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Growth and Yield of Lettuce (*Lactuca sativa* L.) on Peat Soil Supplemented with Cow Manures and Palm Oil Bunches Fertilizer

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ABSTRACT

Lettuce is generally used as a salad, fresh vegetables or green vegetables which have many health benefits. Efforts to increase the production are carried out by expanding growing areas using marginal land, such as peat lands. The application of organic matter to peat soils can increase soil fertility by improving physical, chemical and biological properties of the soil. The objectives of this experiment were to determine the optimum dose of cow manure, empty fruit bunches of oil palm (EFB), and the interaction between cow manure and EFB on the growth and yield of lettuce. The research was conducted in Bengkulu City from June to August 2019. This study was arranged in a completely randomized design (CRD), consisted of two factors and repeated three times. The first factor was cow manure with three levels, included 0, 15, and 30 tons ha^{-1}. The second factor was the dose of EFB fertilizer consisted of four levels, namely 0, 5, 10, and 15 tons ha^{-1}. The result showed that there was an interaction of cow manure with EFB on the leaf length of lettuce. The longest leaf of 18.674 cm was observed at cow manure at 15 tons ha^{-1} without EFB fertilizer. The best dose of cow manure for growth and yield of lettuce was 15 tons ha^{-1}. The EFB fertilizer of oil palm did not affect the growth and yield of lettuce.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one growing season vegetable crop belongs to the Composite family. In Indonesia, it is used as a salad, vegetables, or green vegetables that has many health benefits (Rukmana, 2007). This plant has ingredients such as protein, carbohydrates, fiber, fat, calcium, phosphorus, iron, vitamins (A, B1, B2, B3, C) and water (Supriati and Herliana, 2014). Some benefits for human health are including the ability to repair internal organs, prevent internal heat, launch metabolism, help maintain hair, prevent skin from becoming dry, and treat insomnia.

Lettuce has high prospects to be developed, because its production increases relatively every year. Based on the data from the Badan Pusat Statistik (2014), lettuce production in Indonesia from 2010 to 2013 was 283,770 tons, 280,969 tons, 294,934 tons and 300,961 tons, respectively. One of the efforts to increase the lettuce yield is by expanding the area of growing lettuce. One way is by utilizing marginal lands such as peatlands. Indonesia has the largest peatlands among tropical countries in the world, which is around 14.9

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million ha (Ritung et al., 2011). Data shows that out of 14.95 million hectares of peatlands, approximately 6.66 million hectares or 44.6% have been degraded. Continuous use of peatlands results in the degradation of organic matter. Degradation of organic material on peatlands also occurs due to the human activities, especially in land management (Wahyunto et al., 2014).

To overcome the degradation of organic matter in peat soils can be done by improving soil properties by fertilization. Fertilization is an effort to improve nutrients in the soil, so that plant nutrients are well maintained (Rukmana, 2007). Cow manure is easily obtained and has many advantages, contains high levels of fiber such as cellulose, able to provide macro and micronutrients, improves soil texture and structure, increases soil aeration, porosity and promotes the decomposition of soil microorganisms, and increases water absorption in the soil (Hartatik and Widowati, 2010).

Empty fruit bunches of oil palm (EFB) are one of the most solid wastes produced by palm oil mills. EFB, which constitute 23 percent of fresh fruit bunches; contain lignocellulose at 55 -60 % of dry weight. Also, they contain cellulose of 38.76%, hemicellulose of 26.69%, and lignin of 22.23%. According to Yulia et al. (2010), applying the compost of EFB produced the best leaf area, the number of leaves, and the fresh weight on the second planting, respectively, as 139.4 cm^2, 11.19 strands, and 1,827.50 g The objectives of this experiment were to determine the optimum dose of cow manure, EFB fertilizer, and the interaction of them on the growth and yield of lettuce.

MATERIALS AND METHODS

This research was conducted from June to August 2019 in Kandang Limun, Muara Bangkahulu, Bengkulu city, 10 m above sea level. The study was arranged in a completely randomized design (CRD) with two factors and three replications. The first factor was a dose of cow manure consisted of three levels, including 0, 15 and 30 tons ha^{-1}. The second factor was the application of EFB as organic fertilizer consisted of 0, 5, 10, and 15 tons ha^{-1}.

The materials used were an F1 Grand Rapid variety lettuce seed, cow manure, EFB fertilizer (from PT. Bio Nusantara). The tools used are 30 cm x 40 cm polybags, hoes, seedbed trays, rattles, ruler, meters, analytical scales, digital balance sheets, raffia ropes, labels, hand sprayers, and plastic net.

Seeding was done 2-3 weeks before planting. The seeds were sown in tray boxes filled with soil and manure (1:2). Seedlings were ready for transplanting at three leaves stage. The planting media used were peat top soil with a type of topogenous peat taken from Research Station of the University of Bengkulu. In order to remove litter from the soil, it was first sieved using a 5 x 5 mm Stainless steel sieve. The clean and smooth soil was then filled into a 30 cm x 40 cm polybag for 5 kg, then the polybags were organized with a distance of 40 cm and ready for planted.

Fertilization was done one week after planting. The basic fertilizer used were inorganic urea at a dose of 75 kg ha^{-1}(0.26 g/polybag), TSP 50 kg ha^{-1}(0.17 g/polybag), and KCl 50 kg ha^{-1} (0.17 g/polybag) as recommended by Direktorat Jendral Pertanian Tanaman Pangan (1992). The fertilizers were given around the plants and then backfilled with soil. The variables observed were plant height, number of leaves, level of the greenness of leaves, leaf length, root length, plant fresh weight, fresh root weight, root dry weight.

Preliminary analysis of peat soil, palm oil bunches fertilizer, and cow manure was carried out as supporting data. Data were statistically analysed by ANAVA following the F test at 5% level. If there were significant influences, further analysis were conducted using the Orthogonal Polynomial Test.

RESULTS AND DISCUSSION

Statistical Analysis

The analysis of peat soil at the Soil Science Laboratory, University of Bengkulu showed the levels of N = 0.11%, P2O5 = 4.7 ppm, and K = 0.21 mg / 100 g. After the treatment of cow manure at a dose of 30 tons ha^{-1} and EFB fertilizer of 15 tons ha^{-1} increased the soil pH from 4.2 to 5.5. The treatment of only 30 tons ha^{-1} manure increased pH from 4.2 to 5.2, and

only EFB fertilizer by 15 tons ha^{-1} increased the pH from 4.2 to 4.9 (data not show).

In general, the lettuce grew normally, although pests and diseases were not controlled during the season. At four weeks after planting (WAP), fungus spots and other pathogens appeared on the leaves. Pests that attacked the lettuce plants were Trips, which caused the leaves to be yellow and dry at the tips. The pathogen *Erwinia carotovora* caused of soft rot on lettuce. Symptoms started from the edge of the leaf caused the color of the leaf turned to be brown and eventually whiter. It was due to the effect of humidity because of the uneven sunlight shining on the leaves.

Analysis of variance (ANAVA) on all observed variables showed that the treatment of cow manure significantly affected plant height and plant fresh weight of lettuce (Table 1). There was no effect of EFB fertilizer on the all observed variables. The interaction between the cow manure and EFB fertilizer significantly affected the leaf length of lettuce.

Figure 1. Condition of the research area

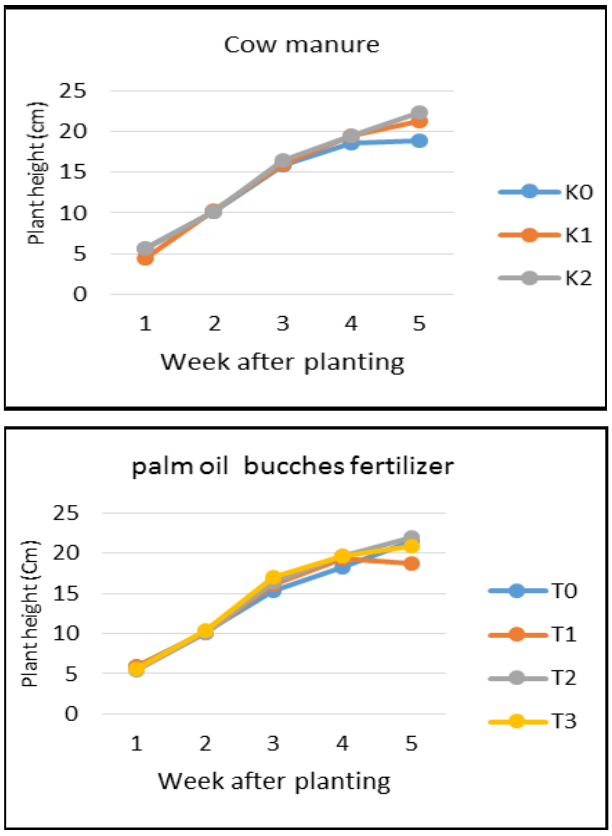

Figure 2. Growth patterns of plant height from one to five weeks after planting (WAP)

Effect of Cow Manure and EFB Fertilizer on the Growth

Vegetative growth of lettuce observed from one to five week after planting (WAP) on plant height, the number of leaves, and leaf length is presented in the Figure 2. Plant growth forms in a sigmoid curve. Variable of plant height can be used as an indicator of growth to measure the effect of treatment because it was easily observed (Sitompul and Guritno, 1995).

Plant height increased from the first to the fourth week after planting. However, at the fifth week, the growth of plant height was stopped. The highest addition of plant height observed on the treatment of cow manure at 30 tons ha^{-1} and the treatment of EFB fertilizer at

Table 1. Analysis of variance (ANAVA) on the growth and yield variables of lettuce

No	Variable	F value base on F table (5%)			Coefficient of variety (%)
		Cow manure	Palm oil bunch fertilizer	Interaction	
1	Plant height	4.33*	2.00 ns	0.12 ns	14.28
2	Leave number	1.76 ns	0.73 ns	0.73 ns	12.64
3	Length leave	0.91 ns	0.51 ns	0.51 *	6.37
4	Fresh weight	4.93 *	0.39 ns	0.39 ns	1.123
5	Root fresh weight	0.44 ns	0.69 ns	0.69 ns	16.88^{t}
7	Length root	1.31 ns	1.00 ns	1.00 ns	16.33
8	Root dry weight	0.32 ns	0.34 ns	0.34 ns	18.74^{t}
9	Level of green leaf	0.19 ns	0.71 ns	0.71 ns	14.23

Note: ns=no significant different, *= significant different at 0.05, t= data transformation

a dose of 10 tons ha^{-1}. Yetti and Elita (2008) stated that organic fertilizers contain high levels of N and low water levels, thereby stimulating the activities of microorganisms in the soil. Ekawati (2006) stated that when nitrogen was fulfilled in the plant, the auxin activities was stimulate the growth of plant height.

The growth of number of leaf is showed in a sigmoid curve in Figure 3. From the first to the third week, the increasing in the number of leaves was not significant. But, from the third to fourth weeks there was a significant increase, then from the fourth to fifth weeks there was no increase in growth. The highest number of leaves resulted from the application of cow manure at a dose of 30 tons ha^{-1} and EFB fertilizer at a dose of 15 tons ha^{-1}. Fahrudin (2009), stated that the number of leaves was related to plant height, because the higher the plant, the more leaves are formed.

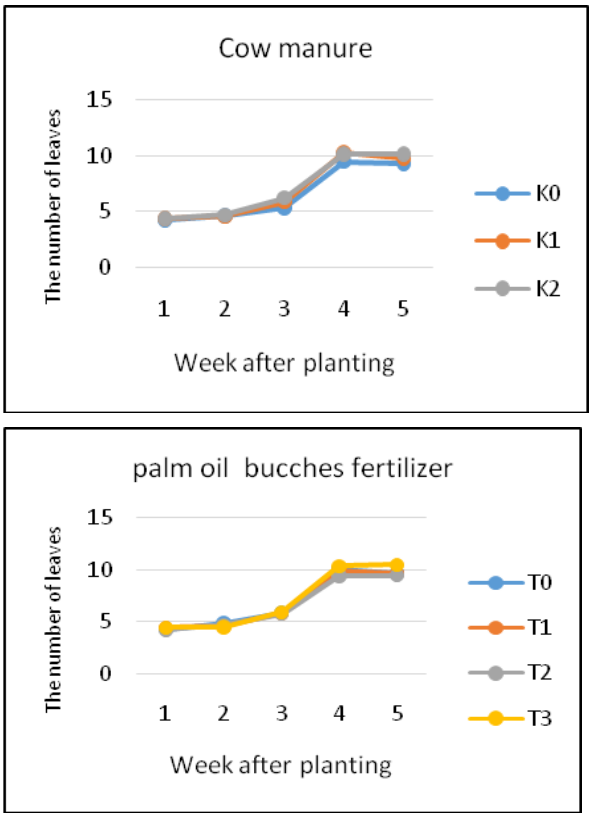

Figure 3. Growth patterns of the number of leaves

Leaf length from the first to the fifth week showed a normal increase. The highest addition of leaf length was observed in cow manure treatment with a dose of 15 tons ha^{-1} and EFB fertilizer with a dose of 15 tons ha^{-1} (Figure 4). According to Sutejo and Kartasapoetro (1992), cow manure contains less nutrients than artificial fertilizers, but cow manure can enhance humus, improve soil structure and stimulate microorganisms' activities in the soil. Meanwhile, excessive manure will increase the acidity of the soil so that the nutrients are actually absorbed in the soil and cannot be absorbed by plants. The organic materials derived from EFB can facilitate the absorption of nitrogen by plants, namely nitrates and ammonium. Both of these elements accelerate the formation of leaf green (chlorophyll) in the photosynthesis process for the vegetative growth of leaf length.

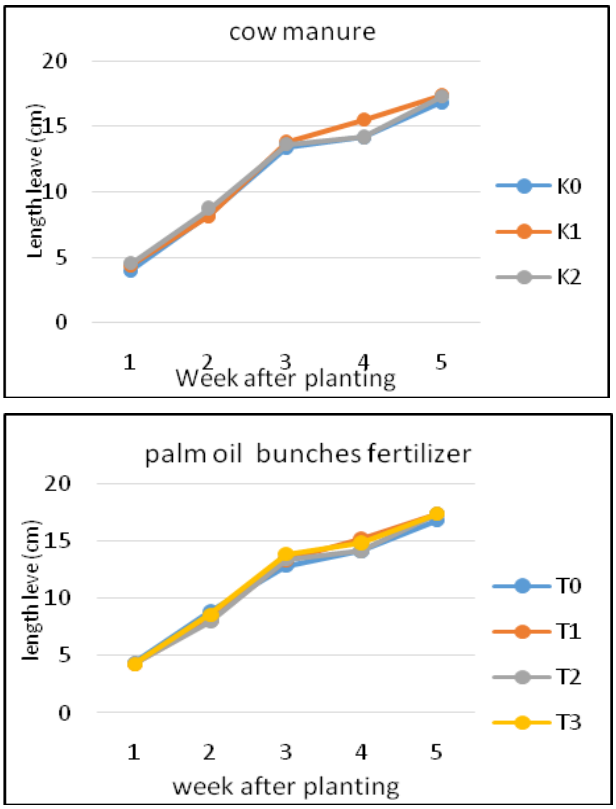

Figure 4. The growth pattern of the length of leaves from the first to the fifth week after planting (WAP)

Analysis of variance indicated that there was an interaction between the dose of cow manure and EFB on leaf length (Table 1). The Orthogonal Polynomial test showed that the application of cow manure and EFB fertilizer has an effect on leaf length. The response of leaf length due to EFB fertilizer forms a quadratic curve at a dose of 0 ton ha^{-1} and cow manure at a dose of 15 tons ha^{-1} forms the equation $y = -0.0122x2 + 0.3567x + 16.067$ with a coefficient of determination $R^2 = 0.7899$. This showed that the increase in leaf length at the optimum dose, namely 14.61 cm, was able to produce a leaf

length of 18.674 cm. The dose of EFB and cow manure affected leaf length with an accuracy of 78.99% (Figure 5).

The response of the number of leaves due to the application of EFB fertilizer at a dose of 5 tons ha^{-1} and cow manure at a dose of 30 tons ha^{-1} formed a linear pattern with the equation of y = 0.033x + 16.644 with the coefficient of determination R^2 = 0.1893 (Figure 5). This showed that each addition of one unit dose of EFB and cow manure will increase the number of leaves by an average of 0.03 cm.

Leaf length response due to the treatment of EFB fertilizer at a dose of 10 tons ha^{-1} and cow manure at a dose of 30 tons ha^{-1} formed a linear pattern on the equation of y = 0.0489x + 16.633 with a coefficient of determination R^2 = 0.3016 (Figure 5). It shows that each addition of one unit dose of EFB and cow manure will increase the average leaf length by 0.048 cm.

Leaves length response due to the treatment of EFB fertilizer at a dose of 15 tons ha^{-1} and cow manure at a dose of 30 tons ha^{-1} formed a linear pattern with the equation of y = -0.01x + 17.55 and the coefficient of determination R^2 = 0.0104 (Figure 5). The application of cow manure without the EFB gave optimal results for leaf length. The dose of cow manure 15 ton ha^{-1} will not increase even though the concentration of cow manure was increased. Nutrients needed have reached optimal conditions, increasing the dose of fertilizer will not provide a significant increase in plant growth. The application of 5 ton ha^{-1} and 10 ton ha^{-1} of EFB fertilizer showed that the higher the fertilizer dose, the higher the leaf length growth. The dosage of palm oil bunches fertilizer 15 ton ha^{-1} showed that the higher the dose given decreased the leaf length.

The Orthogonal Polynomial test showed that the response to leaf length with the application of EFB and cow manure formed a linear curve pattern (Figure 6). The variable response to leaf length without cow manure at a dosage of EFB fertilizer of 15 tons ha^{-1} formed a linear pattern with the equation of y = 0.1073x + 16.037 and R^2 = 0.3189. This showed that each addition of one unit dose of EFB and cow manure will increase the average leaf length unit by 0.10 cm. The treatment of EFB and cow manure has an effect on the length of lettuce leaves with an accuracy of 31% (Figure 6).

The response of leaf length to cow manure treatment of 15 tons ha^{-1} and EFB forms a linear pattern with the equation y = -0.1087x + 18.223 with a coefficient of determination R^2 0.2608. This shows that each addition of one unit dose of EFB and cow manure will reduce the average of leaf length by 0.10 cm. The dosage of EFB and cow manure affected the leaf length with an accuracy of 26% (Figure 6). No reference has been obtained to explain the effect of decreasing leaf length due to an increase in the dose of EFB with cow manure by 15 tons ha^{-1}.

Leaf length response to cow manure treatment of 30 ton ha^{-1} with a dose of EFB of 15 ton

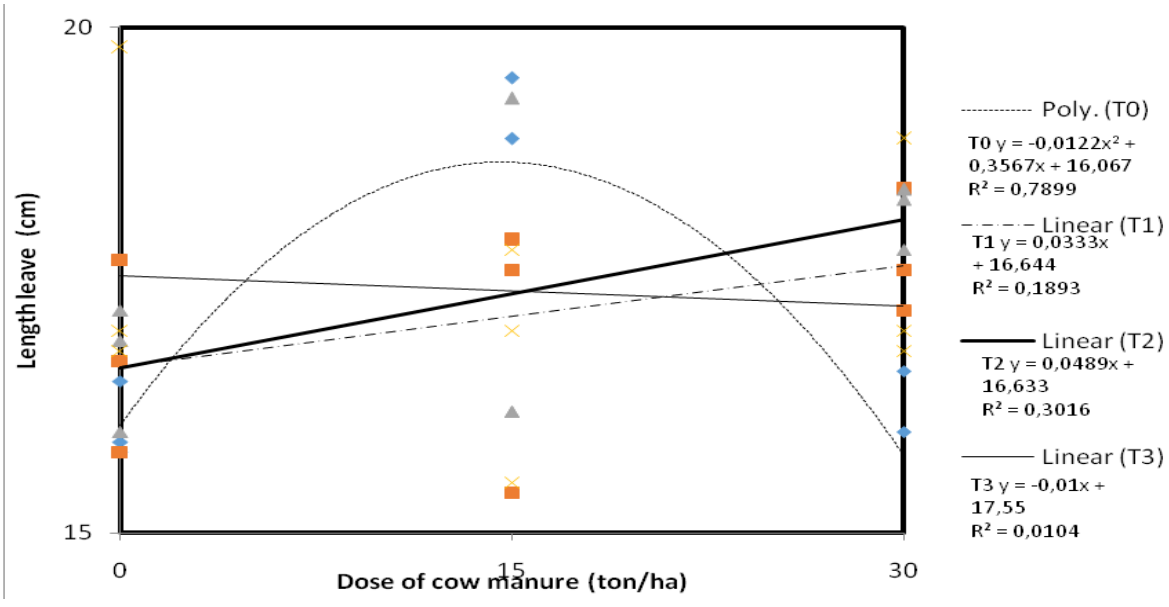

Figure 5. Effect of cow manure on leaf length on several doses of palm oil bunches

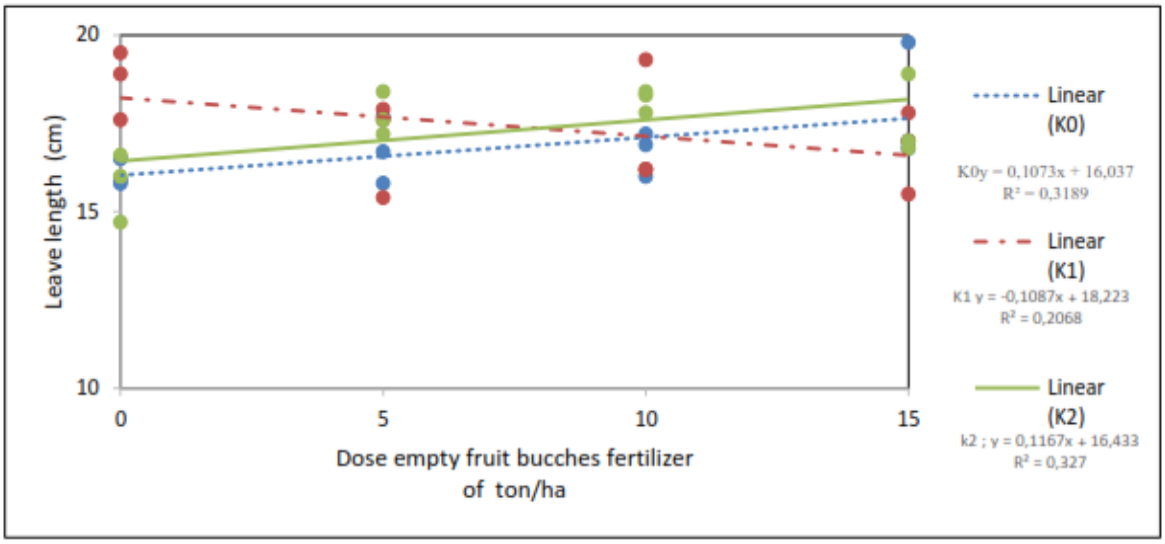

Figure 6. The effect of EFB fertilizer and doses of cow manure on the leaf length

ha^{-1} forms a linear pattern with the equation y = 0.1167x + 16.433, R2 = 0.3189 (Figure 6). It showed that each addition of one unit dose of EFB and cow manure will increase the length of lettuce by an average of 0.11 cm. Cow manure and EFB promoted the formation of leaf length. The interaction of cow manure and EFB affects the leaf length significantly. This occurred due to the role of nitrogen in both fertilizers which affected the growth process. Cow manure had a total N content of 4.92%, and EFB had a total N content of 1.23%. Nitrogen is a constituent of all proteins and nucleic acids. Sutejo Elisabeth *et al*. (2013) explained that plants that get enough N would form the leaves with high chlorophyll content that can produce sufficient to support their vegetative growth. In general, cow manure contains relatively low levels of N, P, and K but can help essential supply micronutrients. Cow manure contains N-total of 4.92%, P 4.03 ppm, and K 4.30%. Nitrogen functions to stimulate the entire growth of plants, while P stimulates the growth of root and create a good root system to absorb nutrients and water efficiently. The K element is needed by plants to activate the enzymes that can accelerate the growth of meristematic tissue (Setyamidjaya, 1986).

Growth is a process of cell differentiation in plants. Growth includes germination, enlargement of stems, roots, and leaves. Growth was supported by the suitable environment for plants. Growth indicators can usually be measured by plant height, which is very easy to observe. Orthogonal polynomial test showed that the treatment of various doses of cow manure on plant height variables formed a positive linear relationship with the equation of y = 0.1231x + 18.851 and R^2 = 0.5823. It means that with addition of one unit dose of cow manure will be followed by an increase in the the plant height of 0.123 cm (Figure 7).

Good plant growth will result in high fresh plant weight due to the amount of water content in plant cells. The N nutrient absorbed is able to support the growth of vegetative organs such as stems and leaves. The orthogonal polynomial test showed the pattern of the relationship between cow manure doses and fresh lettuce weight formed a positive linear pattern with the equation of y = 0.5347x + 44.826 and the coefficient of determination R^2 = 0.7873. It means that by addition of one unit dose of cow manure will increase the fresh weight of lettuce by 0.5347 g (Figure 8).

The availability of nutrients needed in the soil can increase plant growth, which also increases

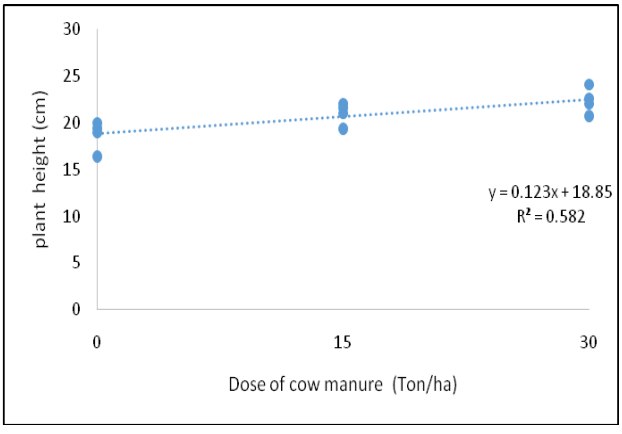

Figure 7. Effect of cow manure on plant height

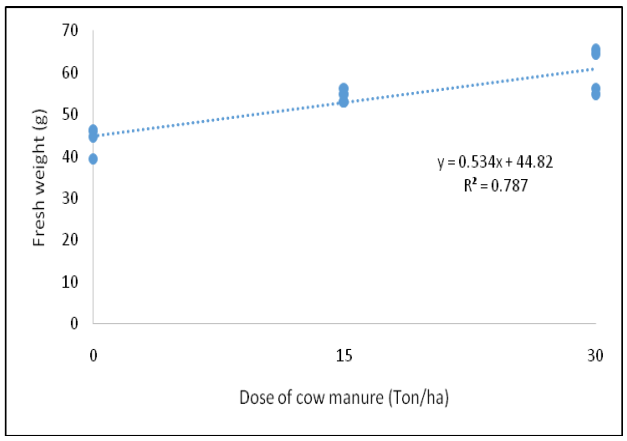

Figure 8. Effect of cow manure on fresh weight

crop yields (Ichsan *et al*., 2017). Macro and micronutrient elements in organic matter can stimulate the growth and yield, thereby increasing the weight of the fruit in each plant. It is in line with the statement by Ashrafida (2013), the more doses of cow manure were given, the better growth and yield of shallots were produced. Plant development and growth that goes well will produce a high fresh weight because it is determined by the amount of water in plant cells (Rasada, 1996).

Effect of EFB Fertilizer on the Yield

The treatment of EFB at 10 ton ha^{-1} produced the highest mean of the observed variable except for the length of the leaves which had the highest at 15 tons ha^{-1}. The highest of root fresh weight of lettuce was produced at the EFB treatment of 5 ton ha^{-1}. Application of EFB fertilizer at 10 ton ha^{-1} produced the highest plant weight and leaf greenery. At the dose of EFB fertilizer of 15 ton ha^{-1} produced the highest fresh weight and root dry weight (Tabel 2).

Statistical analysis in Table 1 showed that the application of EFB fertilizer was not influenced on all the observed variables. This was presumably because EFB fertilizer has nitrogen of 1.23%, while the lettuce plants require 36 g per plant of nitrogen for growth. The content of nitrogen in peat soil was only 0.11%, so that the total nitrogen content in peat soil and from EFB fertilizer at 5, 10, and 15 tons ha^{-1} were not sufficient to meet the needs of lettuce.

CONCLUSION

There was an interaction of cow manure with EFB fertilizer on leaf length of lettuce. Cow manure at 15 tons ha^{-1} without palm oil EFB fertilizer gave the best results at a leaf length of 18.674 cm. The best dose of cow manure for growth and yield of lettuce was 15 tons ha^{-1}. Organic fertilizer of EFB fertilizer did not affect the growth and yield of lettuce.

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Table 2. The average growth and yield of lettuce due to the application of palm oil bunches fertilizer

Dose of palm oil bunches fertilizer (Ton/ha)	Plant height (cm)	Leave number	Leave lenth (cm)	Fresh weight (g)	Root fresh weight (g)	Root lenth (cm)	Root dry weight (g)	Level of green leaf
0	19,43	9,75	16,06	44,50	2,29	16,30	1,03	19,50
5	16,30	9,00	16,73	39,50	2,45	18,15	1,11	21,60
10	20,03	9,50	16,70	46,17	2,27	18,30	1,01	22,00
15	19,63	9,00	17,86	46,33	2,05	15,70	1,12	17,37

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