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Optimization of vermicompost utilization of soil worms (*Lumbricus rubellus*) on the morphology green spinach (*Amaranthus sp.*)

Nanda Agnes Santika¹, Vivi Indriani*²

¹ Department of Animal Science, Faculty of Animal Science, Bogor Agriculture University, Bogor, Indonesia

² Department of Animal Science, Faculty of Agriculture, Universitas Sumatera Utara, Medan, Indonesia

*Corresponding Author: viviindriani@usu.ac.id

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ABSTRACT

Vermicompost is a fertilizer produced by composting organic waste with the help of earthworms that can fertilize the soil. Vermicompost has the measure of being beneficial for plant growth. This study aims to determine the effectiveness of vermicompost levels of worms (*Lumbricus rubellus*) against green spinach plants. The experimental design used was a completely randomized design (CRD) with a factorial pattern (4x3). Factor A is the level of vermicompost (0%, 5%, 10%, and 15%) based on the media and factor B is inorganic fertilizer (0%, 50%, 100%) based on the recommendation each with 5 repetitions. The quality of vermicompost products from the earthworm *L. rubellus* derived from cow dung has met the quality standards of solid organic fertilizers. The optimum level for the growth of green spinach (*Amaranthus sp.*) is a combination of 10% vermicompost and 50% inorganic fertilizer levels. The addition of vermicompost fertilizer to plant media was able to increase plant vegetative growth which included plant height, number of leaves, leaf area, stem diameter of green spinach (*Amaranthus sp.*).

Keyword: *Amaranthus sp.*, *Lumbricus rubellus*, vermicompost



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1. Introduction

Livestock waste, if not utilized, will have an impact on the environment in the form of water, air, and soil pollution which will be a source of disease. Livestock waste can also spur an increase in methane gas (Nenobesia *et al.* 2017). Waste treatment can be carried out in various ways, depending on environmental conditions and treatment objectives. One of the ways of processing livestock waste is waste treatment through the *vermicomposting* process (Badruzzaman *et al.* 2016). Vermicompost is a fertilizer from composting organic waste with the help of earthworms (animals that have the potential in decomposition of organic matter) that are able to fertilize the soil (Astari *et al.* 2016). Vermicompost has the advantage, namely the presence of microbes carried from the digestive organs of worms that are beneficial for plant growth.

Earthworms (*L. rubellus*) play a role in transforming organic matter, both fresh and semi-fresh or weathering, so that it becomes another form of compound that is beneficial for soil fertility (Dahlan *et al.* 2008). Vermicompost fertilizer can be used as an organic fertilizer that contains a lot of macro elements and complete microelements, so that the nutrients needed by plants can be absorbed properly and sufficiently (Mashur 2001). Vermicompost is an organic fertilizer that is in the safe category for soil and plants, this is because worms can improve the union of organic matter under the soil surface, improve water infiltration, increase the amount of water stored in soil aggregates, increase the activity of microorganisms and aeration and root penetration. The

enzyme content in vermicompost amylase, lipase, cellulase and chitinase plays a role in breaking down organic matter in the soil which plays a role in releasing nutrients and making it available to plant roots and can increase the levels of other important enzymes such as alkaline acid phosphatase, enzyme dehydrogenase, and urease. Vermicompost is also very suitable for plant growth because it contains auxins and is very good for maintaining and increasing soil fertility (Fatahillah 2017). Spinach is a type of plant with high responsibility for the level of land fertility. Spinach is a vegetable commodity that has commercial value and is favoured by the Indonesian people. Vermicompost fertilizer contains auxins that are useful for stimulating root growth (Hardiane *et al* 2017).

Vermicompost fertilizer is an alternative source of nutrients to increase the growth of spinach plants because it contains N elements and other elements that are completely needed by plants. Spinach is used on the leaves and stems, so the need for nitrogen for plants is quite high. Plants do not only rely on nutrients from the soil, therefore, plants need to be given additional nutrients from outside, namely fertilizer. Vermicompost fertilizer can increase crop production (Annisa *et al.* 2018). The application of manure for spinach plants is 10 tons. ha⁻¹ (Balitsa 2007). The dose of fertilizer used for spinach plants is 0.25 tons. ha⁻¹ urea, 0.1 tons. ha⁻¹ SP-36 and 0.15 tons. ha⁻¹ KCl. There has not been much research on the optimal level of vermicompost fertilizer utilization in spinach plants, therefore researchers conducted research on the optimization of the use of vermicompost fertilizer from *L. rubellus* earthworms in green spinach plants (*Amaranthus* sp). The importance of creativity and new innovations in finding alternative fertilizers and finding solutions in improving the health of soil ecosystems, research on the use of vermicompost fertilizers needs to be carried out to reduce the use of inorganic fertilizers (Kogoya *et al.* 2018). This study aims to measure the optimal level of vermicompost utilization from earthworms (*L. rubellus*) in green spinach plants (*Amaranthus* sp).

2. Method

2.1. Time and Place

Field testing was carried out at the Greenhouse of the Agrostology Field Laboratory, Department of Nutrition Science and Feed Technology, Faculty of Animal Husbandry IPB. The tools used are rulers, cameras, stationery, hoes, scissors, callipers, pH meters, RHS colour charts, polybags, cups, zealots. The main ingredients used in this study are vermicompost fertilizer from earthworm *L. rubellus* and inorganic fertilizer (NPK) 16: 16: 16. The materials used in the field testing are latosol soil, labels, green spinach seeds, water.

2.2. Working Procedure

2.2.1. Sample Preparation

The vermicompost sample used came from vermicompost obtained from the feces of *L. rubellus* earthworms. Vermicompost products come from Sabisa Farm stores and inorganic fertilizers (NPK) 16:16:16 as well as green spinach seeds purchased at farm stores

2.2.2. Vermicompost Quality Analysis

The N test uses the Kjeldahl method. pH measurement using a pH-meter. The P and K tests used the wet spraying method using HNO₃ and HClO₄. The moisture content test using the Gravimetric method. The C-Organic analysis test was carried out using the Gravimetric method.

2.2.3. Preparation of Planting Media

The preparation of planting media begins with the provision of polybags. The latosol soil is dried for 2 days and then sifted using a sieve to homogeneous. Next, mixing between soil and vermicompost. The soil used is Dramaga latosol soil which was taken around the Agrostology Field Laboratory, Department of Nutrition Science and Feed Technology, Faculty of Animal Husbandry, Bogor Agricultural University. Vermicompost fertilizer is put into each polybag according to the treatment.

2.2.4. Planting and Maintenance

The seeds used are green spinach seeds. Spinach planting is carried out after the soil of latosol is ready to be used as a planting medium. Spinach seeding is carried out by sowing five spinach seeds per polybag. Next, the 3 best plants were selected at the age of 1 Week After Planting (MST). The plants used as test plants are maintained by watering the plants every morning at around 07.00 WIB and in the afternoon at around 16.30 WIB. Weed weeding is carried out daily by uprooting weeds that grow around spinach plants and killing any pests that perch (Toruan *et al.* 2015).

2.2.5. Harvesting

Pulled spinach can be harvested when the age of the plant is between 4 MST (weeks after planting). The way to harvest is to uproot the plant.

2.3. Observed Variables

2.3.1. Plant height

Plant height was measured from the surface of the planting medium or the base of the plant to the highest growing point using a ruler measuring instrument, observations were made at the age of 1, 2, 3, and 4 MST.

2.3.2. Leaf area

The leaf area is calculated by the formula: $LD = P \times L \times k$, while LD = leaf area; P = leaf length; L = leaf width; and k = constant. The constant of spinach leaves is 0.602 (Susilo 2015). Leaf area measurement is carried out once, namely when the plant is 4 MST old or at harvest.

2.3.3. Number of leaves

The leaves that are counted are all plant leaves that have been completely open and are still green, observations were made at the ages of 1, 2, 3, and 4 MST.

2.3.4. Stem Diameter

Measuring the diameter of spinach stalks using a caliper device, observations were made at the age of 1, 2, 3, and 4 MST.

2.3.5. Leaf color

Leaf color is measured using the RHS colour chart tool and measured on each leaf that has been fully exposed. Measurements are taken after the plants are ready to harvest.

2.4. Data Analysis

The design used in this study was a Complete Random Design (RAL) factorial pattern (4x3) with 5 repetitions so that there were 12 experiments. Factor A is the level of vermicompost (0%, 5%, 10% and 15%). Factor B is the dose level of inorganic fertilizer (0%, 50%, and 100%). The data was analyzed with the ANOVA variety test to affect the effect of the treatment and if the treatment had a real effect, it was followed by the Tukey test to distinguish between treatments.

3. Result and Discussion

3.1. Quality Overview of Vermicompost Fertilizer

Vermicompost is compost obtained from the overhaul of organic matter carried out by earthworms. Vermicompost is a mixture of earthworm manure with the rest of the media or feed in earthworm cultivation, therefore vermicompost is an organic fertilizer that is environmentally friendly and has its own advantages (Suparno *et al.* 2013). The quality of vermicompost is affected by C-organic, total N, C/N ratio, P and K, pH, and moisture content. The results of the vermicompost quality analysis of *the earthworm L. rubellus* Sabisa Farm are presented in Table 1

Table 1. Results of vermicompost quality analysis from earthworm *L. Rubellus*

Parameter	Value	Criterion	Quality standards*
pH	8,49**	Good	4-9
Mosturizer (%)	30,36**	Less good	8-20
C-Organik (%)	30,63	Good	Min 15
Nitrogen (%)	1,30	Good	
Phosphorus (%)	2,74	Good	Min 2
Potassium (%)	0,61	Good	
C/N Ratio(%)	23,56	Good	≤ 25

Source: Results of Soil Chemistry and Plant Nutrition Laboratory Test at Padjajaran University

Description: * KEPMENTAN Number 261 of 2019 concerning Minimum Technical Requirements for Organic Fertilizers, Biofertilizers, and Soil Enhancers

** Measurements are carried out manually by researchers

Vermicompost products come from Sabisa Farm Bogor which has been commercialized. Vermicompost products come from cow manure with residual media or feed that goes through *the vermicomposting* process

with the help of earthworms *L. rubellus*. The *vermicomposting* process is said to run well if it produces vermicompost quality that is in accordance with the standards set in the SNI on solid organic fertilizer (POP) standards which include C, N, P, K content (Badruzzaman *et al.* 2016). A high C/N ratio indicates that the amount of nutrients available to plants is small while the moderate C/N ratio indicates the availability of sufficient nutrients for plants (Surtinah 2013). It is known that the C/N ratio of vermicompost from earthworms *L. rubellus* is 23.56% which is still classified as a good criterion, this indicates that the vermicompost is mature so that it can be applied directly to the soil.

The pH of mature vermicompost is usually close to neutral. Vermicompost from earthworm *L. rubellus* is known to have a pH of 8.49. This indicates that vermicompost can be applied to the soil because the pH is relatively close to neutral. The results of vermicompost pH measurement are relevant to the Regulation of the Minister of Agriculture No.1 of 2019 which states that organic compost can be used if it meets the pH standard between 4-9. The pH value is too high, it will cause ammonia gas, and oxygen consumption will be higher which has a negative impact on the environment. Then if the pH is too low, it will cause death in microorganisms that help the composting process. The moisture content of vermicompost from *L. rubellus* earthworms is 30.36%, the result does not meet the quality standards of solid fertilizers. The content of elements N, P, and K in vermicompost is relatively good, in vermicompost there are macro elements and other important elements in full. These elements are present in vermicompost, so they can be absorbed by plant roots to be carried to all parts of the plant which are eventually available to the plant and will be absorbed slowly.

3.2 Plant Height

Plant height is one of the parameters used to determine the response of plant growth to the application of vermicompost fertilizers and inorganic fertilizers (Malik 2014). The results of observation of the height of spinach plants are presented in Table 2.

Table 2 Height of green spinach plants with different levels of application of vermicompost fertilizer and inorganic fertilizer

Inorganic Fertilizer (%)	Level Vermicompost				Average
	0	5	10	15	
	cm				
<u>1 MST:</u>					
0	1,20±0,26 ^b	2,93±0,38 ^a	2,40±0,24 ^a	2,69±0,09 ^a	2,30±0,24
50	1,62±0,15 ^b	2,42±0,15 ^a	2,81±0,36 ^a	2,94±0,52 ^a	2,45±0,34
100	1,28±0,19 ^b	2,42±0,49 ^a	2,44±0,36 ^a	2,64±0,34 ^a	2,20±0,34
Average	1,36±0,20	2,59±0,34	2,55±0,30	2,76±0,31	
<u>2 MST:</u>					
0	2,17±0,47 ^c	7,83±1,21 ^{bcd}	9,53±1,83 ^a	7,60±0,71 ^{bc}	6,92±1,05
50	3,60±0,73 ^c	7,90±1,64 ^{abcd}	9,43±1,05 ^{ab}	8,30±1,12 ^{ab}	7,30±1,13
100	3,24±0,34 ^c	6,45±1,15 ^d	7,07±0,55 ^{cb}	7,90±0,66 ^{abcd}	6,16±0,64
Average	3,18±0,51	7,39±1,33	8,68±1,14	7,93±0,83	
<u>3 MST:</u>					
0	0,00±0,00 ^c	12,70±3,34 ^{bc}	15,37±3,07 ^{ab}	12,53±1,21 ^{bc}	10,15±1,90
50	4,80±2,91 ^d	13,80±2,59 ^{abc}	15,86±1,55 ^a	13,83±2,49 ^{abc}	12,07±2,38
100	6,23±1,05 ^d	11,30±1,40 ^c	11,09±1,20 ^c	12,63±1,80 ^{bc}	10,31±1,36
Average	3,67±1,32	12,60±2,44	14,11±1,94	13,00±1,83	
<u>4 MST:</u>					
0	0,00±0,00 ^c	19,60±4,73 ^{bc}	22,75±4,24 ^{ab}	18,90±2,46 ^{bc}	15,31±2,85
50	7,20±4,19 ^d	20,33±5,73 ^{abc}	24,82±1,81 ^a	21,77±3,27 ^{abc}	18,53±3,75
100	8,06±1,97 ^d	17,73±2,75 ^c	17,90±2,49 ^{bc}	19,41±1,90 ^{bc}	15,77±2,27
Average	5,08±2,05	19,22±4,40	21,84±2,83	20,02±2,54	

The numbers in the same column followed by the same letter did not differ significantly at the 5% test level (Tukey's multiple interval test).

The results of the variety-based analysis showed that the level of vermicompost fertilizer had a significant effect ($p < 0.05$) on plant height at each age of green spinach (*Amaranthus sp.*). Table 2 shows that the best treatment is shown at the level of 10% vermicompost at the plant age of 2 MST - 4 MST which is not significantly different from the level of 15% vermicompost, but is significantly lower than the level of 0% vermicompost. The increase in the ability to grow high plants is caused by the ability of vermicompost to increase aggregate stability and increase the total porosity of the soil [16]. The addition of 10% vermicompost

fertilizer to the soil is more balanced between the content of nutrients and aeration or aggregates in the soil. The addition of 10% vermicompost is noticeably different from the 5% level, but not significantly different from the 15% vermicompost level. An increase in vermicompost levels is not always followed by an increase in plant height. This is thought to be due to the nature of vermicompost, which increases the amount of water stored in soil aggregates. Excessive doses of vermicompost are suspected to be able to increase the moisture content in the media, saturation of the media that is considered excess of plant needs can negatively impact plant growth. Therefore, the excess water causes the elongation of the stem to decrease and the plant grows abnormally. Table 2 shows that inorganic fertilizers have a significant effect ($p < 0.05$) on plant height at each age of green spinach (*Amaranthus sp.*). The best plant height is indicated by the addition of a dose of 50% inorganic fertilizer. The dosage of 50% inorganic fertilizer is significantly better than the dosage of 0% and 100% inorganic fertilizer.

Based on the results of the analysis, there was an interaction between the level of vermicompost fertilizer and inorganic fertilizer on the height of green spinach (*Amaranthus sp.*) plants at each age of spinach plants. A combination treatment of 10% vermicompost and 50% inorganic fertilizer yielded the highest crop, while treatment without the addition of vermicompost fertilizer and organic fertilizer (control) yielded the shortest plant height. The availability of nutrients in the soil derived from vermicompost fertilizers and inorganic fertilizers at the age of 1 MST can be absorbed by plants, thus affecting the height of the spinach plant. In the observation of 2 MST to 4 MSTs, it was shown that the difference in the dosage applied in all treatments had a significant effect on the high growth of spinach plants. Inorganic fertilizers are able to increase the presence of nutrients and vermicompost fertilizers are more about improving soil structure or soil aggregate stability so that the medium becomes ideal for plants, there are mineral elements needed by plants even in limited or small amounts. These results show that the combined levels of 10% vermicompost and 50% inorganic fertilizer levels are the optimal levels to increase the tall growth of green spinach plants.

Treatment without the addition of vermicompost fertilizer and inorganic fertilizer causes the plant to die in the third week, this is because the basic medium is not ideal for nutrient adequacy, without the intake of vermicompost fertilizer and anorganic fertilizer makes the plant unable to grow properly. The influence of insufficient nutrients that most often occur in most plants causes plants to become dwarfed to death. Plants that are fed vermicompost grow more luxuriant and taller compared to plants that are not given vermicompost fertilizer [17]. Plant growth will be optimal if the required nutrients are available in quantities that suit the needs of the plant [18].

3.3 Leaf area

Leaf area is one of the variables to measure the vegetative growth of green spinach plants. The results of the calculation of the leaf area of the spinach plant are presented in the following table 3:

Table 3 Leaf area of green spinach plants with different levels of application of vermicompost fertilizer and inorganic fertilizer

Pupuk Anorganik (%)	Level Vermicompost				Average
	0	5	10	15	
	cm				
4 MST:					
0	0,00±0,00c	35,82±6,28a	44,95±7,15a	33,13±3,58a	28,47±4,25
50	11,30±6,81cb	40,04±7,14a	45,31±1,63a	35,93±7,98a	33,14±5,89
100	15,15±4,01b	36,39±10,08a	35,74±16,35a	36,29±6,20a	30,89±9,16
Average	8,81±3,60c	37,41±8,01ab	42,00±8,37a	35,11±5,92b	

*The numbers in the same column followed by the same letter did not differ significantly at the 5% test level (Tukey's multiple interval test).

Based on the analysis of various fingerprints, it was shown that the level of vermicompost application had a real effect ($p < 0.05$) on the area of green spinach leaves. Table 4 shows the lowest leaf area with 0% treatment. The highest leaf area yield is shown to be 10% vermicompost level treatment. The 0% level of vermicompost is significantly lower than the levels of 5%, 10% and 15% vermicompost. Spinach plants that are not given vermicompost have a small leaf area when compared to spinach plants that are given vermicompost fertilizer. This is because the basic medium is not ideal for nutrient adequacy, without the intake of vermicompost and anorganic fertilizers, plants are unable to grow properly. This is supported by Lakitan (2010) who states that

plants that do not receive nutrients according to their needs will grow dwarf and small leaves, on the other hand, plants that get nutrients that are in accordance with their needs will grow tall and leaves that are formed wide. Vermicompost contains nutrients such as N, P, K. According to Hasibuan (2006) who states that N is needed in large amounts at each stage of plant growth. Spinach plants that rely only on soil N cannot grow or die, because the N content in the soil is only small and is not able to meet the N needs of plants. The P element contained in vermicompost fertilizer will affect the leaf area, low P concentration can lead to a decrease in leaf area. P deficiency can suppress the rate of cell division and expansion of epidermal cells which can ultimately lead to a decrease in the number and area of leaves (Setiawati *et al.* 2018). Hariyono (2016) stated that plants with good leaf growth will have a high rate of photosynthesis so that they are able to produce carbohydrates which will later function to improve the growth process and yield of a plant.

Table 4 shows that the 10% vermicompost level is significantly different from the 15% vermicompost level, but not significantly different from the 5% vermicompost level. This is suspected to be due to the nature of vermicompost which is able to hold water, at the level of 15% of vermicompost planting media contains a high amount of water. Excess water in plants will affect all metabolic processes in plants that can interfere with growth so that it can reduce plant yields (Haerani 2018). The results of the fingerprint analysis showed that the administration of inorganic fertilizer dosage had no real effect ($p < 0.05$) on the growth of green spinach leaves. The highest leaf area was indicated by the addition of 50% dose of inorganic fertilizer, while the lowest yield was indicated by the addition of 0% dose of inorganic fertilizer.

The results of the fingerprint analysis showed that there was an interaction between the application of vermicompost levels and inorganic fertilizers to the leaf area of green spinach (*Amaranthus sp.*). The combination of 10% vermicompost and 50% inorganic fertilizer results in the highest leaf area. Meanwhile, the treatment of 0% vermicompost and 0% inorganic fertilizer produces the lowest leaf area. The direct effect of applying vermicompost fertilizer into the soil can increase nutrient absorption by plants while the addition of inorganic fertilizers will provide the availability of nutrients that will play a role in plant growth, especially needed to encourage the growth of organs such as leaves that are closely related to photosynthesis.

3.4 Number of leaves

The quality of spinach plants is influenced by the number of leaves, because this is related to the availability of nutrients in the soil that are easily absorbed and can be used by plants, especially leaves. Based on the results of the study, the number of leaves of the spinach plant is presented in the following table 4.

Table 4 Number of leaves of green spinach plants with different levels of application of vermicompost fertilizer and inorganic fertilizer

Inorganic Fertilizer (%)	Level Vermicompost				Average
	0	5	10	15	
	cm				
<u>1 MST:</u>					
0	2,00±0,00d	2,93±0,43bc	3,20±0,38ab	3,26±0,43ab	2.85±0,31a
50	2,00±0,00d	2,66±0,64bc	3,13±0,18ab	3,60±0,43a	2.85±0,31a
100	2,00±0,00d	2,40±0,36cd	2,93±0,72bc	2,93±0,43bc	2.56±0,37b
Average	2,00±0,00c	2,66±0,47b	3,08±0,42a	3,26±0,43a	
<u>2 MST:</u>					
0	3,00±0.60b	5,06±0,54a	5,26±0,43a	5,26±0,27a	4,65±0,46
50	3,40±0.49b	4,66±0,47a	5,26±0,59a	5,33±0,33a	4,66±0,47
100	3,66±0.47b	4,60±0,27a	4,73±0,27a	5,13±0,18a	4,53±0,29
Average	3,35±0,52c	4,7±0,42b	5,08±0,43ab	5,24±0,29a	
<u>3 MST:</u>					
0	0,00±0.00e	7,60±0,64b	8,40±0,86ab	7,93±1,21ab	5,98±0,67b
50	4,47±2.60d	7,93±0,27ab	8,60±0,59ab	8,93±0,64a	7,48±1,36a
100	6,00±0.00c	7,73±0,14ab	7,80±0,50ab	8,60±0,27ab	7,53±0,22a
Average	3,48±0,08c	7,75±0,35b	8,26±0,65ab	8,48±0,70a	
<u>4 MST:</u>					
0	0,00±0.00e	9,40±0,76abc	10,26±0,49ab	9,20±0,69abc	7,21±0,48b
50	6,53±3.70d	8,40±1,65bcd	10,60±0,95a	9,93±0,43ab	8,86±1,68a
100	7,60±0.89cd	9,86±0,80ab	9,46±0,76abc	9,86±0,86ab	9,20±0,82a
Average	4,71±1,53b	9,22±1,07a	10,11±0,73a	9,66±0,66a	

*The numbers in the same column followed by the same letter did not differ significantly at the 5% test level (Tukey's multiple interval test).

The results of the fingerprint analysis showed that the level of vermicompost fertilizer had a real effect ($p < 0.05$) on the average number of leaves at each age of spinach plants. The treatment level of 0% vermicompost was significantly lower with the levels of 5%, 10%, and 15%. The application of vermicompost fertilizer is able to increase the number of leaves of green spinach plants. It is suspected that vermicompost fertilizer contains nutrients needed in the formation of leaf vegetative organs, including macroelements nitrogen and potassium. Vegetative growth phase, plants need a lot of N especially for stem and leaf formation. Lingga & Marsono (2008) stated that elements N and K function to stimulate leaf growth and play a role in strengthening leaves so that they do not fall off. One of the important factors that causes the increase in the number of leaves in spinach plants is the sufficiency of nutrient supply to the plant.

The 10% vermicompost level is not significantly different from the 15% vermicompost level at each plant age, but it is significantly lower with the 5% vermicompost level and 0% at 1-3 MST. The increase in vermicompost levels was not followed by an increase in the average number of spinach leaves. This is not in line with Palupy (2014) who explained that the addition of a dose of vermicompost is able to increase the number of plant leaves. The use of inorganic fertilizers had a significant effect on the number of leaves at 1,3,4 MST presented in table 4. The dosage of 50% and 100% inorganic fertilizer is significantly different from the dosage of 0% vermicompost.

Table 5 shows that there is an interaction between the application of vermicompost fertilizer and inorganic fertilizer at 2-4 MST. The combination of 10% vermicompost with 50% inorganic fertilizer results in the highest leaf count. Plants without treatment produce the lowest average number of leaves. The increase in the number of leaves is thought to occur because vermicompost fertilizer contains a considerable amount of nutrients and is readily available to plants, whereas inorganic fertilizers will release complete nutrients (both macro and micro) in indeterminate and relatively small amounts during the mineralization process. The addition of a balanced combination of vermicompost fertilizers is able to support inorganic fertilizers in providing nutrients for plants. So that with enough nutrients to be absorbed by plants, plants can grow more optimally (Simamora *et al.*, 2019). These results show that a combination of 10% vermicompost and 50% inorganic fertilizer levels is the optimal treatment that can increase the number of leaves of spinach plants.

3.5 Stem Diameter

The results of the fingerprint analysis showed that vermicompost fertilizer had a real effect ($p < 0.05$) on the diameter of spinach plants at each age of spinach plants. This shows that vermicompost fertilizer is effective in increasing plant diameter at each plant age. Table 5 shows the addition of 5%, 10%, 15% of different vermicompost fertilizers is significantly higher with the 0% treatment. This is suspected because the application of vermicompost can affect the physical properties of the soil, soil chemistry and soil biology, so that the growing requirements of the plant are met. This is supported by Atiyeh (2000) who stated that vermicompost applied to the soil of plant growth media in greenhouses can increase plant growth and yield. Applying vermicompost at this level can be sufficient to grow the diameter of spinach stalks. The increase in the diameter of the stem is affected by the content of nutrients contained in the vermicompost.

Table 6 of the 10% vermicompost level shows the highest yield, but it is not significantly different from the 15% vermicompost level at each plant age. The addition of stem diameter was not followed by the addition of the level of vermicompost fertilizer. This is suspected because vermicompost fertilizer is able to supply the nutrient needs of plants in the growth process. This is not in accordance with the opinion according to Mahrita (2003) who stated that the higher the dose of vermicompost fertilizer given, the more N needs of plants are met and able to increase plant growth. The addition of 50% inorganic fertilizer looks significantly different ($p < 0.05$) with the addition of 0% and 100% inorganic fertilizer.

Based on the analysis of the variety, it was shown that there was an interaction between vermicompost fertilizer and inorganic fertilizer on the diameter of the stem at each plant age. The level of 10% vermicompost and 50% inorganic fertilizer yields the highest diameter and is not significantly different from 10% vermicompost and a combination of 15% vermicompost and 50% inorganic fertilizer. Plants with the lowest average diameter are with 0% vermicompost and 0% inorganic (control) treatment. Control plants are plants that grow in the best conditions where there is no addition of vermicompost fertilizers or inorganic fertilizers. A 10% vermicompost and 50% vermicompost treatment showed the best treatment that resulted in a better highest stem diameter than a treatment without the addition of fertilizer. This is suspected because the addition of vermicompost fertilizers and inorganic fertilizers to the soil is more balanced between the aeration content and nutrients or aggregates in the soil. According to Simamora *et al.* (2019) states that vermicompost fertilizer will release complete nutrients both macro and micro in indeterminate and relatively small amounts during the

mineralization process, while inorganic fertilizers contain a considerable amount of nutrients and are quickly available to plants. This shows that the treatment of 10% vermicompost and 50% inorganic fertilizer is the optimal treatment that can increase the diameter of the spinach plant stem.

Table 5. Stem diameter area of green spinach plants with different levels of application of vermicompost fertilizer and inorganic fertilizer

Inorganic Fertilizer (%)	Level Vermicompost				Average
	0	5	10	15	
	cm				
<u>1 MST:</u>					
0	0,10±0,00 ^e	0,13±0,02 ^{de}	0,24±0,01 ^{abc}	0,27±0,02 ^a	0,18±0,01 ^b
50	0,10±0,00 ^e	0,20±0,01 ^{bc}	0,30±0,03 ^a	0,26±0,02 ^{ab}	0,21±0,01 ^a
100	0,10±0,01 ^e	0,18±0,02 ^{cd}	0,28±0,01 ^a	0,24±0,05 ^{abc}	0,20±0,02 ^{ab}
Average	0,10±0,00 ^c	0,17±0,01 ^b	0,27±0,01 ^a	0,26±0,03 ^a	
<u>2 MST:</u>					
0	0,34±0,05 ^f	0,56±0,08 ^d	0,75±0,07 ^{bc}	0,84±0,05 ^{ab}	0,62±0,06 ^b
50	0,40±0,06 ^{ef}	0,59±0,06 ^d	0,96±0,10 ^a	0,80±0,08 ^{bc}	0,69±0,07 ^a
100	0,53±0,06 ^{df}	0,68±0,15 ^{cd}	0,88±0,09 ^{ab}	0,87±0,11 ^{ab}	0,74±0,10 ^a
Average	0,42±0,05 ^c	0,61±0,09 ^b	0,86±0,08 ^a	0,84±0,08 ^a	
<u>3 MST:</u>					
0	0,00±0,00 ^e	2,12±0,40 ^{bc}	2,66±0,53 ^{ab}	2,18±0,32 ^{bc}	1,74±0,31 ^b
50	0,55±0,43 ^{de}	2,50±0,74 ^{ab}	2,99±0,19 ^a	2,54±0,28 ^{ab}	2,14±0,41 ^a
100	0,69±0,19 ^d	1,88±0,49 ^c	2,17±0,35 ^{bc}	2,30±0,22 ^{bc}	1,76±0,31 ^b
Average	0,41±0,20 ^c	2,16±1,00 ^b	2,61±0,35 ^a	2,34±0,27 ^{ab}	
<u>4 MST:</u>					
0	0,00±0,00 ^f	3,91±0,99 ^{bc}	5,16±0,89 ^{ab}	4,30±0,42 ^{abc}	3,34±0,57 ^b
50	1,62±0,60 ^e	3,90±0,62 ^{bc}	5,54±0,33 ^a	4,72±0,38 ^{ab}	3,94±0,48 ^a
100	1,86±0,36 ^{de}	4,08±0,57 ^{bc}	3,05±1,87 ^{cd}	4,31±0,50 ^{abc}	3,32±1,10 ^b
Average	1,16±0,32 ^c	3,96±0,72 ^b	4,58±1,03 ^a	4,44±0,43 ^{ab}	

*The numbers in the same column followed by the same letter did not differ significantly at the 5% test level (Tukey's multiple interval test).

The diameter of spinach stems increases at the age of 2, 3, and 4 MST. It is suspected that the nutrient content in the vermicompost has been fully utilized by the spinach plant stems so that there is an increase in the increase in stem diameter. The increase in plant diameter is due to the translocation of assimilated products in the plant growth phase, mostly used for the process of forming and developing vegetative organs in plants such as stems (Fatahillah 2017).

3.6 Leaf color

Observations of leaf colour were carried out using the *Royal Horticulture Society (RHS) Colour Chart*. Leaf color observation was carried out by matching the color of each observation sample with the color code on the *RHS Colour Chart*. Observation of leaf color was carried out at the age of 4 MST plants. The results of the average leaf color due to the effect of the treatment of dosing vermicompost fertilizer and inorganic fertilizer are presented in Table 6.

Table 6. Leaf color of green spinach plant with different levels of application of vermicompost fertilizer and inorganic fertilizer

Pupuk Anorganik (%)	Level Vermicompost (%)			
	0	5	10	15
4 MST:				
0	-	144B 100%	144A 100%	144A 100%
50	144B 86%	144A 93%	144A 100%	144A 93%
100	144B 80%	144A 93%	144A 100%	144A 100%

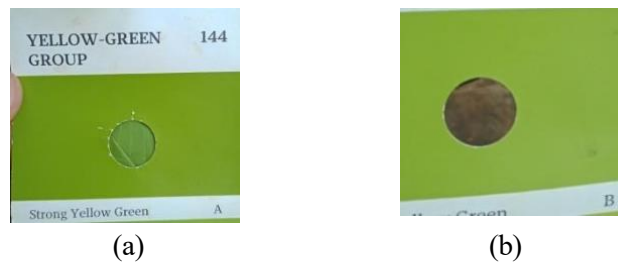


Figure 1. The leaf colour score on *the RHS Colour Chart* (a) is a strong yellow green colour A (b) is a strong yellow green B colour

The color of the leaves indicates the high and low chlorophyll content in the leaves, the greener the color of the leaves, the more chlorophyll. Vermicompost contains plant nutrients such as N, P, K which will be absorbed by plants which have a positive effect on the photosynthesis process, namely increasing the chlorophyll content of leaves. Enough N element can stimulate the vegetative growth of plants, namely the color of the leaves to green (Annisa *et al.* 2018). An adequate supply of nutrients will increase the formation of chlorophyll in plants. Chlorophyll is the basic part of the plant's energy system during the process of photosynthesis. Based on the results of the study, it was shown that treatment without the application of vermicompost fertilizer and the addition of 5% vermicompost had a lighter leaf color when compared to other treatments. The addition of vermicompost causes the leaves of the spinach plant to be greener. This is in line with Putra *et al.* (2020) which states that vermicompost applications are able to increase higher chlorophyll content when compared to control plants. The best green leaf color is with a color score of 144A (*Yellow Strong Green*) throughout the treatment.

4. Conclusion

The quality of vermicompost products derived from *L. Rubellus earthworms* derived from cow manure has met the quality standards of solid organic fertilizers. The optimal level for the growth of green spinach (*Amaranthus* sp) is a combination of 10% vermicompost and 50% inorganic fertilizer levels. The addition of vermicompost fertilizer to the plant medium is able to increase the vegetative growth of plants which includes plant height, number of leaves, leaf area, and stem diameter of green spinach plants (*Amaranthus* sp).

Declaration of generative AI use

The authors declare that no generative AI or AI-assisted technologies were used in the preparation of this manuscript.

References

- Annisa, D. N., Darmawati, A., & Sumarsono. (2018). Pertumbuhan dan produksi bayam merah (*Amaranthus tricolor* L.) dengan pemberian pupuk kandang dan giberelin. *J Agro Complex*, 2(2), 102-108.
- Astari, K., Yuniarti, A., Sofyan, E. T., & Setiawati, M. R. (2016). Pengaruh kombinasi pupuk n, p, k dan vermicompos terhadap kandungan c-organik, n total, c/n dan hasil kedelai (*Glycine max* L. Merrill) kultivar edamame pada inceptisols jatinangor. *J Agroekotek*, 8(2), 95-103.
- Badruzzaman, D. Z., Juanda, W., & Hidayati, Y. A. (2016). Kajian kualitas kascing pada vermicomposting dari campuran feses sapi perah dan jerami padi. *J Ilmu Ternak*, 16(2), 43-48.
- Balemi, T. (2009). Effect of phosphorus nutrition on growth of potato genotypes with contrasting phosphorus efficiency. *J African Crop Science*, 17(4), 199 – 212.
- [Balitsa] Balai Penelitian Tanaman Sayuran. (2007). *Budidaya Tanaman Sayuran*.
- Dahlan, M., Mulyati, & Dulur, N. W. D. (2008). Studi aplikasi pupuk organik dan anorganik terhadap perbuahan beberapa sifat tanah entisol. *Agroteksos*, 18, 1-3.
- Fahriani, Y., (2007). Pengaruh Pemberian Vermikompos Sampah Daun Terhadap Beberapa Sifat Fisik Tanah dan Pertumbuhan Tanaman Jagung (*Zea mays* L.) pada Alfisol Jatikerto. Thesis. Universitas Brawijaya. Malang.
- Fatahillah. (2017). Uji penambahan berbagai dosis vermicompos cacing (*Lumbricus rubellus*) terhadap pertumbuhan vegetatif cabai rawit (*Capsicum frutescens* L.). *J Biotek*, 5(2), 191-204.
- Hardiane, K., Maryani, Y., & Kusdiarti, L. (2019). Pengaruh intensitas cahaya dan dosis pupuk kascing terhadap pertumbuhan dan hasil tanaman bayam merah (*Amaranthus tricolor* L.). *J Ilmiah Agroust*, 1(2), 116-124.
- Kogoya, T., Dharma, I. P., & Sutejda, I. N. (2018). Pengaruh pemberian dosis pupuk urea terhadap pertumbuhan tanaman bayam cabut putih (*Amaranthus tricolor* L.). *J Agroekoteknologi Tropika*, 7(4),

557-584.

- Malik, N. (2014). Pertumbuhan tinggi tanaman sambiloto (*Andrographis paniculata*. Ness) hasil pemberian pupuk dan intensitas cahaya matahari yang berbeda. *Agroteknos*, 4(3), 189-193
- Mashur. (2001). Vernikompos, pupuk organik berkualitas dan ramah lingkungan. Instansi Penelitian dan Pengkajian Teknologi Pertanian (IPPTP) Mataram. Badan Penelitian dan Pengembangan Pertanian. Mataram. Media Yogyakarta.
- Nenobesia, D., Mellab, W., & Soetedjob, P. (2017). Pemanfaatan limbah padat kompos kotoran ternak dalam meningkatkan daya dukung lingkungan dan biomassa tanaman kacang hijau (*Vigna radiata* L.). *J Pangan*, 26(1), 43-55.
- Setiawati. T., Rahmawati, F., & Supriatun T. (2018). Pertumbuhan tanaman bayam cabut (*Amarantus tricolor* L.) dengan aplikasi pupuk organik kascing dan mulsa serasah daun bamboo. *J Ilmu Dasar*, 19(1), 37-44.
- Suparno, Prasetya, B., Talkah, A., & Sumarno. (2013). Aplikasi vermikompos pada budidaya organik tanaman ubi jalar (*Ipomoea batatas* L.). *Indonesian Green Technology*, 2(1), 37-44.
- Susilo, D. E. H. (2015). Identifikasi nilai konstanta bentuk daun untuk mengukur luas daun metode panjang kali lebar pada tanaman hortikultura di tanah gambut. *Anterior*, 14(2), 139-146.
- Surtinah. (2013). Pengujian kandungan unsur hara dalam kompos yang berasal dari serasah tanaman jagung manis (*Zea mays*). *J Ilmiah Pertanian*, 11(1), 16-26.
- Toruan, S. M. C. L., Mukarlina, & Lovadi, I. (2015). Pertumbuhan bayam kuning (*Amaranthus blitum*) dengan pemberian pupuk organik cair tumbuhan paku *Acrosticum aureum*, *Nephrolepis biserrata*, dan *Stenochlaena palustris*. *J Protobiont*, 4(1), 190-196.