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Organic Fertilizer from Starfruit Waste SustainableAgriculture Solution

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Abstract. Waste from starfruit cultivation could attract flies around the plantation which can reduce the quality of starfruit plants and also reduce the aesthetic value. To resolve these problems, waste from starfruit cultivation could be utilized as organic fertilizer. The utilization of starfruit waste into organic fertilizer can increase added value as a source of organic material for vegetable crops grown in starfruit plantations in a sustainable agriculture system. Organic fertilizer from starfruit waste was expected to replace inorganic fertilizer in pakcoy vegetable crops on verticulture system. The objectives of this study were: (1) to determine the nutrient content of organic fertilizer made from starfruit leaves and fruits waste; (2) to determine the effect of starfruit organic fertilizer on pakcoy growth as substitution of inorganic fertilizer. This study was conducted in October 2018 - February 2019. The location for this tudy was at Attaqie Agroeduwisata Farm, Tuban Regency, East Java. Soil and fertilizer analysis were carried out at the Soil Research Institute, Bogor. The study used Randomized Block Design (RBD) with three replications. The first factor was the dose of inorganic fertilizer with 3 levels namely 0%, 50%, and 100% of the standard dose and the second factor was starfruit leaf compost dose with 4 levels namely 0 ton/ha, 10 tons/ha, 20 tons/ ha, and 30 ton/ha. The treatment of compost 20 ton/ha + 50% inorganic fertilizer showed no significant difference with the use of 100% inorganic fertilizer, which was the best treatment with optimal results on plant height, leaf width and fresh weight of pakcoy. Thus, that the use of 20 tons/ha + 50% inorganic fertilizer can save 50% use of inorganic fertilizer on verticulture system.

1. Introduction

Most people who live in developing countries depends on agriculture as their livelihoods. Reported in 2014, the number of people dependent on agriculture in developing countries reached 5.5 billion [1]. In fact, limitations such as small land ownership (< 2 ha), limited resources, and land degradation are getting increasingly worrisome. Soil degradation becomes a problem affecting agronomic production, lowering soil quality, and hampering economic growth [2]. Even worse, the environmental, economic, and soil fertility risks due to erosion [3] and other degradation processes.

On the other hand, the increase in area of starfruit plantation in Tuban, East Java was is proportional to the increasing amount of waste originating from the cultivation and production processes. Wastes from starfruit cultivation include twigs and leaves from pruning, buds from fruit thinning, and damaged fruits from sorting. Those wastes reduce aesthetic value of the plantations and the living environment. Furthermore, starfruit wastes can attract fruit flies around the plantation. Breeding of flies can reduce production in several ways, such as reduction of fruit quality from the black spot caused by fruit flies' puncture and reduction in yield caused by fruit fall before reaching the desired maturity [4].

The use of organic matter become an effective solution in reducing land degradation. Organic matter is easy to applied in form of organic fertilizer and its easily available in nature. Good agricultural

practice depends on adequate nutrition and fertilizer efficiency. The intensive use of chemical fertilizer can contribute to decreasing soil fertility and causing serious environmental degradation, such as oil and ground water pollution, salinization and desertification [5]. Efforts to solve the environmental problems mentioned above is by utilizing the wastes from starfruits cultivation processes as organic fertilizer. Organic fertilizers are able to provide nutrition that plants need, its easily available, and can help avoid pests and diseases [6]. Other research results mention the use of a combination of durian skin waste compost and 50% inorganic N fertilizer can increase plant height and fresh weight of caisim plants [7]. The use of fertilizers from organic waste added with biological microorganisms can increase the height of green mustard plants compared to using other organic fertilizers [8].

Management of fruit and star fruit leaf waste into organic fertilizer can increase added value as a source of organic material for vegetable crops. Vegetables can be cultivated using sustainable agriculture system inside star fruit plantation using verticulture system. Sustainable agriculture systems are more directed at the use of organic products that are friendly to the environment. This agricultural system is emerged as the answer for various problems caused by conventional farming system that use high amount chemicals such as chemical fertilizer and pesticides. The implementation of sustainable agriculture is expected to minimize the negative effect of chemical-based farming, maintaining the ecosystem balance and can be used as a concept of future thinking.

As agriculture practices developed, verticulture system get more and more attention. Vericulture planting system is a system of crop cultivation which is carried out vertically or stratified, which is widely developed by gardening enthusiasts to use as much as possible the area of land in their yards. Types of plants that can be planted with verticulture are seasonal fruit and vegetable plants (pakcoy, lettuce, cabbage, carrots, tomatoes, eggplant, chili, etc.), as well as flowers such as orchids, bougenville, roses, jasmine, azalea and hibiscus when its height is regulated with trimming. Verticulture systems can be a solution to the difficulty of finding agricultural land which displaced by the development of settlements and industry [9].

Pakcoy is one of leafy vegetables that highly popular and can grow well in verticulture system. Pakcoy productivity is affected positively by fertilization. Fertilization efficiency and nutrient absorption of pakcoy are still low [10]. Pakcoy is a leafy vegetable plants that require high nitrogen (N), so it needs fertilizer with high N content [11].

Utilization of starfruit fruits and leaves wastes as organic fertilizer was expected to replace inorganic fertilizer for pakcoy plant. The objective of this study was to determine the nutrient content of organic fertilizer made from starfuit waste and to determine the effect of starfruit organic fertilizer on pakcoy growth as substitution of inorganic fertilizer.

2. Materials and Methods

This study was conducted in October 2018 – February 2019. The location for this study was Attaqie Agroeduwisata Farm, Panyuran Villahe, Palang District, Tuban Regency, East Java. Soil and fertilizer analysis were conducted in Soil Research Institute, Bogor.

Materials used for organic fertilizer were honey starfruit fruits and leaves waste as the main material of compost, EM-4, water, molasses, and husk. Materials used for verticulture shelf were angle iron, nails, welding, water duct size 4 ", duct closure. The materials needed for organic fertilizer testing were top soil, pakcoy seeds (Nauri variety), NPK fertilizer, Furadan. The tools used are tarpaulins, thermohydrometers, pH meters, scales, measuring cups, verticultural shelves, trays, agricultural equipment and technical equipment.

This study used Random Block Design (RBD) with three replications. The first factor was the dose of inorganic fertilizer with 3 levels namely 0% (A0), 50% (A1), and 100% (A2) of the standard dose and the second factor was starfruit leaf compost dose with 4 levels namely 0 ton/ha (K0), 10 ton/ha (K1), 20 ton/ ha (K2), and 30 ton/ha. There were 36 experimental units and every unit consisted of 5 plant samples. One experimental was one verticulture shelf, 1 meter in length and with planting space of 20 x 20 cm between packoy plant, located inside a net house. Planting medium was filled into verticulture shelf up to ¾ of shelf volume. Pests and diseases control were adjusted according needs.

2.1. Preparation of Organic fertilizer

starfruit waste was divided into two main ingredients, namely leaves only and fruits + leaves from Attaqie Farm, Tuban. Leaves were obtained from fallen leaves and leaves from pruning with maximum age of 1 week after fallen. While fruits were obtained from fallen fruits or small immature fruits from thinning and sorting. Ingredients were minced and mixed with EM-4, decomposed up to 15 – 20 cm in height, and covered by tarpaulin. The mixture was tightly covered and mixed daily to make sure all mixed well. Temperature changes, color and smell were observed. When the mixture was no longer had smell and the color turned to brown then it was ready to use as organic fertilizer. For fruits + leaves mixture the steps were the same. Organic fertilizers from starfruit leaves and starfruit fruits + leaves then analyzed to determine its nutrient content.

2.2. Organic fertilizer test on pakcoy grown in verticulture

Pakcoy seeds were sown in nursery tray using mixture of soil + organic fertilizer as planting medium. The seedlings were transplanted to a verticulture shelf 10 days after planting (DAP) with 1 seedling per planting hole. The placement of each shelf was adjusted to Randomized Block Design. Each treatment was grouped into one group and replicated three times. Fertilization was done using organic fertilizers and NPK with dose as assigned by each treatment. NPK fertilizer applied at 1 week after planting (WAP). Watering was done twice a day (morning and evening) and or adjusted to the conditions of the growing media. Pakcoy plants can be harvested at 4-5 weeks after planting. Harvesting was conducted manually by pulling pakcoy plants to its roots. Observations include: (1) observations of plant growth, conducted every week up to 4 WAP (plant height, number of leaves, leaf width and stem diameter), (2) production observations conducted at harvest (plant fresh weight, root fresh and dry weight), (3) soil analysis: carried out before the field experiment, the analysis was carried out at the Research Institute for Medicinal Plants and Spices, Bogor, (4) analysis of organic fertilizer: carried out at the Soil Research Institute, Bogor.

3. Results and Discussions

3.1. Soil and Starfruit Compost Ingredient Characteristic

Soil was obtained from AttaqieAgroeduwisata Farm. Panyuran Village, Palang District, Tuban Regency, East Java. Soil analysis showed in Table 1. Analysis results showed that total-N, P2O5, Ca, Mg, K and NA value was high. High nutrient content in soil would make it easier for plants to uptake the nutrients. High P content was not supported by pH that was slightly acidic, meaning that P was abundant in soil yet not available for plants. The addition of organic fertilizer was expected to increased soil pH and made nutrient more available, and support soil microbes food source. Organic fertilizer was able to made chelate with Al3+, which hinder Al3+ hydrolysis reaction that could lower soil pH [12][13].

Table 1. Soil Analysis Result from Panyuran Village, Palang District, Tuban Regency

Soil Parameter	Value*	Unit	Criteria**
pH (H_2O)	6.38	-	Slighly Acidic
C-Organik	1.95	%	Low
N-Total	0.95	%	Very High
P_2O_5 Bray 1	32.52	Ppm	High
Ca	15.41	cmol (+)/kg	High
Mg	4.57	cmol (+)/kg	High
K	3.77	cmol (+)/kg	Very High
Na	2.2	cmol (+)/kg	Very High

*Attaqie Farm Soil Analysis Result from Research Institute of Medicinal plants and Spices (2018)
**Soil Research Institute (2009)

3.2. Starfruit Wastes Nutrient Content: Starfruit Leaves and Fruits + Leaves

Organic fertilizer from different main ingredients of starfruit waste resulted in different nutrient content. Analysis results showed that C-Organic, C/N ratio and pH of organic fertilizer made from starfruit fruits and leaves waste were in accordance with quality standard of organic fertilizer according to PERMENTAN (2011). High nutrient content of organic fertilizer can fulfill plant nutrient requirement and reduce the utilization of inorganic fertilizer [14] and improve soil fertility without causing soil degradation, and increasing product quality and quantity [15].

Nutrient content of starfruit fruits + leaves compost was higher than compost from only starfruit leaves (Table 2). This is presumably due to nutrient uptake obtained from photosynthesis was allocated mostly to fruits, thereby increasing the nutrient status of organic fertilizer made from starfruit fruits + leaves. Starfruit fruits + leaves organic fertilizer also had a distinctive odor of starfruit, did not had a pungent odor.

The addition of microbe and molasses affected the nutrient content of fruits + leaves organic fertilizer. Microbes helped in accelerating the process of decomposition of organic fertilizer and also helped in providing nutrients. The addition of microbes and molasses increased organic matter content in organic fertilizer. This was in accordance another research that addition of microbes and molasses in organic fertilizer would produce high organic matter content, thus increasing the quality of organic fertilizer[16].

The process of making organic fertilizer would also affect the quality of organic fertilizer produced. Decomposition process must be supported by the environment. Increased temperature, changes in pH and composting time would affect the quality of organic fertilizer. Composting that is too long would affect the nutrient content, presumably because decomposition process is too long and reduce the microbial activity [17].

Table 2. Starfruit leaves only compost and starfruit fruits + leaves compost analysis results

No	Testing Parameter	Leaves compost	Fruits + Leaves compost	Unit	Quality Standard*
1.	pH H_20	8.9*	8.3*	-	4-9
2	Moisture Content	58.79	77.44	%	20-25
3	C- Organic	50.09*	46.89*	%	Min 15
4	N-Total	2.71	6.19*	%	Min 4
5	C/N Ratio	18*	8	%	15-25
6	P_20_5	0.73	0.94	%	Min 4
7	S-total	0.05	0.33	%	
8	K-interchangeable	1.42	75.04	$Cmol_c/kg$	Min 4
9	Na- interchangeable	0.85	6.96	$Cmol_c/kg$	
10	Ca- interchangeable	20.5	20.13	$Cmol_c/kg$	
11	Mg- interchangeable	82.14	47.23	$Cmol_c/kg$	
12	CEC	80.72	58.4	$Cmol_c/kg$	

*Quality standard from Permentan NOMOR 70/Permentan/SR.140/10/2011

Source: Soil Reseach Intitute Test Result (2019)

3.3. Growth of pakcoy plant

3.3.1. Plant height

The growth of pakcoy with inorganic fertilizer and starfruit organic fertilizer treatments was shown in Table 3. The observation on pakcoy plant height on inorganic fertilizer treatment showed that the highest plant height at 1 WAP was 3.21 cm on treatment 0 % inorganic fertilizer. There was changes in plant height, in which at 3 WAP pakcoy without addition of inorganic fertilizer was the shortest compared to other treatments. In the end of observation (4WAP) showed that pakcoy with 50% inorganic fertilizer

resulted in highest plant height that was 8.11 cm. Meaning that application of 50% recommended dosage of inorganic fertilizer was already effective in meeting pakcoy nutrient needs.

Organic fertilizer treatments showed that 20 ton/ha starfruit fruits and leaves organic fertilizer resulted in the highest plant compared to other dosage. But application of 10 ton/ha was resulted in plant height that was not significantly different from 20 ton/ha treatment. Application of 10 ton/ha was quite efficient in meeting nutrient needs of pakcoy. The content of organic fertilizer affected the nutrient uptake and plant growth. Nutrient uptake efficiency is affected by soil, proction potential, chemical fertilizer content used by plant, interaction factor, environmental factors and root system which affected by microbes [18][19].

The increase of plant height is affected by nutrient availability in soil. Other important factors are (1) nutrient concentration (2) the rate of nutrient ion replacement and (3) the amount of nutrients dissolved in the soil. It is also influenced by the ability of the soil to bind nutrients so that it can be well absorbed by plants [20]

Table 3. Pakcoy plant height parameter 1, 2, 3, and 4 WAP

Treatment	1 WAP		2 WAP	3 WAP		4 WAP	
	(cm)						
0% of fertilizer recommended dose	3.21	a	3.78	4.91	B	6.91	b
50% of fertilizer recommended dose	2.79	b	3.60	5.58	A	8.11	a
100% of fertilizer recommended dose	2.79	b	3.72	5.30	A	7.65	ab
0 ton/ha compost	2.85		3.67	5.06		7.09	B
10 ton/ha compost	3.03		4.02	5.70		7.82	ab
20 ton/ha compost	3.04		3.73	5.61		8.30	a
30 ton/ha compost	2.79		3.38	4.54		7.03	b

Note: numbers followed by the same letter in each parameter showed no significant difference in DMRT test alpha= 5%.

3.3.2. Number of Leaves

Inorganic fertilizer treatments were not significantly affected number of leaves in the beginning. At 2 WAP and 4 WAP, 50 % of recommended dose resulted in the highest number of leaves (Table 4). While organic fertilizer treatment showed that plant height from treatment 10 ton/ha was not significantly different from 20 ton/ha. This showed that fertilization efficiency was reached at 10 to/ha.

Application of organic fertilizer from starfruit waste gave a significant effect on number of leaves of pakcoy. Application of organic fertilizer adds supply of N, resulted in more leaves which is good for plants [21]. More number of leaves means more yield in leafy vegetables such as pakcoy. Higher number of leaves would improve packoy production.

3.3.3. Leaf Width

The effect of inorganic fertilizer and starfruit fruits and leaves compost was shown in Table 5. In the early growth f pakcoy, 10 ton/ha of compost gave the highest leaf width compared to other treatment, while inorganic fertilizer treatment showed no difference. Leaf width was continuing to increase at 2 WAP to 4 WAP, where the application of 50% and 100 % of inorganic fertilizer recommended dose resulted in higher leaf width compared to control. Compost dose of 20 ton/ha was consistently able to increasing leaf width at 2 to 4 WAP with maximum leaf width of 8.15 cm. Increased leaf width is supported by nutrient availability. Low or excessive amounts of nutrients will reduce crop production. This is in line with the statement that the use of organic matter can increase the availability of nutrients and the application of appropriate organic matter can increase the leaf area of green mustard plants thereby increasing the fresh weight of the plant [22].

Table 4. Pakcoy number of leaves parameter 1, 2, 3, and 4 WAP

Treatment	1 MST		2 MST		3 MST	4 MST	
	(cm)						
0% of fertilizer recommended dose	3.87		5.95	b	7.60	9.60	b
50% of fertilizer recommended dose	3.87		6.27	a	8.75	11.18	a
100% of fertilizer recommended dose	3.87		6.07	b	9.48	10.58	a
0 ton/ha compost	3.62	b	5.51	b	6.93	8.39	c
10 ton/ha compost	3.98	a	6.29	a	8.49	11.38	a
20 ton/ha compost	3.91	a	6.33	a	8.89	11.62	a
30 ton/ha compost	3.96	a	6.24	a	10.13	10.44	b

Note: numbers followed by the same letter in each parameter showed no significant difference in DMRT test alpha= 5%.

Table 5. Effect of inorganic fertilizer and starfruit fruits and leaves compost dose on pakcoy leaf width

Treatment	1 WAP		2 WAP		3 WAP		4 WAP	
	(cm)							
0% of inorganic recommended dose	2.00		3.71	b	5.39	b	6.6	b
50% of inorganic recommended dose	2.03		4.28	a	6.28	a	8.03	a
100% of inorganic recommended dose	2.04		4.13	a	5.86	a	7.72	a
0 ton/ha compost	1.85	c	3.29	c	4.67	c	6.3	c
10 ton/ha compost	2.23	a	4.64	a	6.46	a	8.02	a
20 ton/ha compost	2.06	b	4.46	a	6.68	a	8.15	a
30 ton/ha compost	1.96	b	3.77	b	5.56	b	7.33	b
CV	5.44		7.87		9.53		6.87	

Note: numbers followed by the same letter in each parameter showed no significant difference in DMRT test alpha= 5%.

3.3.4. Stem Diameter

The effect of inorganic fertilizer and starfruit fruits and leaves compost dose on pakcoy stem diameter can be seen in Table 6. Stem diameter in 20 ton/ha compost and 50% of inorganic fertilizer recommended dose were not significantly different with stem diameter in 20 ton/ha or 30 ton/ha. It indicated that application of starfruit fruits and leaves compost could reduce 50% of inorganic fertilizer use. Durian skin compost can reduce 50 % of inorganic N fertilizer in caisim plant [7].

3.3.5. Yield Component

The result of yield parameters are pakcoy fresh weight showed interaction between inorganic fertilizer and starfruit waste organic fertilizer. Pakcoy fresh weight in all treatments was shown in Table 7. The highest fresh weight was found at 50 % of inorganic fertilizer recommended dose and 20 ton/ha organic fertilizer. This indicated that starfruit fruits and leaves compost was able to substitute 50% of inorganic fertilizer dose. Fresh weight is an important factor in pakcoy production. Pakcoy quality is determined by high fresh weight ehich also mean high plant production.

Table 6. Effect of inorganic fertilizer and starfruit fruits and leaves compost dose on pakcoy stem diameter

Treatment	0 ton/ha compost		10 ton/ha compost		20 ton/ha compost		30 ton/ha compost	
	(cm)							
0% of inorganic recommended dose	0.53	b	0.61	b	0.75	b	0.69	a
50% of inorganic recommended dose	0.69	a	1.00	a	1.01	a	0.73	a
100% of inorganic recommended dose	0.53	b	0.71	b	0.98	a	0.72	a

Note: numbers followed by the same letter in each parameter showed no significant difference in DMRT test alpha= 5%.

Optimum fresh weight can be obtained when plant get enough nutrient, so that an increase in number and size of cells can reach optimal levels and also allow for an increase in plant water content. One of nutrients that are important for planting pakcoy is Nitrogen (N). N is absorbed by plants in many ways. N is easily lost from the soil. The loss of N from the soil can be through the washing process NO3-, denitrification of NO3- to N2, volatilization of NH4+ to NH3-, fixed by clay minerals or consumed by soil microorganisms [23].

Table 7. Effect of inorganic fertilizer and starfruit fruits and leaves compost dose on pakcoy fresh weight

Treatment	0 ton/ha compost		10 ton/ha compost		20 ton/ha compost		30 ton/ha compost	
	(gram)							
0% of inorganic recommended dose	13.6	a	27.9	c	31.4	b	29.7	b
50% of inorganic recommended dose	23.6	a	72.3	a	82.5	a	58.2	a
100% of inorganic recommended dose	21.3	a	56.8	b	73.5	a	44.9	a
CV	18.32							

Note: numbers followed by the same letter in each parameter showed no significant difference in DMRT test alpha= 5%.

3.3.6. Root Lengh and Root Fresh Weight

Root length parameter showed that inorganic fertilizer treatment resulted in longer root length compared to plants without inorganic fertilizer (Table 8). While starfruit fruits and leaves compost treatment showed that 10 ton/ha and 20 to/ha resulted in better root length compare to other treatments. This indicated that application of compost as source of organic material for microbes will help roots in nutrient absorption. Microbes also promotes root system activities, so that the absorption of nutrient is maximal.

Table 8. Effect of inorganic fertilizer and starfruit fruits and leaves compost dose on pakcoy root length and root fresh weight

Treatment	Root Length (cm)		Root Fresh Weight (gram)	
0% of inorganic recommended dose	7.71	b	1.05	b
50% of inorganic recommended dose	9.05	a	2.26	a
100% of inorganic recommended dose	9.81	a	1.87	a
0 ton/ha compost	7.87	b	0.89	c
10 ton/ha compost	9.78	a	1.75	b
20 ton/ha compost	9.43	a	2.35	a
30 ton/ha compost	8.34	b	1.92	ab
CV	11.75		28.89	

Note: numbers followed by the same letter in each parameter showed no significant difference in DMRT test alpha= 5%.

4. Conclusions

The use of 20 ton/ha compost + 50% inorganic fertilizer showed best response in pakcoy optimum plant height, leaf width, number of leaves and fresh weight. This combination of treatments showed no significant difference with 100% inorganic fertilizer. Thus, application of 20 ton/ha starfruit waste organic fertilizer + 50% of inorganic fertilizer recommended dose can reduce 50% the use of inorganic fertilizer.

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