of chemical fertilizers and conversion of agricultural land into residential or commercial land, thereby influencing agricultural products. A modern way soilless cultivation system with organic fertilizers is believed to be a prominent way to overcome this issue.

Kangkong (*Ipomoea reptans* pair) is one of the most popular vegetables in the world, especially in the tropics. Cultivation of kangkong can be done either conventionally or in a modern way, one of which is a soilless cultivation system. Currently, the soilless cultivation system is growing rapidly due to a decline in the area of productive agricultural land

and problems in conventional agricultural cultivation such as decreased soil fertility, attacks of insects, plant diseases, soil acidity, and salinity (Gruda *et al.*, 2013). Soilless cultivation can increase plant production efficiency per metrics of land, water, and energy use, further, can further enhance the quality of the yields (Barbosa *et al.*, 2015; Putra & Yuliando, 2015).

There are many substrate materials (organic & inorganic), that can be used as growing media for soilless cultivation (Gruda *et al.*, 2013). Soilless culture systems generally use inorganic fertilizers as a source of nutrition due to their high solubility and easy absorption by plant roots. However, the inorganic fertilizers in soilless culture systems must be supplied regularly and continuously since they are released easily and also easily washable (Savvas & Gruda, 2018). This excess inorganic nutrient solution can cause environmental pollution, especially in the soil and water environment. Reducing the use of inorganic fertilizers can reduce production costs and environmental pollution. On the other hand, the use of organic substrates is recommended in soilless cultivation to avoid water and soil pollution and utilize locally available materials. The use of organic materials such as cocopeat and rice husk biochar is highly recommended to increase production efficiency (Gruda *et al.*, 2013; Gruda *et al.*, 2013). In addition to media substrate materials derived from organic matter, the use of organic fertilizers is also recommended in soilless cultivation systems. Many benefits are obtained by using organic fertilizers, including improvement of the physical condition of the growing media, consistent nutrient availability, help in the development of beneficial microbes, more environmentally friendly, and prevention of pests and plant diseases (Verma & Verma, 2012). However, the use of organic fertilizers in soilless cultivation systems is still less explored. One of the reasons is the lower nutrient content of organic fertilizers than inorganic fertilizers (Verma & Verma, 2012). To provide sufficient nutrients, a large amount of organic fertilizers are required compared to inorganic fertilizers. Nevertheless, the application of organic fertilizers has a long-term effect. The basic difference between organic and inorganic fertilizers is the form of nitrogen released. Organic fertilizers produce nitrogen compounds in the form of complex molecules such as proteins that need to be broken down into simpler nitrogen elements before being absorbed by plants. The process of changing organic compounds into ammonium than to nitrate is due to the activity of microorganisms, while inorganic fertilizers have easily N and Nitrate even in greater quantities than organic fertilizers (Altamimi *et al.*, 2013). Organic fertilizers are slow-release fertilizers compared to chemical fertilizers which release nutrients faster in the soil and run out quickly. Organic fertilizers such as compost need at least three years to release all the nutrients (Sinha *et al.*, 2017). Initially, the compost provides large amounts of potassium (K), with a slower release of nitrogen (N) and phosphorus (P). In general 20% N, 40% P, and 80% K in the compost are available in the first year of application. N and P are not all available to plant roots in the first year because N and P in organic matter are resistant to decay (Sinha *et al.*, 2017). The dynamics of the availability and uptake of N, P, and K nutrients as direct and residual effects of this vermicompost during the four planting periods of mustard were reported, and explored further by Nurhidayati *et al.* (2018). Little is known about the dynamics of kangkong yields during the four planting periods associated with chlorophyll content in response to the availability of nutrients, especially nitrogen. This study examined the direct and residual effects of vermicompost during four planting periods of kangkong on the yield and chlorophyll content.

MATERIALS AND METHODS

Experimental site and design

A pot experiment from May 2020 to October 2020 was conducted at the greenhouse of the Faculty of Agriculture, University of Islam Malang, East Java, Indonesia. The greenhouse is situated 520 m above sea level, and throughout the experiments, the average temperature in the greenhouse was 22 - 32.3 °C. The experimental design used was a simple randomized complete block design (RCBD) which consisted of six treatments, namely Control = using inorganic fertilizer (mixture of nutrients for hydroponics; A & B solutions), V1 - V5 used vermicompost fertilizers as follows: V1 = 100 g pot^{-1}, V2 = 200 g pot^{-1}, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1}, and V5 = 500 g pot^{-1}. Each treatment was repeated in three replications and each replication had 5 pots. The cylindrical pot diameter was 22 cm and height 25 cm. Each pot contained 12 plants.

Vermicompost and growing media preparation

Vermicompost synthesis was carried out at the composting laboratory of the Faculty of Agriculture, University of Islam Malang. A vermicomposting bin of size 80 cm × 120 cm × 30 cm was utilized for the synthesis of vermicompost. The materials used were spent mushroom waste, leaf litter, vegetable residue, cow dung, and *Lumbricus rubellus* earthworm. The vermicompost was done by mixing all the materials and putting them into the vermicomposting bin. At the bottom 30 kg of spent mushroom waste was kept and above that a layer was added with a mixture of leaf litter (10 kg), vegetable residue (20 kg), and cow dung (25 kg). The top layer was again spent mushroom waste (20 kg). After the composition was fulfilled, the *Lumbricus rubellus* earthworm was inoculated with a composition of 750 g per bin (Nurhidayati *et al.*, 2017). The vermicomposting process took four weeks, thereafter composting continued for two weeks.

The growing media used in this study consisted of three types, namely cocopeat, biochar, and sand (1:1:1 w/w). Before use as a growing media, cocopeat was first fermented using effective microorganisms for two weeks. The evenly mixed growing media materials were put into a plastic pot. Vermicompost was incorporated with the growing media one week before planting. The vermicompost was applied only once at the first planting, thereafter was no supply of vermicompost from the second tills fourth planting. Inorganic fertilizer treatment was given from the first to fourth planting with a concentration of 5 mL of solution A and 5 mL of solution B dissolved in 1 liter of water every day during plant growth.

Measurement of yield and chlorophyll content

Kangkong seeds were planted in plastic pots that have been irrigated to 50% humidity by watering until two days before harvest. After harvesting in the first cropping, the kangkong seeds were planted again in the same way on the growing media for the second, third, and fourth cropping to determine the effect of different fertilizers. The direct effect on the first crop and the residual effects in the rest crop were analyzed. Plant fresh weight and dry weight per plant and per pot in individual cropping were determined. The chlorophyll A, B, and total chlorophyll contents in plants were measured at individual cropping by the spectrophotometer method (Azimovic *et al*., 2016).

Statistical analysis

The systematic data was collected and tested by analysis of variance (ANOVA) or F-test with a significance level of 5% using Minitab Version 14.12. If the results of the ANOVA showed a significant effect, then the least significant difference (LSD) test was employed with a significance level of 5%.

RESULTS AND DISCUSSION

Figure 1 depicts the flow chart of the whole process. The plant's weights (fresh & dry) were measured after harvesting.

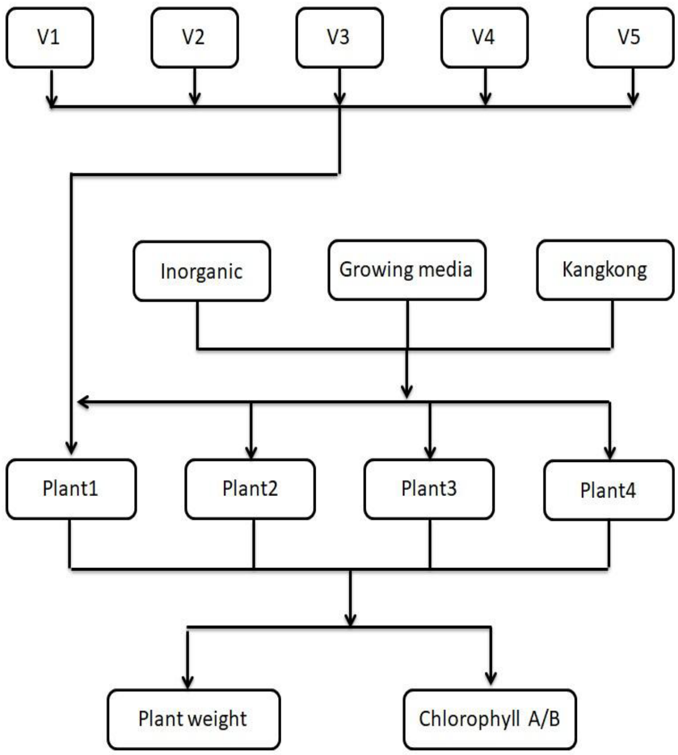


Fig. 1. Flow chart depicts the experimental process.

Yield of plant

The addition of vermicompost increased plant fresh weight per pot per plant, significantly different in response to different fertilizers and doses of vermicompost at all crops (first, second, third & fourth harvest) (P< 0.05) (Figures 1 & 2). Table 1 shows the highest plant weight in different planting along with the highest weight in inorganic treatment. The plant fresh weight per pot was found to increase with increasing doses of vermicompost to 500 g pot^{-1} in the first and the fourth harvests. In the case of second harvest, high yields were found at doses of 300 g pot^{-1} (172.42 g pot^{-1}) and 400 g pot^{-1} (178.27 g pot^{-1}), then decreased at a dose of 500 g pot^{-1} (148.62 g pot^{-1}). However, this result was not statistically significantly different from the inorganic treatment. A similar pattern was found in the third harvest with a lower yield than the second harvest (Figure 2).

Table 1. The highest plant weight in different planting along with the highest weight in inorganic treatments.

Planting (P)	Highest Plant Fresh Weight (g)		Highest Plant Dry Weight (g)	
	Per pot	Per Individual	Per pot	Per Individual
1st	120.25 (V5)	13.63 (V5)	8.59 (V4)	0.95 (V4)
2nd	178.27 (V4)	18.25 (V4)	13.90 (V4)	1.43 (V5)
3rd	131.60 (V4)	15.71 (V4)	10.22 (V4)	0.88 (V5)
4th	83.67 (V5)	8.96 (V5)	15.07 (V4)	1.51 (V4)
Inorganic	163.40 (3rd P)	17.56 (4th P)	11.87 (4th P)	1.34 (4th P)

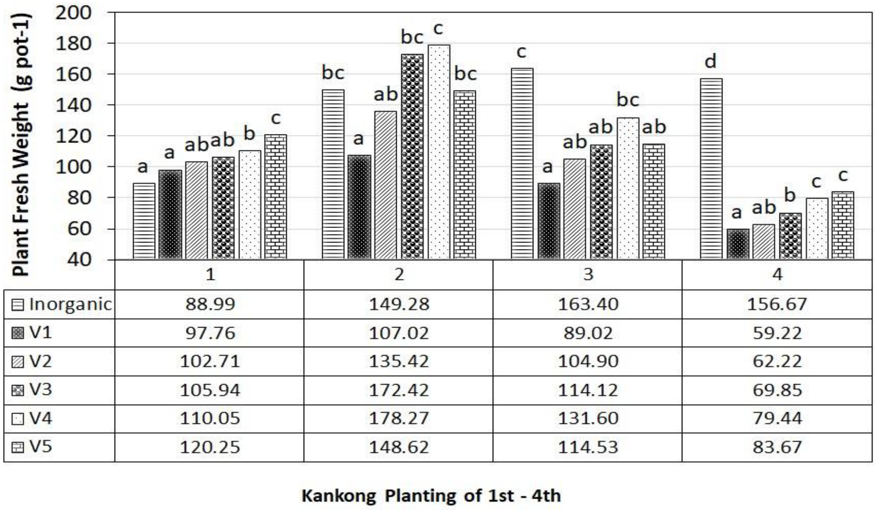
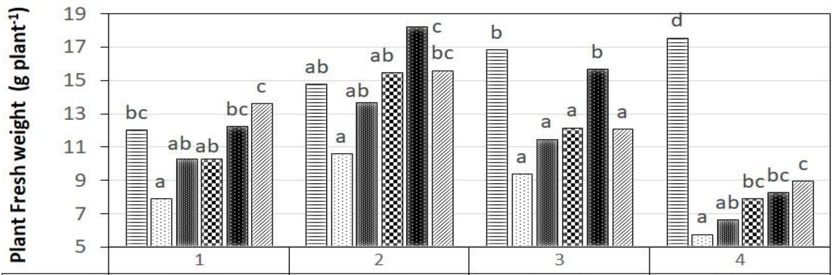


Fig. 2. Effect of vermicompost doses (V1 = 100 g pot^{-1}, V2 = 200 g pot$_{-1}$, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1} & V5 = 500 g pot^{-1}) on the plant fresh weight per pot at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (hydroponic solutions) (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).

Such yield dynamics were also found in the fresh weight of plants per individual (Figure 3). The highest fresh plant weight per individual was found to be 18.25 g pot^{-1} in the second harvest as the first residual effect of vermicompost applied at a dose of 400 g pot^{-1}. This is significantly greater than the inorganic treatment. However, it was not statistically significantly different from the vermicompost dose of 500 g pot^{-1} (Figure 3).

The average plant fresh weight per individual at the first, second, third, and fourth harvests for all doses of vermicompost were 10.88, 14.73, 12.16, and 7.51 g plant^{-1}, compared to the inorganic treatments 12.05, 14.77, 16.84, and 17.56 g plant^{-1}, respectively. The yield dynamics occurred in the fresh weight of plants per pot with a fresh weight of 148.34 g pot^{-1} in the second harvest as compared to the inorganic treatment (149.28 g pot^{-1}), while the lowest yield was found in the fourth harvest 70.88 g pot^{-1} compared with inorganic treatment 156.67 g pot^{-1}. This indicated that the yield obtained in the treatment using vermicompost in soilless cultivation was lower than the treatment using inorganic fertilizer, except in the second harvest. The effect of the application of an inorganic nutrient solution increased plant yields and significantly differed (P<0.05) with a dose of vermicompost 100 - 400 g pot^{-1} (Figure 2 – Figure 5). This is because this nutrient solution contains complete nutrients with a certain concentration and is ready to be absorbed by plants. This solution also contains nitrogen in the form of ammonium and nitrate compounds so the effect is very fast on plants (Olfati *et al*., 2012). The first residual effect of vermicompost gave higher yields than the direct effect, while the second and third residual effects, crop yields decreased.



	1	2	3	4
Inorganic	12.05	14.77	16.84	17.56
V1	7.93	10.61	9.38	5.77
V1	10.30	13.68	11.48	6.63
V3	10.28	15.48	12.17	7.91
V4	12.26	18.25	15.71	8.28
V5	13.63	15.61	12.07	8.96

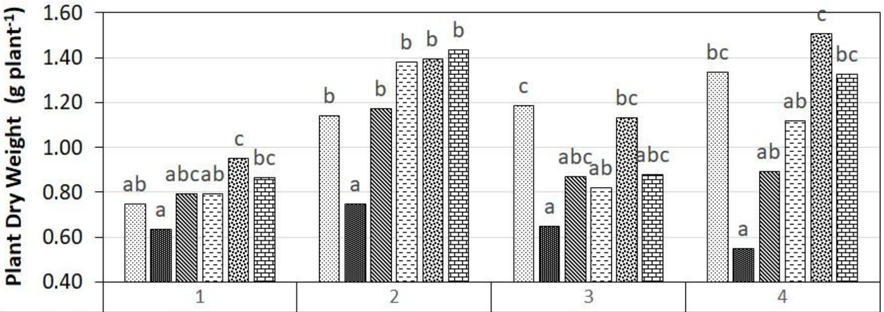
Kangkong Planting of 1st-4th

Fig. 3. Effect of vermicompost doses (V1 = 100 g pot^{-1}, V2 = 200 g pot^{-1}, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1} & V5 = 500 g pot^{-1}) on the plant fresh weight per individual at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (hydroponic solutions) (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).

Plant fresh weight per pot and plant were significantly in response to different fertilizers and doses of vermicompost at all crops; the first, second, third, and fourth harvest (P< 0.05) (Figures 2 & Figure 3). However, the treatments that produced the best fresh weight in each cropping were different. In the first planting, it was found that increasing the dose of vermicompost at 400 - 500 g pot^{-1} (V4 - V5) showed the highest fresh weight per pot and plant. However, in fresh weight per plant, these doses (V4 - V5) (12.26 - 13.63 g plant^{-1}) showed the results were not different from the application of inorganic fertilizer (12.05 g plant^{-1}). The use of inorganic fertilizers in every planting up to the fourth planting was found to continuously increase the fresh weight per pot (88.99 - 156.67 g pot^{-1}) (Figure 2) and per plant (12.05 -17.56 g pot^{-1}) (Figure 3). While using vermicompost of all doses (V1 - V5), even when applying only the first planting, there was still an increase in fresh weight in the second planting. In the third cycle, although, the fresh weight in all treatments of vermicompost doses (V1 - V5) that were applied only in the first planting showed the values declined, they were still close to the values of the first cycle in each treatment. For the fourth planting, all vermicompost treatments (V1 - V5), the fresh weight per pot and plant were significantly reduced compared to the result in the first planting. The addition, in the second and third planting, it was found that V4 had the highest fresh weight per pot (178.27 & 131.60 g pot^{-1}, respectively) but was not significantly different from inorganic fertilizer application (149.28 & 163.40 g pot^{-1}, respectively (Figure 2). The single application of vermicompost at 400 g pot^{-1} (V4) was also found higher fresh weight per plant than other vermicompost treatments in the second and third planting (Figure 3). These results showed that the yields in fresh weight obtained in the treatment using vermicompost in kangkong soilless cultivation were equivalent to the treatment using inorganic fertilizers until to third planting.

Similar to the effect on fresh weight, inorganic fertilizer application at every planting time resulted in higher dry weight (either per pot or per plant) from the first planting onwards (Figures 4 & 5). Compared among inorganic fertilizer applications at different plantings, it was found that dry weight yield (either per pot or per plant) was higher in the second planting cycle, but the value was relatively stable from the second to fourth planting (11.65 - 11.87 g per pot and 1.14 - 1.34 g per plant) (Figure 4 & 5). The influence of vermicompost treatments had different effects on dry weight and fresh weight either per pot or per plant in the fourth planting.

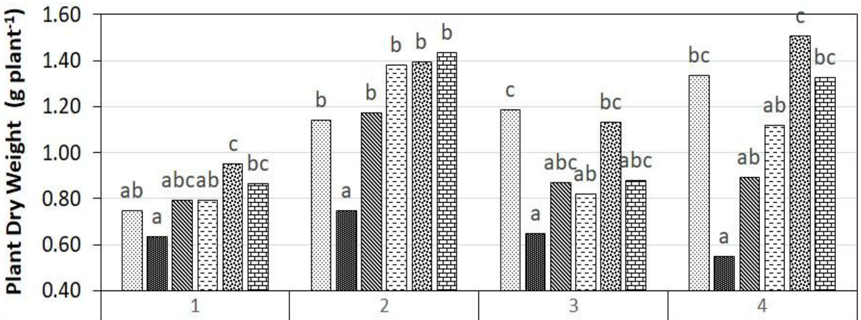
However, the influence of vermicompost application on dry weight (either per pot or per plant) (Figures 4 & 5) was different from fresh weight (Figures 2 & 3). There was an increase in dry weight (either per pot or per plant) in all vermicompost treatments since the second planting. Moreover, dry weight yields remained high until the fourth planting cycle in some treatments such as V4 (15.07 g per pot & 1.51 g per plant) and V5 (14.02 g per pot & 1.33 g per plant).



	1	2	3	4
Inorganic	0.75	1.14	1.19	1.34
V1	0.64	0.75	0.65	0.55
V2	0.80	1.17	0.87	0.89
V3	0.79	1.38	0.82	1.12
V4	0.95	1.40	1.13	1.51
V5	0.87	1.43	0.88	1.33

Kangkong Planting of 1st-4th

Fig. 4. Effect of vermicompost doses (V1 = 100 g pot^{-1}, V2 = 200 g pot^{-1}, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1} & V5 = 500 g pot^{-1}) on the plant dry weight per pot at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).



	1	2	3	4
Inorganic	0.75	1.14	1.19	1.34
V1	0.64	0.75	0.65	0.55
V2	0.80	1.17	0.87	0.89
V3	0.79	1.38	0.82	1.12
V4	0.95	1.40	1.13	1.51
V5	0.87	1.43	0.88	1.33

Kangkong Planting of 1st-4th

Fig. 5. Effect of vermicompost doses (V1 = 100 g pot^{-1}, V2 = 200 g pot^{-1}, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1} & V5 = 500 g pot^{-1}) on the plant dry weight per individual at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (hydroponic solutions) (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).

The high fresh weight and dry weight of the crops supplemented with inorganic fertilizers in each planting cycle resulted from two issues. The first is because this nutrient solution contains complete nutrients with a certain concentration and is ready to be absorbed by plants. This solution also contains nitrogen in the form of ammonium and nitrate compounds so the effect is very fast on plants (Olfati *et al*., 2012). The second, inorganic fertilizer was applied in every planting cycle, so the dry weight of this treatment was constant during all planting cycles, especially cycles second onwards. Increasing fresh weight and dry weight in all treatments were observed in the second planting. These reasons may be because of partially the adsorption ability of nutrients by growing media and released in the second cycle. The difference in yields obtained in each planting period was due to the availability of different nutrients in the growing media was found in vermicompost treatments as well. In the first planting, the vermicompost mineralization process was slow so plant nutrient needs were not optimally met. The availability of nitrogen from organic fertilizers in the first year was reported only 20% (Sinha *et al*., 2017). Kim *et al*. (2010) stated that the majority of organic fertilizers contain balanced amounts of raw nitrogen and thus work as slow-release fertilizers. They must be mineralized by the biological population to be absorbed by plants. However, the rate of nutrient release from organic fertilizers varies depending on the structure of organic compounds and the population of microorganisms in the growing media. Which, organic matter with a C/N ratio 15 has a balance in the mineralization and immobilization processes (Brust, 2019). In this study, vermicompost used has a C/N ratio of 15. Therefore, the release of nutrients from vermicompost is still controlled by the activity of microorganisms. Vermicompost acts as an energy source for microorganisms in the organic substrate media, thereby improving the physical properties of growing media and increasing plant growth. It also releases nitrogen, phosphate, and potash in a manner easily absorbed by plants. For this reason, a significant increase in yield (both fresh weight & dry weight) of the vermicompost treatments was observed in the second planting. Moreover, the residual effects of vermicompost application were still observed in the third and fourth planting cycles for dry weight yield; either per pot or per plant. Vermicomposts have outstanding chemical and biological properties with plant growth regulators and diverse microbial populations (Arancon *et al*., 2006; Lazcano & Domínguez, 2011), where the content is higher than conventional compost (Ravindran *et al*., 2016). In the case of soil application, vermicompost can stimulate soil microbial growth and activity and the subsequent mineralization of soil-plant nutrients. It increases soil fertility and quality and contains plant growth-promoting substances (e.g., vitamins, hormones, enzymes) that favor plant growth (Gutiérrez-Miceli *et al*., 2007; Ievinsh, 2011).

Different levels of vermicompost applied affected the yield of both fresh weight and dry weight since the first planting, with the highest values seen at 400 (V4) and 500 g pot^{-1} (V5) applications. The difference between the influence of different vermicompost supplementation was even greater in the second planting onwards. When using high-dose vermicompost at V4 and V5, the yield was still the highest although there was no significant difference from that using inorganic fertilizer.

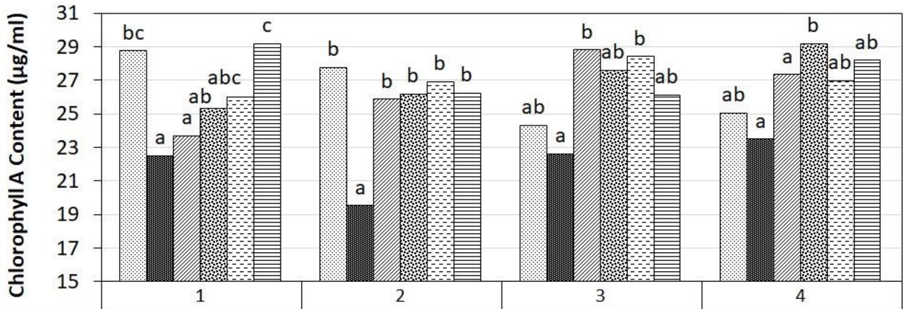
Generally, the production of plant dry matter is determined by numerous variable factors, one of which is soil fertility or growing media and applied fertilizers (Kim *et al*., 2010). For organic fertilizers, it was reported to increase soil fertility; as indicated by the availability of macronutrients N, P, and K, which was higher in the residual effect than the direct effect (Latare *et al*., 2014). Therefore, the benefit of vermicompost application cannot be assessed within the first planting, which is a direct effect of vermicompost. The results of this study are in line with those reported by Shaji *et al*. (2021) that the release of nutrients slowly and steadily, especially Nitrogen can meet the growth needs of the next plant. Nurhidayati *et al*. (2018) added the vermicompost on Pak-coi mustard plants showed that the highest yields occurred affected by residual effect in the next cropping (the second planting), but the yields obtained varied depending on the earthworm media material used.

Chlorophyll content

Inorganic fertilizer application resulted in a high content of chlorophyll A, B, and total chlorophyll throughout the four plants (Figure 6 - 8). Table 2 depicts the highest chlorophyll A and Chlorophyll B content in different planting. For chlorophyll A, vermicompost application can increase the content as high as using inorganic fertilizer (28.75 µg/mL) when applied in doses of 400 g pot-1 (V4) (25.29 µg/mL) and 500 g pot-1 (V5) (29.19 µg/mL) vermicompost in the first planting (Figure 6). However, in the second to fourth plantings, it was found that the content of chlorophyll A was increased equal to that of inorganic fertilizer, especially in V2, V3, V4, and V5 (Figure 6). Whereas the content of chlorophyll B of different treatments varied between planting cycles (Figure 7). The relatively stable chlorophyll B content was observed at vermicompost application in V2, V3, V4, and V5. Therefore, considering the total chlorophyll content, all three treatments including V2, V3, V4, and V5 showed a high content and were relatively stable compared to the rest of the treatments (Figure 8). It can be said that the content of chlorophyll B and total chlorophyll was highest in the first planting and decreased in the next planting respectively.

Table 2. The highest chlorophyll A and Chlorophyll B content in different planting

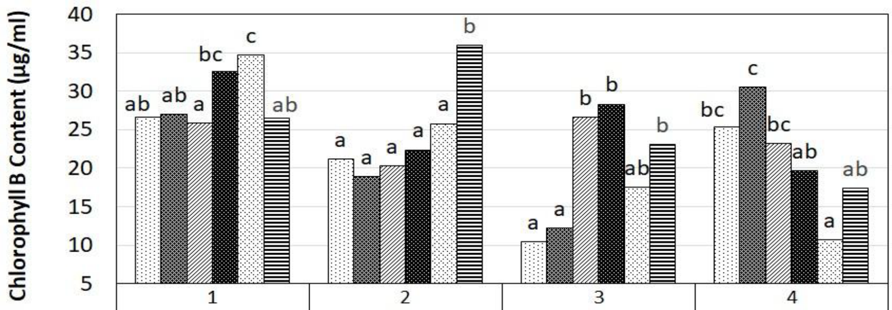
Planting (P)	Highest Chlorophyll content (µg/mL)	
	A	B
1st	55.99 (V4)	34.74 (V4)
2nd	26.90 (V4)	35.99 (V5)
3rd	28.81 (V2)	28.37 (V3)
4th	29.19 (V3)	30.63 (V1)
Inorganic	28.75 (1st P)	26.73 (1st P)



	1	2	3	4
Inorganic	28.75	27.76	24.30	25.03
V1	22.49	19.53	22.61	23.49
V2	23.70	25.87	28.81	27.33
V3	25.29	26.16	27.60	29.19
V4	25.99	26.90	28.41	26.95
V5	29.19	26.24	26.11	28.18

Kangkong Planting of 1st-4th

Fig. 6. Effect of vermicompost doses (V1 = 100 g pot^{-1}, V2 = 200 g pot^{-1}, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1} & V5 = 500 g pot^{-1}) on the chlorophyll A content at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (hydroponic solutions) (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).

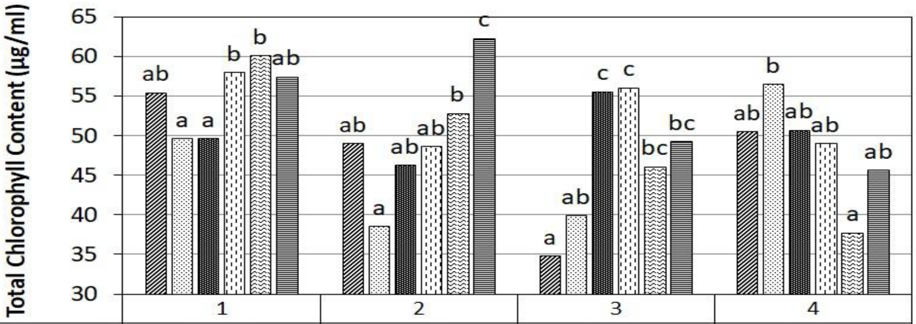


	1	2	3	4
Inorganic	26.73	21.19	10.45	25.43
V1	27.06	18.97	12.23	30.63
V2	25.90	20.37	26.70	23.30
V3	32.65	22.43	28.37	19.73
V4	34.74	25.84	17.61	10.70
V5	26.53	35.99	23.09	17.43

Kangkong Planting of 1st-4th

Fig. 7. Effect of vermicompost doses (V1 = 100 g pot-1, V2 = 200 g pot-1, V3 = 300 g pot-1, V4 = 400 g pot-1 & V5 = 500 g pot-1) on the chlorophyll B content at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (hydroponic solutions) (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).

Chlorophyll molecules are magnesium-tetrapyrrole pigments that give plants green color and are the primary pigments used in plant photosynthesis as the basic unit of plant energy (Kiang *et al*., 2007). A deficiency of nitrogen leads to a loss of green color in the leaves, a decrease in leaf area, and intensity of photosynthesis (Gastal & Lemaire, 2002). Vermicompost contains fairly high nitrogen. Therefore, the higher the dose of vermicompost, the greener the leaf color of the plant was observed. Maybe, available nitrogen is released at the first planting (direct effect of vermicompost) and the chlorophyll in plants responds positively to increasing the dose of vermicompost. Chlorophyll molecules facilitate the conversion of absorbed solar radiation into stored chemical energy, by harvesting light energy, transferring excitation energy to reaction centers, and driving charge separation in the reaction centers (Chen *et al*., 2014).



	1	2	3	4
Inorganic	55.48	49.0	34.75	50.46
V1	49.54	38.5	39.83	56.45
V2	49.60	46.2	55.51	50.62
V3	57.95	48.6	55.97	48.92
V4	60.06	52.7	46.02	37.65
V5	57.39	62.2	49.20	45.61

Kangkong Planting (1st-4th)

Fig. 8. Effect of vermicompost doses (V1 = 100 g pot^{-1}, V2 = 200 g pot^{-1}, V3 = 300 g pot^{-1}, V4 = 400 g pot^{-1} & V5 = 500 g pot^{-1}) on the total chlorophyll content at four planting of Kangkong (*Ipomea reptans* Poir) sequences compared with inorganic fertilizer treatment (hydroponic solutions) (Remarks: The column chart followed by the same letter in each planting period showed no significant difference at LSD 5%).

This difference in the level of chlorophyll production shows that it is not only the more than availability of nitrogen, light quality, mineral nutrition, and chemical metabolites produced in the plant system were reported influenced to chlorophyll production as well (Khaleghi *et al*., 2012).

Chlorophyll greatly determines photosynthetic capacity and thereby plant growth. Only plant chlorophyll content cannot be directly related to plant productivity. As a result, in the first cultivation (direct effect of vermicompost) the chlorophyll content seems higher than in the second planting (the first residual effect of vermicompost) but the biomass and dry matter produced were lower. Therefore, chlorophyll content may be used as an indirect indicator of Nitrogen levels in fertilizer management (Bojovic & Markovic, 2009). For this reason, plant yields are not only determined by chlorophyll content but also by biotic factors that are beyond human control (climate, soil), as well as abiotic factors, i.e. agrotechnical treatments and crop and soil management (Kołodziejczyk *et al*., 2012; Mystkowska, 2019). These factors can affect various plant physiological processes that determine the accumulation of biomass in plants including distribution in plants and crops involving many aspects of growth and development.

CONCLUSION

The application of vermicompost at a dose of 100 to 500 g pot^{-1} in the soilless culture of kangkong gave an increase in fresh weight yield per pot and per individual plant both on the direct effect (the first planting) and the residual effect (the second, third & fourth planting). However, the use of vermicompost doses at 400 and 500 g pot^{-1}, in addition to increasing yields from the first planting, was found to be able to produce higher yields in dry weight than using inorganic fertilizer in the second to fourth planting. There was an increase in the yield of fresh-weight plants per individual and per pot from the first planting to the second planting using vermicompost doses by approximately 35 - 54%., in the second planting, the highest average plant yield in treatments using vermicompost was not significantly different from the treatment using inorganic fertilizers (control). In the third planting, the average yield was slightly lower than the second planting, but still higher than the first planting. In the fourth planting, there was a decrease in yield. The content of chlorophyll A during the four plantings was relatively constant, while the content of chlorophyll B and total chlorophyll was highest in the first planting and subsequently decreased until the fourth planting.

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ETHICAL STATEMENT

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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