The Effect of Mushroom Waste Compost and Defoliation on the Growth and Yield of Okra (*Abelmoschus esculentus* L. Moench)

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Abstract: Okra (*Abelmoschus esculentus L. Moench*), better known as Arabic bean or lady's finger, is a crop that was introduced as a new vegetable crop in Indonesia. The use of compost is expected to improve productivity, and compost used in this study was made from straw waste of mushroom media. This study aims to determine the effect of compost doses and defoliation on the growth and yield of okra plants and the interaction between those two factors. This research was conducted from May to September 2017 at Experimental Garden and Physiology Laboratory of Agricultural Faculty, Syiah Kuala University, Banda Aceh. This research used a factorial randomized block design with two treatments, compost doses consist of 4 levels (0, 10, 20 and 30 ton ha^{-1}) and defoliation consists of 2 levels (with and without defoliation). Parameters observed included plant height, stem diameter, wet cropping weight, number of fruits per plant, fruit weight per plant, and harvest index. The result of this research showed that the compost doses had a very significant effect on wet cropping weight and had significant effect on stem diameter at 60 Day After Planting (DAP) while the other parameters had no effect. The best compost dose on growth and yield is 30 tons ha^{-1} on growth and yield of okra crops. The defoliation treatment has no significant effect on all growth and yields parameters of okra crop. There was an interaction between defoliation and compost dose 30 tons ha^{-1} on stem diameter at 30 DAP.

1 INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) or better known as Arabic bean or lady's finger (female fingers), is a plant that has not been too famous in Indonesia. This plant is commonly found in the Philippines, Malaysia, Thailand, and Vietnam. This plant is known by many local names in various parts of the world, including okura (Japan), bendi (Malaysia), je thew (China), as well as kacang lendir (Riau). Okra is a type of vegetable that is popular in the household, supermarkets, restaurants and hotels. Therefore okra plants can be a farming business that brings huge profits for vegetable farmers (Pure, 2009).

Okra plants are cultivated by Chinese farmers as daily vegetables since 1800's. In Indonesia okra was first cultivated in West Kalimantan. Currently in Aceh, okra plants are still rare and less popular among the people. Thus, okra can be cultivated for a wide marketing opportunity as a business in the agricultural sector that brings benefits to vegetable farmers in Aceh.

The people use okra's fruit commonly as vegetables. Okra's fruit is very good in consumption both for vegetables and as a medicine because it has many benefits. In the research conducted by Rachman and Yudo (1991), the results of nutrient content analysis of young okra fruit obtained nutritional content as follows, water content 85.70%, protein 3.90%, fat 2.05%, potassium 6.68% , 0.77% phosphorus, 1.4% carbohydrate and 39.97 / 100g of calories.

One way to increase the production of okra and other horticultural plants is through fertilization. Fertilization aims to replace missing nutrients and increase the nutrient supply needed by plants to increase the production and quality of plants. The availability of complete and balanced nutrients that can be absorbed by plants is a factor that determines the growth and production of plants (Nyanjang *et al*., 2003).

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Improving the physical, chemical and biological properties of soil can be done by giving organic fertilizer in order to restore soil fertility. This indicates that organic fertilizer has a positive effect on plant roots health so that plant growth will also be better. In addition, the potential of waste raw materials for the production of organic fertilizer is also abundant (Sardjono *et al*., 2012).

According Sutanto (2006), soil biological ecosystem becomes unbalanced when chemical fertilizers used continuously, so the purpose of fertilization to fulfill the nutrients need is not achieved. Therefore we must change the pattern of using inorganic fertilizer by using organic fertilizer. One of the sources of organic fertilizer is the utilization of compost from mushroom media waste.

Mushroom media waste from rice straw will be reused as the main material of compost for nutrients source in okra plants. Thus, it will form an activity that resembles a cycle and is also an implementation of the concept of "Zero waste production management" in agriculture that utilizes waste products as a source of nutrients.

Mushroom media waste is one source of potassium (K) which is cheap and easily available. The return of mushroom media waste to the soil can meet most of the K nutrients needed by plants. Naturally potassium is easily lost from the soil, so the application of K fertilizer should be given in two types, as inorganic form (KCl fertilizer) and organic form (straw compost) (Hartatik, 2009).

Research from Tamtomo *et al*. (2015) showed that the interaction of compost and rice husk ash had significant effect on all variables of sweet potato growth and production which included variable length of stem, number of branches, number of leaves, tuber weight per plant, tuber weight per plot and tuber content. The treatment using 20 tons ha^{-1} straw compost and 20 tons ha^{-1} husk ash produced the best growth.

Research Salbiah *et al*. (2012) showed that 20 ton ha^{-1} of hay compost has very significant effect to panicle per hill and rice yield per hectare compared to zero dose of straw compost and 10 ton ha^{-1} dose of straw compost. In another study, the application of straw compost significantly affected plant height and dry weight of corn plants. Composting of 30 tons ha-1 straw produced the highest value on the parameters of plant height and dry weight of maize, compared to the dose of 10, 20 tons ha^{-1} (Maulana *et al,* 2014).

In addition to fertilizing with compost media waste mushroom, defoliation is also an attempt to increase crop production. Defoliation is an attempt to reduce vegetative growth of a plant so it can stimulate the growth of certain parts of a plant and can accelerate the generative growth of the plant. The defoliation treatment should pay attention to the condition of the environment itself (Saptarini and Widayati, 1991).

In the study Nadira *et al*. (2009), the application of defoliation in okra plants gives the best results than without defoliation in some parameters such as plant height, number of young fruit per plant and the yield of okra per hectare. Yadi *et al*. (2012) showed that defoliation had a very significant effect on the number of leaves, fruit length, fruit weight and diameter of cucumber plant. The length and weight of fruits and the highest yield of cucumber was shown on the pruning of 2 leaves and 2 branches with yield of 49.98 ton ha^{-1}.

The results of research conducted by Jaya (2009) states that the pruning of branches on broccoli plants grown in the lowlands at the time of planting flowers can accelerate the age of harvest and can improve crop yields. The highest increase in yield (23.7%) was obtained from the pruning treatment of 100% branch followed by branch pruning 75% (20.2%), branch pruning 50% (16.8%) and 25% (9.6%).

Treatment of pruning productive branches will stimulate the growth of fruit that can increase the number of plant fruit. The increasing productive branch is due to the increased of growth hormone activity around the trimmed parts of the plant. By doing defoliation in okra plants is expected to reduce vegetative growth that can increase fruit production (Nadira *et al*., 2009).

Based on those descriptions, an experiment was conducted to examine the effect of compost dosage of mushroom media waste and defoliation on growth and yield of okra plants.

2 MATERIAL AND METHODS

This study was conducted from May to September 2017 at the Experimental Garden and Physiology Laboratory of Faculty of Agriculture, Syiah Kuala University of Darussalam Banda Aceh. The tool used in this research is hoe, stake, scales, calipers, sprinkler, ruler, scissors, paper label and stationery. The material used in this research is the green okra seed (Naila IPB varieties), alluvial soil obtained from Indrapuri, polybag (size 20 kg) for planting as many as 48 polybags, compost media mushroom waste of 7.2 kg, Urea fertilizer 96 g, SP 36 fertilizer 124.8 g, and KCl fertilizer 48 g.

This experiment used Factorial Block Randomized Design (RAK), with 2 treatment factors.

The first treatment was 4 levels of mushroom media waste compost (0, 10, 20, and 30 ton ha^{-1}) and the second treatment was defoliation and without defoliation. There were 3 times repetitions, so that obtained 24 unit experiments. There are 2 plants in each experimental unit so there are 48 plants at all.

Cleaning the research area was done before planting such as cleaning weeds or other waste from the research site. Planting medium was 10 kg soil of top soil mixture and mushroom media waste compost in accordance with each treatment (0, 10, 20, and 30 ton ha^{-1}). The mixture of the planting media is then loaded into a polybag (size 40 cm x 50 cm). The compost media of the mushroom waste used is compost that has been decomposed naturally.

Labeling is done before planting. The usage of the label is adjusted to the combination of the treatments. Okra seeds were sown directly to the soil. There were 2 seeds sown in depth of 4 cm for each polybag. After two weeks, one well grown plant was left. Defoliation was done at the 30-Day after palnting (DAP) for leaves number 3, 4 and 5. Defoliation is performed on the petiole using a clean and sterile blade (Nadira *et al*., 2009).

Okra plant maintenance activities include watering 2 times a day, morning and evening. Weeding is done by cleaning the weeds manually around the plant at age 14, 28 and 42 DAP. Effective weeding is done when weeds are young, so they can not compete or interfere the okra plants. The bursting was done simultaneously with weeding and fertilizing. The bursting aims to improve the soil structure around the roots of plants and to facilitate plant roots in the process of nutrient uptake. This bursting was done at plant age 14, 28 and 42 DAP.

Pest and disease attacks that occur in okra plants were aphids, and pest control was done by using the insecticide Curacron 500 EC at the age of 21 and 28 DAP. The fertilization used inorganic fertilizer as basic fertilizer, those were 200 kg Urea ha^{-1} (2 g $polybag^{-1}$), 256 kg SP-36 ha^{-1} (2.6 g $polybag^{-1}$) and 100 kg KCl ha^{-1} (1 g $polybag^{-1}$). Fertilization was done at the plant 14 DAP.

Okra harvest was done at the plant age 55 DAP or 5-6 days after flowering. Best harvest time is in the morning or afternoon with a harvest time interval of 2 days, harvesting can last up to 2 months. The harvested okra fruit is young, about 7 cm long with marks on the ends of the fruit easily broken, white and slimy. Harvest was done by using a sharp knife because the stem of okra fruit is quite flexible.

The parameters observed in this study were plant height (at 15, 30, 45 and 60 DAP), diameter of base of stem (at 15, 30, 45 and 60 DAP), plant wet weight (after harvesting), fruit number per plant, fruit weight per plant, fruit lenght, and harvest Index.

3 RESULT AND DISCUSSIONS

3.1 Effect of Wastewater Media Compost to Germs Growth and Yield

F test result on analysis of variance showed that the dosage treatment of mushroom media compost had a very significant effect on the stem diameter of 60 DAPS and significantly affected the plant wet weight. Otherwise, the effect was not significant on plant height 15, 30, 45 and 60 DAP, stem diameter 15, 30 and 45 DAP, fruit number per plant, fruit weight per plant, fruit length and harvest index. The average growth and yield of okra plants due to the treatment of mushroom media compost can be seen in Table 1. Table 1 shows that the plant at 15 DAP tends to be higher at the dosage of 20 tons/ha of mushroom media compost. At the age of 30 DAP, plants given mushroom media compost 30 ton ha^{-1} tends to be higher than other compost dosage treatment. While at age 45 and 60 DAP, okra plants given waste mushroom compost 20 ton ha^{-1} tend to be higher.

The stem diameter at 15, 30 and 45 DAP was larger in the mushroom media compost 30 ton ha^{-1} while the largest at 60 DAP diameter was found in plants with doses of mushroom media compost 30 ton ha^{-1} which was significantly different from the dose of 0 tons ha^{-1}, but was not significantly different with the doses of 10 and 20 tons ha^{-1}. For the plant wet weight, the dose of mushroom media compost of 30 tons ha^{-1} yielded the heaviest wet weight significantly differ from the dose of 0 tons ha^{-1}, but not significantly differ from the dose of 10 and 20 tons ha^{-1}.

Overall, the best dosage of mushroom media compos for plant growth was at a dose of 30 tons ha^{-1}. This suggests that the higher the mushroom media compost, the more nutrients available to the plant. This is presumably because the use of mushroom media compost can provide nutrients optimally in the soil so that will cause the organic material to process mineralization.

Table 1. The average growth and yield of okra plants by the treatment of mushroom media compost

Observed Parameters		Compost Dosage (ton ha^{-1})				HSD
		0	10	20	30	
Plant Height (cm)	15 DAP	12.89	13.12	13.15	13.03	-
	30 DAP	22.70	24.33	24.83	25.00	-
	45 DAP	34.21	34.00	36.04	36.04	-
	60 DAP	52.13	53.21	56.33	56.13	-
Stem Diameter (mm)	15 DAP	2.28	2.37	2.40	2.46	-
	30 DAP	4.65	4.86	5.34	5.42	-
	45 DAP	10.12	10.16	10.87	11.41	-
	60 DAP	17.51a	19.39ab	19.15ab	20.67b	2.18
Plant wet weight (g)		654.83a	919.50ab	901.17ab	1077.50b	371.07
Number of Fruit per Plant (fruit)		2.50	3.25	2.83	3.17	-
Fruit weight per Plant (g)		86.82	114.79	101.22	117.67	-
Fruit length per Plant (cm)		12.43	12.48	12.82	13.35	-
Harvest index		0.14	0.13	0.12	0.12	-

Note : Number followed by the same alphabet in the same row is not significantly difference at 5% level (HSD Test 0.05)

The result of this overhaul of organic matter increases the N element in the soil, resulting in differences in plant height. According Susanti (2006), organic materials have macro and micro nutrients needed by plants, so when applied to the plant, it will provide a good vegetative growth in plants. This is also supported by the opinion of Roesmarkam and Yuwono (2002) who stated that organic fertilizer will release nutrients for plants with complete (N, P, K, Ca, Mg, S and micro nutrients) and the addition of organic fertilizers with high doses can improve soil structure so easily penetrated by plant roots and keep the nutrients of plants so as not easily washed and produce better plant growth.

In this research, the difference dose of mushroom media compost did not give a significant effect to the result parameters. The dosage of mushroom media compost of 10 tons ha^{-1} produced the highest amount of fruit, while the dosage of compost of mushroom media waste of 30 tons ha^{-1} produced the highest fruit weight per plant because the length of the fruit at 30 tons ha^{-1} compost yielded fruit length which tends to be longer than other compost doses. It is suspected that it was influenced by high nutrient content of phosphor and potassium in the of mushroom media compost so that the elements were absorbed by plants and play a role in activating enzymes that play a role in metabolism or energy. The energy is used to perform photosynthesis which results in the form of photosynthesis. Mas'ud (1993), translocation of photosynthates to fruits is affected by potassium which causes the movement of photosynthates from mexofil cells to the roots, thereby increasing root growth and development. With the increase of growth and root development, the process of nutrient uptake by plant roots will increase and photosynthates to fruit will be more produced, so that will increase the weight of fruit.

The treatment of organic fertilizer in the form of mushroom media compost 30 tons ha^{-1} has the best growth and yield of okra plants compared to other compost treatment. Susi *et al*., (2013) stated that organic fertilizer can maintain soil condition and support the development of rooting and nutrient absorption process, so that the nutrient needs of plants will be fulfilled during its growth, whether from organic or inorganic fertilizer (urea). The increase of production achieved in dosage of mushroom media compost of 30 tons ha^{-1} was 36.32% and the dosage 20 tons ha^{-1} increased by 16.58% when compared to treatment without compost (0 ton ha-1).

In the index parameter of harvest yield,dosage of mushroom media compost did not have a significant effect to growth and yield of plant. The highest harvest index value was at 0 tons ha^{-1} compost dose of 0.14 (14%) and the lowest value was at compost dose 20 and 30 ton ha^{-1} 0.12 (12%) whereas at the dosage of 10 ton ha^{-1} compost of the harvest index value is 0.13 (13%), the value of the harvest index is less than 50% means okra plant treated with mushroom media compost produces large biomass at various doses test.

3.2 Effect of Defoliation on Growth and Yield of Okra Plants

Table 2 shows that the growth parameters of okra plant at age 45 and 60 DAP and stem diameter at age 45 DAP with the highest value are in defoliation treatment, whereas stem diameter of 60 DAP and plant wet weight with the highest value is found in the treatment without defoliation.

The treatment with and without defoliation tested did not have a significant effect on the outcome parameters. However, overall treatment without defoliation tends to result in higher fruit quantities and higher fruit weight per plant, while the fruit length in plants with defoliation treatment tends to produce okra fruit longer than the treatment without defoliation. The treatment with and without defoliation had the same harvest index value that is about 0.13 (13%).

Table 2. The average growth and yield of okra plants by the treatment of defoliation

Observed Parameters		Defoliation		HSD 0,05
		Without	With	
Plant Height (cm)	15 DAP	13.11	13.19	-
	30 DAP	22.60	25.83	-
	45 DAP	34.06	36.08	-
	60 DAP	53.83	55.06	-
Stem Diameter (mm)	15 DAP	2.37	2.39	-
	30 DAP	5.03	5.11	-
	45 DAP	10.33	10.95	-
	60 DAP	19.30	19.06	-
Plat wet weight (g)		909.33	867.17	-
Number of fruits per plant(buah)		3.08	2.79	-
Fruit weight per Plant (g)		109.17	101.08	-
Fruit lenght per Plant (cm)		12.62	12.92	-
Harvest Index		0.13	0.13	-

Note : Number followed by the same alphabet in the same row is not significantly difference at 5% level (HSD Test 0.05)

The treatment with defoliation showed better values on the plant height at age 45 and 60 DAP, stem diameter at 45 DAP. Accordance to Nadira *et al*. (2009), defoliation or trimming provides the best results than without defoliation to plant height, number of young pods per plant and yield per hectare. Defoliation of old leaves spurred in diverting of assimilation results to the early growth of young leaf buds, so the plants become higher.

The long growth of the plant is affected by the auxin produced by the apical tip and the cytokines that is transported from the roots. Cytokines will stimulate cell division by increasing the rate of protein synthesis so as to spur the growth of plant height. The auxin and nutritive hormones originally in the apical are no longer sent to the defoliated but split stalks at the end of the active plant growing stem (Lakitan, 1996)

Treatment without defoliation shows the most amount of fruit per plant and the weight of fruit per plant tends to be better, this is inversely proportional to what we expect that with defoliation will increase the production of okra plants. The defoliation done on the 3rd, 4th and 5th leaves can not affect the results, it is suspected that because the photosynthate produced is small and does not affect the increase of fruit formation, it is not in accordance with Warsana (2009) which states that the pruning of plants means reducing distribution of photosynthate to many branches so more directed to increase fruit formation in plants. The effect of pruning of plants also shows that the response tends to be better on the fruit length although it has no significant effect.

3.3 Influence of Interaction between Mushroom Media Compost and Defoliation to Growth and Yield of Okra

The result of F test on the analysis of variance shows that there is a significant interaction between the dosages of mushroom media compost with defoliation treatment to stem diameter at 60 DAP. The stem diameter at 60 DAP in the defoliation treatment became larger due to the use of mushroom media compost of 30 tons ha^{-1}, which was significantly differ from the dosage of mushroom media compost 0 ton ha^{-1}. While the stem diameter in the treatment without defoliation due to of mushroom

media compost 0, 10, 20 and 30 ton ha^{-1}, did not make a significant difference. For more details, the interaction between doses of mushroom media compost with defoliation to stem diameter of 60 DAP can be seen in Figure 1.

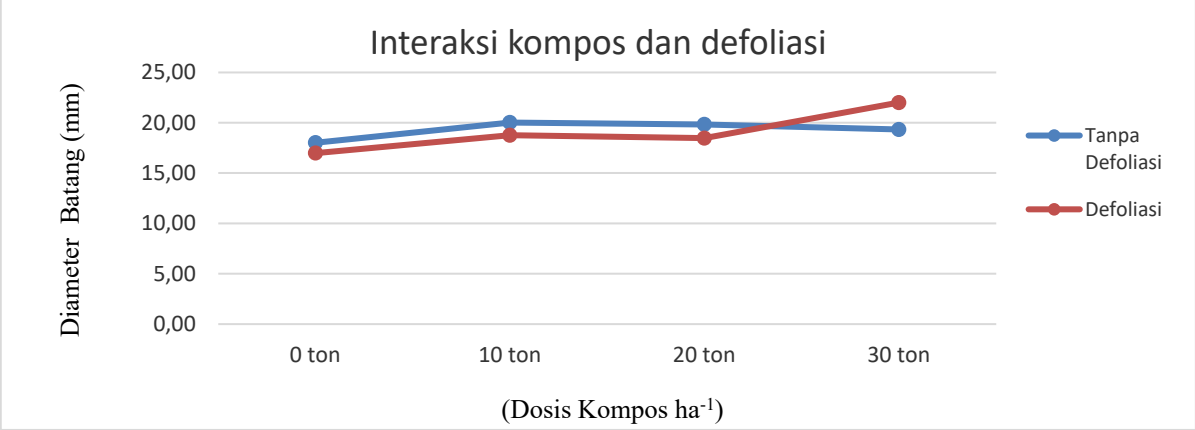

Figure 1. Interaction between mushroom media compost and defoliation on stem diameter at 60 DAP.

The results showed that the interaction between dosage of mushroom media compost with defoliation only had significant effect on growth of stem diameter at 60 DAP. The defoliation treatment resulted in the largest growth of stem diameter of 60 DAP with dosage of 30 tons ha^{-1} of mushroom media compost. Darmanti $^{et\ al}$. (2008) stated that the growth of lateral branch diameter in plants due to defoliation treatment is due to cambium vascular activity. The stem part of the plant will increase in diameter as the initial form of the cambium from the secondary xylem to the inside and the secondary phloem to the outside. Accumulation of secondary vessel tissue has a big role to increase the diameter of woody plant.

4 CONCLUSION

The treatment of mushroom media compost at doses of 30 tons ha^{-1} is better than other doses on growth and plant yield parameters. The treatment without defoliation resulted in the best growth and yield on the observed parameters. There was a significant interaction between the mushroom media compost and the defoliation treatments on the stem diameter of 60 DAP.

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