Extract Vermicompost

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IMPROVING N FERTILIZER EFFICIENCY WITH THE ADDITION OF COMPOST EXTRACTS ON THE KAILAN (*Brassica oleracea* L.) PLANTS WITH WICK HYDROPONIC CULTIVATION

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ABSTRACT

The increase in kailan production was done with the application of both organic and inorganic fertilizers. The study aimed to determine the effects of applying types of compost extract and urea fertilizer on the growth of kailan plants in a wick system hydroponic. The research was arranged in a factorial randomized block design with the first factors were without compost extract; with cow manure compost extract, rice straw compost extract and vermicompost extract. The second factors were nitrogen fertilizer application 0, 100, and 200 kg ha^{-1}. The results showed that the application of compost extracts significantly affected the growth and production of the kailan plants. The application of vermicompost extract showed the highest growth 59.27 cm, number of leaves 23.00, total weight of the plants 93.92 g $plant^{-1}$, weight of canopy 61.37 g $plant^{-1}$, canopy dry weight 7.17 g $plant^{-1}$, fresh root weight 33.40 g $plant^{-1}$, leaf greenness 183.80 SPAD, and nutrient uptake 6.32 g $plant^{-1}$. The urea application resulted in significant effects on plant height, number of leaves, total fresh weight of plant, N uptake, and greenness of kailan leaves. The best treatment found at a dose of 200 kg ha^{-1} which resulted in the highest growth 42.18 cm, number of leaves 17.75, total weight of plant 60.42 g $plant^{-1}$, greenness of leaves 166.23 SPAD, and N uptake 3.73 g $plant^{-1}$. The interaction between compost extract and urea did not affect the growth and production of kailan plants. Vermicompost extract produced the highest absorption efficiency of N of 112.05 % at the addition of 100 kg urea ha^{-1}. The used of vermicompost extract in the vegetable cultivation with hydroponic wick system could satisfy the nutritional needs of plants.

Keywords: urea fertilizer, leaf greenness, vermicompost, nutrition

Introduction

Kailan is a leaf vegetable that has nutritional content such as protein, energy, carbohydrates. Kailan is rich in various vitamins, including vitamin A (Rambe *et al.*, 2018). The advantages of kailan makes this vegetable attractive to many consumers so that its productivity must compliant with the demand of the society.

So far, farmers only use land as a medium for farming vegetables including kailan, while in fact the farmers can apply the hydroponic system in cultivating vegetable crops. Hydroponic is a way of farming without soil and uses water as plant growth medium (Kazzaz and Kazzaz, 2017). The water and nutrient management in a hydroponic technology is focused on the optimal method of application which comply to the plant requirement, plant age, adequate light and environmental conditions to achieve maximum results (Wachjar and Anggayuhlin, 2013). The advantages of using a hydroponic system are more practical to maintain, less

labor requirement, more efficient use of fertilizers, grow plants more rapidly with guaranteed health to consume, continuous planting independent of the season, scheduling harvests to produce plants continuously, and higher selling price.

Manure is widely used as a basic fertilizer for plants because of its abundant availability and easy to manufacture. The nutrient contents in extracts of manure are very beneficial for plants to supply plant nutrients, increase tolerance and resistance to pests and diseases so as to increase plant growth and production (Asadu and Igboka, 2014).

The study of Ghorbani *et al.* (2008) stated that the application of compost extract manure affected the growth, production, resistance to pests and diseases, and longer shelf life of tomatoes. Compost extract manure was able to provide organic material as a nutrient source on tomato plants. The compost extract could be used as an environmentally friendly alternative fertilizer.

Rice straw is another material to make compost. Composted rice straw can be extracted. According to Yehia and Saleh (2012), the application of rice straw extract showed efficiency in controlling phytopathogenic fungi (*A. flavus, A. alternate, B. cinerea*) indicated that rice straw extract acted as a natural fungicide which was environmentally friendly. Another ther research also stated that the use of rice straw extract could increase calcium content in mustard plants (Wahyuni and Asngad, 2017).

Vermicompost is another material which can be extracted. Vermicompost extract had been proven to improve plant health, production, nutritional quality and protection of pests and pathogens such as aphids, caterpillars, and thrips by increasing the beneficial microbial community (Najafabadi, 2014). Vermicompost extract was also used as an ingredient to stimulate germination of flaxseed (levinsh *et al.*, 2017), and increased the chlorophyll content in legume plants (levinsh *et al.*, 2011). However, the researches on the benefits of compost extract on kailan plants planted hydroponically with the wick system were not many.

Urea contained nitrogen required by vegetables, especially broccoli. Nitrogen is important for plant growth and development, especially for photosynthesis because nitrogen increased the amount of chlorophyll. The adequacy of N made photosynthesis became effective as well as the formation of protoplasms, proteins, and nucleic acids (Yoldasa *et al.*, 2008). Nitrogen is a building material of proteins, nucleic acids, enzymes, nucleoproteins and alkaloids, and sufficient N is expected to result in better vegetative growth and fresh leaf color. On the other hand, N deficiency limits the division and enlargement and of cells (Napitupulu and Winarto, 2010).

Less optimal availability of nutrients in organic fertilizer in the form of compost or extracted is one obstacle faced in cultivating vegetables including kailan. The solution to this problem is by applying a combination of inorganic and organic fertilizers. The method can satisfy the needs of nutrients in plants and can reduce chemical residues in kailan plants which will be consumed. This study aimed to determine the effects of compost extracts cow manure, rice straw, vermicompost and urea fertilizer on the growth of kailan plants using wick system hydroponic.

Material and Methods

A. Research Location

This research was conducted in a greenhouse and in the Soil Science Laboratory of the College of Agriculture, University of Lampung. The study was conducted from January to October 2018.

B. Research Design

This research was arranged in a 4x3 factorial Randomized Block Design (RBD) with the first factors were without extract; with cow manure compost extract, rice straw compost extract and vermicompost extract. The second factors were nitrogen fertilizer application 0 (0), 100 (0.4), and 200 kg ha^{-1} (0.8 g $plant^{-1}$). Each treatment was repeated 3 times, each repetition of 6 plants. Each treatment combination amounted to 18 plants. Overall there were 216 plants in this study.

C. Compost

Cow manure compost was bought from a farm shop. Rice straw compost was made using chopped rice straw arranged on the ground and added with chicken manure with a ratio of 2: 1 (20 cm rice straw and 10 cm chicken manure). The mixture was covered with plastic sheet and was turned upside-down every week Water was added to complete the decomposition process for 3 months. Vermicompost was obtained from the GGFC (Great Giant Fruit Company), Central Lampung in a mature or ready to use condition. Worms used in making vermicompost were *Lumbricus rubellus*. The worms were fed with pulp and pineapple leftovers during the vermicompost process.

D. Compost Extract

The composts were extracted by putting each of them into a fabric bag and then placed in a container. One kg of compost was added with 20 ml molasses or 50 g sugar and 10 l of water (1 : 10 ratio) and then was aerated using an aerator for the aquarium. After 48 hours the compost extract was ready for use (Kovacik *et al.*, 2015).

E. Hydroponic Media

Planting boxes used hydroponic tubs with mats to place the netpot and rock wool. On the bottom of the netpot there was a wick made of flannel cloth to absorb compost extract (Kazzaz and Kazzaz, 2017).

F. Application of Compost Extract

Compost extract in form of liquid organic fertilizer was applied to each hydroponic tub. Each tub required 3 l of compost extract for 6 plants. Because this study used manual hydroponics without a nutrient/water stirrer, stirring was done to the extract every day. Stirring made the nutrients in compost extract could be absorbed by the plant perfectly and the compost extract did not settle.

G. Urea Application

Urea was applied by dissolving it with 150 ml of water and mixing it with compost extract in the hydroponic tub. Urea was given as the recommended dosage at the age of 1 week after planting (WAP).

H. Observation Variables and Absorption of N

Observation variables included measuring the plant height (1, 2, 3, 4 WAP), number of leaves (1, 2, 3, 4 WAP), plant fresh weight (40 WAP), canopy fresh weight (40 WAP), plant dry weight (40 WAP), root weight (40 WAP), and leaf greenness (SPAD). Nitrogen uptake was calculated following the formula: N uptake =% N X Plant Dry Weights (g) (Turner and Hummel, 1992), and N uptake efficiency was calculated using the formula (Habbib *et al*., 2016).

$$ESN = \frac{SP-SK}{HP} \text{ x } 100\ \%$$

Note: SP: N uptake of fertilized plants (kg N ha^{-1})
SK: N uptake on plants that are not fertilized (kg N ha^{-1})
HP: N fertilizer given (kg N ha^{-1})

I. Data Analysis

The data obtained were tested for homogeneity of variances using the Bartlett test and the addition of the model was tested with the Tukey test. If the assumptions were met then a variety analysis was performed. Separation of the mean value was tested with the Least Significant Difference (LSD) test at the 5 % level.

Results and Discussion

The results of compost extract analysis (cow manure, rice straw, vermicompost) can be seen in Table 1.

Table 1. The analysis of extract compost (cow manure, rice straw, vermicompost)

No.	Analysis	Cow Manure Extract	Rice Straw Extract	Vermicompost Extract
1.	Total N (mg kg^{-1})	28.04	21.13	35.01
2.	Dissolved P (mg kg^{-1})	25.83	26.51	23.35
3.	Dissolved K (mg kg^{-1})	161.11	319.69	179.01
4.	Organic-C (%)	0.01	0.02	0.01
5.	Ca (mg kg^{-1})	73.42	66.54	15.91

Source: Soil Sciences Laboratory, Department of Agrotechnology University of Lampung (2018).

Based on the laboratory analysis, the N content in vermicompost extract was higher compared to other extracts. The P and Organic-C content of the three compost extracts were relatively the same (Table 1).

Kailan Growth and Yield

Based on the visual observation at the greenhouse, the growth and development of kailan plants were good and healthy. Seedling growth was evenly distributed, but in their subsequent developments there were differences in plant growth between plants which received compost extract and urea as compared to control. The analyses of variances showed that compost extracts had highly significant effects on plant height (Table 2), number of leaves (Table 3), total plant fresh weight, canopy fresh weight, canopy dry weight, and root fresh weight (Table 4) of the kailan plants. Nitrogen application gave highly significant effects on the plant height and significant effects on the number of leaves, as well as the total fresh weight of plants. The canopy

fresh weight, canopy dry weight, and root fresh weight had no effects on N application. There was no interaction on all observed variables in the combination of compost extract and N application.

Vegetative yields

Kailan plants grew the highest in the treatment of vermicompost extract at each observation week (Table 2). Vermicompost extract contained nutrients which could stimulate the growth of kailan plants in dissolved form to be quickly absorbed by plant roots to be carried to all parts of the plant. According to Kovacik *et al.* (2015) the application of vermicompost extract gave a good vegetative growth in plant height, thick stem, and according to Pant *et al.* (2009) the number of leaves increased significantly with vermicompost extract. Furthermore, vermicompost extract gave the highest number of leaves compared to other treatments (Table 3), because vermicompost extract gave the highest contribution of total N-nutrient content compared to other compost extracts (Table 1). Levinsh (2011) also stated that vermicompost extract contained plant growth hormones such as auxin and cytokinin which could stimulate leaf formation and large amounts of chlorophyll to increase photosynthesis rate.

Application of urea at 200 kg ha^{-1} gave the highest plant height compared to other treatments (Table 2). When was given optimally, urea was able to provide sufficient N for plants to stimulate the growth of apical meristems which made plants grew longer. When the N requirement was met, plants would grow larger and expanded the surface of the leaves for photosynthesis. A high N supply would accelerate the conversion of carbohydrates into proteins and be used to synthesis cell walls (Fahmi *et al.*, 2010). Furthermore, the application of urea at the dose of 200 kg ha^{-1} yielded the highest number of leaves at the age of 3 WAP and 4 WAP compared to other treatments (Table 3). According to Yeshiwas *et al.* (2018), applying high nitrogen could increase nitrogen levels in plant tissue which encouraged the plant to grow more leaves.

Table 2. The effects of the application of three types of compost extract and urea to the average height of the kailan plants at every week.

Treatment	Plant Height (cm)			
	1 WAP	2 WAP	3 WAP	4 WAP
Compost Extract				
Without	12.38 a	17.92 a	22.83 a	28.68 a
Cow Manure	14.34 b	19.75 b	26.52 b	32.51 b
Rice Straw	16.01 c	21.82 c	28.25 c	35.67 c
Vermicompost	18.69 d	26.72 d	38.05 d	59.27 d
LSD 5 %	0.47	0.11	0.88	0.11
Urea Fertilizer				
0 kg ha^{-1}	14.24 a	19.79 a	26.43 a	35.65 a
100 kg ha^{-1}	15.20 b	21.69 b	29.08 b	39.26 b
200 kg ha^{-1}	16.63 c	23.16 c	31.23 c	42.18 c
LSD 5 %	0.41	0.09	0.76	0.09

Note: The numbers accompanied by the same letter were not different at the LSD 5%.

Tabel 3. The effects of the application of three types of compost extract and urea to the average number of leaves of the kailan plants at every week.

Treatment	Number of Leaves	
	3 WAP	4 WAP
Compost Extract		
Without	11.67 a	13.00 a
Cow Manure	12.67 b	14.67 b
Rice Straw	13.67 c	14.67 b
Vermicompost	17.00 d	23.00 c
LSD 5 %	0.66	0.77
Urea Fertilizer		
0 kg ha^{-1}	12.50 a	14.75 a
100 kg ha^{-1}	13.50 b	16.50 b
200 kg ha^{-1}	15.25 c	17.75 c
LSD 5 %	0.57	0.67

Note: The numbers accompanied by the same letter were not different at the LSD 5%.

Generative Results

The observed variables of the total plant fresh weight, canopy fresh weight, canopy dry weight, and root fresh weight were the greatest in vermicompost extract compared with other treatments (Table 4). The total fresh weight, canopy fresh weight, and canopy dry weight showed the greatest results due to the greatest number of leaves gave the greatest leaf area increase to increase the photosynthesis. The photosynthates used to the grow plant organs, the larger the plant organs were the more water which could be absorbed by the plants. Photosynthesis had an important role from the vegetative phase, in the process of growth and development, to the generative phase in the process of flower and seeds formation, and postharvest quality. Vermicompost extract had a high amount of N (Table 1), contained many kinds of microbes and was rich in nutrients. In addition, vermicompost extract contained high quality humus, had hormones which could stimulate plant growth, enzymes and other substances which were able to protect plants against pests and diseases (Hanc *et al.*, 2016). The benefits contained in vermicompost extract could increase growth, development, and crop production, and could control pests and diseases.

The kailan plant was harvested for their leaves to make the canopy fresh weight was an important indicator for kailan production. The heaviest canopy fresh weight was found in vermicompost extract treatment due to the fact that vermicompost extract had the highest N content compared to other compost extracts. The vermicompost met the nutritional needs of the vegetative growth of the kailan plants. The result was the same with the result of Pant *et al.* (2011) that the effect of vermicompost extract was large on the growth of pakcoi (*Brassica rapa* ssp. chinensis) plants, mostly due to mineral nutrients especially N which was required in a high dose by many plants.

The application of urea at 200 kg ha^{-1} gave the highest total fresh weight compared to other treatments (Table 4). It was assumed that the application of 200 kg ha^{-1} nitrogen fertilizer was able to meet the needs of N in plants, so as to increase growth and yield of the kailan plants. This was agreeable with Baloch *et al.* (2014), that the provision of sufficient quantities of nitrogen played a role in accelerating overall plant growth especially stems, leaves and roots. The role of nitrogen in plant growth was to build new cells, increase cell size, and increase the protoplasmic portion. While the analyses of variances for canopy fresh weight, canopy dry weight, and root fresh weight variables resulted in no differences of the N treatments.

Table 4. The effects of the application of three types of compost extract and urea to plant fresh weight, canopy fresh weight, dry weight, and plant root fresh of the kailan plants at every week.

Treatment	Plant Fresh Weight (g)	Canopy Fresh Weight (g)	Dry Weight (g)	Plant Root Fresh Weight (g)
Compost Extract				
Without	39.52 a	12.82 a	1.13 a	27.23 c
Cow Manure	44.10 c	14.01 b	1.17 b	27.22 b
Rice Straw	42.43 b	19.54 c	1,49 c	22.93 a
Vermicompost	93.92 d	61.37 d	7.17 d	33.40 d
LSD 5 %	0.36	0.37	0.16	2.36
Urea Fertilizer				
0 kg ha^{-1}	50.19 a	8.00	2.38	25.51
100 kg ha^{-1}	54.38 b	8.11	2.51	29.21
200 kg ha^{-1}	60.42 c	9.02	2.77	28.36
LSD 5 %	0.31	0,32 tn	0.14 tn	2.04 tn

Note: The numbers accompanied by the same letter were not different at the LSD 5 %.

Nitrogen Uptake and Leaf Greenness

The analysis of variance showed that compost extract significantly effected the uptake of N and the level of greenness of the kailan leaves. The results of urea-N analysis showed highly significant differences in nutrient uptake of N and the greenness level of kailan leaves. There were no interactions between nutrient uptake of N and the greenness level of kailan leaves combined with the compost extract and N. fertilization.

The highest N uptake was obtained by vermicompost extract compared to other treatments (Table 5). This was because the N content of vermicompost extract was higher compared to other extracts to enable the plants to absorb more N. Meanwhile, the plants experienced N deficiency showed slower growth, reduced leaf quality which reduced the amount of plant chlorophyll and photosynthesis (Asadu and Igboka, 2014).

The application of urea at 200 kg ha^{-1} showed the highest results in nutrient uptake of N compared to other treatments (Table 5). The availability of N uptake in this study was obtained from urea-N as a treatment. Prasetya *et al*. (2009) explained that an increase in plant N uptake was followed by the increase in plant growths included plant height, number of leaves, and total plant fresh weight.

The number of leaves could be used as a criterion for determining plant growth and development rates. The leaves were one of the most important plant organs due to their chlorophyll content which was useful to determine the level of N absorbed by the plants related to their production. Chlorophyll levels were influenced by a number of factors, among others were the nitrogen absorbed by the plants (Bojovic and Marcovic, 2009).

The highest level of greenness of leaves was obtained in vermicompost extract treatment compared to other treatments (Table 5). This happens because the N content of vermicompost extract was higher compared to other treatments resulted in the higher value of leaf greenness. This was in line with the results by Suwardi and Effendi (2009), stating that applied N could increase leaf greenness and crop yield. According to

Alcantara *et al.* (2016), because the N, P, and K as well as other elements contained in liquid organic fertilizers that were available to be absorbed by the kailan plants, the photosynthesis run optimally and the photosynthate produced were increasing.

The highest level of greenness of leaves was obtained on urea at 200 kg ha^{-1} compared to other treatments (Table 5). Increasing the dose of urea as a source of N was important in improving vegetative growth of the plants. The higher the applied dose of urea, the higher the SPAD value and carotenoid content the leaves produced (Pangaribuan *et al.*, 2018).

Table 5. The effects of the application of three types of compost extract and urea to the leaf greenness and N uptake of the kailan plants at every week.

Treatment	Leaf Greenness (SPAD)	N Uptake (g)
Compost Extract		
Without	111.8a	2.23 b
Cow Manure	143.6b	2.09 a
Rice Straw	152.7c	2.42 c
Vermicompost	183.8d	6.32 d
LSD 5 %	0.32	0.20
Urea Fertilizer		
0 kg ha^{-1}	127.88 a	2.86 a
100 kg ha^{-1}	149.95 b	3.21 b
200 kg ha^{-1}	166.23 c	3.73 c
LSD 5 %	0.28	0.17

Note: The numbers accompanied by the same letter were not different at the LSD 5 %.

The control treatment and without urea showed the slower growth rate and lower production of the kailan plants compared to other treatments which were fertilized. According to Rambe *et al.* (2018), N deficiency limited the production of protein and other important ingredients in the formation of new plant cells and could reduce the amount of plant chlorophyll and the rate of photosynthesis, and consequently reduced the photosynthate and the yield of plants. Onyango *et al.*, 2012 explained that N content in leaf vegetables would increase along with increasing N fertilization.

Efficiency of N Absorption

Table 6. The effeciency of N uptake of the three types of compost (cow manure, rice straw, vermicompost) and urea application on the kailan plants.

Treatment	N Uptake Efficiency (%)		
	Cow Manure Extract	Rice Straw Extract	Vermicompost Extract
100 kg ha^{-1}	28.53	0.01	112.05
200 kg ha^{-1}	38.70	6.83	86.39

The application of vermicompost extract as plant nutrients gave the highest N absorption efficiency compared to other compost extracts. Vermicompost extract with the addition of urea-N 100 kg ha^{-1} resulted in a higher yield 112.05 % compared with 86.39% from urea treatment at 200 kg kg ha^{-1} (Table 6). The use

of vermicompost extract as plant nutrition and urea-N fertilizer at 100 kg ha^{-1} was able to minimize N loss compared to the application of urea-N at 200 kg ha^{-1}. This showed that the amount of N absorbed by the the kailan was higher than the N added, meaning that some N did not originate from the added urea, but from vermicompost extract. This indicated that in the kailan cultivation in the wick hydroponic system there was no need to add urea because the vermicompost extract had fulfilled the N requirements of the kailan plants. According to Doberman (2007), the most that influenced absorption efficiency was the amount of nutrients released from the fertilizer. The more the release was, the higher the efficiency of fertilization as an addition to the absorption efficiency influenced by the balance between the plant needs and the amount of nutrients supplied from fertilizer.

According to Piya *et al.* (2018), vermicompost was rich in macro and micro nutrients, increased biomass and microbial respiration, had a positive effect on crop productivity and quality in various plants such as okra, cucumber, lettuce, strawberry, and cabbage. The use of vermicompost had a positive influence on the productivity and quality of tomato plants compared to the use of inorganic fertilizers (Kashem *et al.*, 2015). Extracted vermicompost could be used as foliar fertilizer. Further researches on the use of compost extracts and their combination with N fertilizer on the kailan plants were needed in determining the right doses and application time as to result in the right combination for the growth and production of the kailan plants.

Conclusion

The use of vermicompost extract showed the best results on all observations which were the plant height, number of leaves, total plant fresh weight, canopy fresh weight, canopy dry weight, root fresh weight, leaf greenness level, N uptake, and N uptake efficiency. Urea fertilization at 200 kg ha^{-1} resulted in the highest on the yields of kailan plants, number of leaves, total plant fresh weight, N uptake, and greenness of leaf SPAD. There was no interaction between the compost extracts and urea-N application on all variables of the kailan plants. Vermicompost extract produced the highest absorption efficiency of N of 112.05 % with the addition of 100 kg urea ha^{-1}. Wick system hydroponics using compost extract as N source could be recommended.

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PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13