OPEN ACCESS International Journal of Applied Biology

ISSN : 2580-2410
eISSN : 2580-2119

The Utilization Potential of Tasikamdu Star Fruit Composted Waste for Mustard Cultivation (*Brassica rapa* L.) In Supporting Sustainable Agriculture

Inanpi Hidayati Sumiasih*, Mutiara Dewi Puspitawati, Fayyadh Yusuf Maulana, Yadarabullah
Faculty of Science, Technology, and Design, Trilogi University, Jakarta. Jl. TMP. Kalibata No. 1, Jakarta 12760 Indonesia

Abstract

Attaqie Farm Agroedutourism produced 1.5 tons/ha of star fruit waste in 2018, which was wasted because it was not utilized by starfruit farmers. Attaqie farm strives to implement the Sustainable Agriculture System (SPT) to support sustainable agriculture. The waste originating from one cultivation can be used as a resource in other forms. The application of integrated and sustainable agriculture is beneficial for farmers to preserve the ecology while maintaining the culture adopted in an area. Farmers' objectives for agricultural cultivation are good, healthy, and maximum yields, therefore the availability of compost is needed. The technology that has developed makes it easier for farmers or researchers to make compost in a short time. The study began with making compost with star fruit waste, namely residual leaves and fruit from thinning. This research was carried out using a Randomized Block Design (RBD). The treatment was replicated 4 times, with 3 experimental units, and 5 dose levels. Nutrients in the star fruit waste compost showed good results for compost criteria according to SNI 19-7030-2004 standard. The effective dosage for star fruit compost in mustard cultivation was 20 tons/ha (equivalent to 40 g/polybag).

Article History
Received January 10, 2023
Accepted June 21, 2023

Keyword
Compost,
Mustard,
Star fruit waste,
Sustainable agriculture

Introduction

Attaqie Farm Agroedutourism produced 1.5 tons/ha of star fruit waste in 2018, which was wasted because it was not utilized by starfruit farmers (Siahaan 2021). Waste left in the field would reduce the aesthetic aspect of the tourism sector. Attaqie farm strives to implement the Sustainable Agriculture System to support sustainable agriculture, so the waste must be used in another form. The star fruit waste can be utilized as organic fertilizer that would also support the sustainability of the farm. Cultivation based on the use of compost, control of Plant Pest Organisms (PPO), and integrated resource management is a proper development concept in the agricultural sector. This is with the aim that the

CONTACT : INANPI HIDAYATI SUMIASIH inanpihs@trilogi.ac.id

management of the agricultural sector is socially, economically, and sustainably feasible (Wihardjaka 2018).

Cultivation systems can be developed and combined to be integrated as one system. According to Ummah (2017), waste from cultivation can be used as a resource for other cultivation. The application of integrated and sustainable agriculture is beneficial for farmers to preserve the ecology while maintaining the culture adopted in an area. Sustainable agriculture can bring positive impacts such as more accessible information about integrated farming, better knowledge about the agricultural sector, and increasing usage of organic fertilizer by farmers who aim to cultivate food both conventionally and non-conventionally.

Organic materials such as agricultural waste or household waste can undergo decomposition which resulted in available nutrients for plants. Plant cultivation using organic fertilizer or organic based is preferred by the general public because of the notion that it can be more beneficial and healthier for consumers. Since more people care about their health, the utilization of organic fertilizer is increasing. A healthy lifestyle has become the basis for abandoning various unhealthy habits such as the use of excess chemicals, the use of artificial pesticides, plant growth regulators, and inorganic fertilizers.

Mustard is one of the popular vegetables that is favored by the community (Fuad 2010) because it is easy to grow and cultivated. The benefits of mustard according to Vivonda et al. (2016), are that it can reduce coughs and headaches because mustard has substances and vitamins that are important for human health.

Farmers prefer the use of chemicals fertilizer due to fast plant growth, high yields, and relatively cheap prices. However, excessive use of chemical fertilizer could damage the soil. To reduce chemical use, organic fertilizers such as compost are needed.

Farmers' objectives for agricultural cultivation are good, healthy, and maximum yields, therefore the availability of compost is needed. The technology that has developed makes it easier for farmers or researchers to make compost in a short time. This acceleration of composting should still happen naturally to produce good quality compost (Murbandono 2010). The composting process consists of three stages, namely intensive decomposition which can produce hot temperatures due to the presence of bacteria from the bio-activator. The second stage is conversion and synthesis for compost maturation. Then the third stage is post-maturation. Good compost that can be used, can be seen from the standard characteristics of organic compost, which are containing nutrients, brownish-black in color, and crumbles (Setyorini et al. 2006). Tasikmadu star fruit waste at Attaqie farm produces waste such as residual fruit, twigs, and leaves from thinning. With this, it is necessary to use it as compost and to support sustainable agriculture in the ecology.

Materials and Methods

Time and Place

This research was conducted t Attaqie Farm, Tuban in Augustus – November 2021. The analysis of star fruit waste compost content and the soil content were conducted at Soil Research Center, Bogor.

Materials

The tools used were: buckets, machetes, branch shears, digital scales, trays, stationery, popsicle sticks, polybags, watering jugs, leaf chopping machines, carts, tarpaulins, and leaf color chart. The materials used were: leave and fruit residue from thinning, EM-4, water, molasses, and Mustard Nauli F1 (East-West Seed Indonesia) seeds.

Research Method

The research began with the production of compost using star fruit waste as material. This research was carried out using a Randomized Block Design (RBD). The treatment was replicated 4 times, with 3 experimental units, and 5 dose levels. The doses given were:

d0: 0 ton/ha compost (equivalent to 0 g/polybag)
d1: 10 ton/ha compost (equivalent to 20 g/polybag)
d2: 20 ton/ha compost (equivalent to 40 g/polybag)
d3: 30 ton/ha compost (equivalent to 60 g/polybag)
d4: 40 ton/ha compost (equivalent to 80 g/polybag)

The compost produced and the soil from Attaqie Farm were analyzed. The compost was tested 3 times, at 1, 3, and 6 months old. The soil sample was collected from five points sampling from different spots.

The data collected were analyzed using ANOVA (Analysis of Variance) using STAR (Statistical Tools for Agriculture Research) application. If when analyzed there was a significant difference found the data was further analyzed using Duncan's Multiple Range Test with $\alpha = 5\%$.

The Procedure for Producing Star Fruit Waste Compost

The making of star fruit waste compost started by:

1) Pruning of 50 kg star fruit leaves. pruning was carried out for 3 days to collect enough leaves and twigs for materials for making the compost.
2) Separation of leaves and twigs. This was done conventionally with a machete.
3) Chopping leaves using a leaf chopper machine. This process was repeated 3-4 times so that the organic material reaches a size of 2-3 cm. If the organic material is too fine (<1 cm), it will experience compaction and will damage the process of oxygen availability so that organic matter will be moist and the decomposition process will be hampered.
4) Sorting and collecting residual fruit to collect 50 kg star fruit. The fruit to be composted was sorted by criteria: the size of small to medium and yellow-brown star fruit. The yellow-brown star fruit was selected due to the sufficient water content available in the star fruit to make it easier when pounding takes place

5) Pounding of residual star fruit. The fruits collected were pounded until becoming mush so they can decompose properly.
6) Preparation of the solution, namely with 5 liters of water, 3 liters of molasses, and 50 ml of EM-4 then mixed for the bacterial culture process. The mixture was then fermented for 1x24 hours.
7) Accumulation of organic matter. Chopped leaves and pounded fruit were mixed and the prepared solution was administered to the organic material.
8) Storage for 4 weeks. The mixture was stirred twice a day while in storage. After that, the pH and temperature were measured.
9) Compost was ready to use

The Application of Star Fruit Compost to Mustard Cultivation:

1) Mustard seeds were planted in a seedling tray with a planting medium with a ratio of 1:1:1.
2) Before transplanting, a medium for planting the seedling was prepared. The soil was mixed with star fruit compost with the soil in the polybag is mixed with compost and left for 1 week
3) Transplant from tray to polybag when Mustard seedlings had 4 leaves
4) Observations started after transplanting

Results and Discussion

Nutrient Content of Attaqie Farm Soil

The analysis of soil samples from Attaqie Farm was conducted at Soil Research Center, Bogor. The results showed that the soil sample was suitable for cultivation, as Attaqie Farm was a productive star fruit orchard. Table 1 shows the analysis results of the soil sample. The compost contained N, P, K, Ca, and Mg. The nutrients can affect the growth of cultivated plants. And from the results, it is shown that the N-total of the soil was 0.27% which is categorized as moderate according to Soil Research Center (2009).

The soil sample also had natural P content in the form of phosphate which involves the synthesis of protoplasm and then decomposed with phosphate bacteria (Andraski et al. 1985). The high P content in the soil is not fully absorbed by plant roots. Nutrients bound by cations of micronutrients such as Ca and Mg will be deposited in the soil and cannot be absorbed (Hanafiah 2005). According to Puspitawati & Sumiasih (2021), phosphorus nutrients in the soil with low pH (acidic) cannot be available for plants. The additional compost in the soil can help to make phosphate available for plants and also support microbes in the soil.

Table 1. Attaqie Farm Soil Nutrient Content

Soil Parameter	Value	Unit	Criteria
pH H2O	6.50	-	Slightly acidic
KCL	5.92	-	Slightly acidic
C-Organic	2.00	%	Moderate
N-Total	0.27	%	Moderate
P*	59.9	ppm	High
P	1.045	ppm	-
Ca	19.65	cmol(+)/kg	High
Mg	6.30	cmol(+)/kg	High
K	1.56	cmol(+)/kg	Very High
Na	0.89	cmol(+)/kg	High
KTK	22.74	cmol(+)/kg	Moderate
Al	tr	cmol(+)/kg	-
H	0.69	cmol(+)/kg	-
Fe	12.0	ppm	High
Cu	3.8	ppm	Sufficient
Zn	3.9	ppm	Sufficient
Mn	49.6	ppm	High
Sand	11.44	Texture (Pipette Methods)	-
Dust	35.35	Texture (Pipette Methods)	-
Loam	53.21	Texture (Pipette Methods)	-

Notes: Attaqie Farm soil sample analysis results from Bogor Soil Research Center. Criteria based on Soil Research Center (2009).

Nutrient Content of Star Fruit Waste Compost

Nutrient content in compost will affect plant growth from root to shoot. The nutrient content of star fruit compost is shown in Table 2. The presence of nutrients showed that there had been a decomposition process by thermophilic bacteria during composting so the organic material turned into available nutrients. C-organic was the parameter to determine the organic matter available in star fruit waste compost. The ratio of C/N in the first month of the composting process had already met the compost SNI quality standard.

The readiness of organic compost can be seen in Table 2, that in the first- and third-month N, P, and K had increased. Nitrogen (N) in the compost is needed by the mustard plant, especially in the vegetative period (Kurniawan et al. 2017). According to Puspitawati & Sumiasih (2021), the accumulation of photosynthate in the generative phase of star fruit resulted in a good nutrient amount in the star fruit compost.

The addition of molasses and Local Micro-organism (LMO) in the compost-making process was helpful because the LMO supported by molasses breaks down organic material. Anaerobic bacteria working to decompose the organic matter in a compost pile causes the

pile to warm up. As the temperature rises, different organisms thrive, such as thermophilic and mesophilic bacteria. All the bacteria are active to continue the organic material degradation process.

The making of star fruit compost is also supported by environmental factors. In this study, acidity level (pH) and temperature were observed. When pH reached >8, lime was added and when the temperature reached > 70 the compost pile was mixed thoroughly to reduce the temperature.

Table 2. Nutrient Content of Star Fruit Waste Compost from Attaqie Farm

Parameter	Compost 1 month	Compost 3 month	Compost 6 month	Quality Minimum
		Value		
C-Organik	51.53	49.90	45.61	27
C/N	19	16	37	20
Kadar air	68.8	76.7	83.01	50
pH	9.1	9.0	8.8	7.49
Hara Makro : N	2.78	3.06	1.22	0.40
P	0.88	0.44	0.62	0.10
K	2.70	2.50	4.57	32
Ca	2.65	2.36	3.46	25.50
Mg	1.34	1.25	1.63	0.60
S	0.01	0.03	0.02	-

Notes: Quality minimum from SNI No,19-7030-2004. Source: Soil Research Institute Test Result (2021), Bogor

Mustard Harvest

In this study, mustard was harvested 4 weeks after planting (WAP). The criteria for mustard that was ready to be harvested had 8-9 leaves, leaves were fully developed in an oval shape, leaf color was green all around, stalk color was light green, and plant height was adequate. Figure 1 showed mustard samples from different compost dosages. There was no significant visual difference among harvested mustard. However, the absorbed nutrient can affect plant growth and the yield of mustard (Brassica rapa L.). According to research by Habibi et al. (2017), the addition of compost in the soil can support the symbiotic relationship between bacteria and mustard. This symbiosis can improve the absorption of N through the root nodule, to support mustard growth.

Figure 1: Comparison of mustard at various doses of starfruit waste compost. d0: control, d1: 10 tons/ha, d2: 20 tons/ha, d3: 30 tons/ha, d4: 40 tons/ha.

Research Parameters Results (plant height, leaf width, number of leaves, yield)

Mustard plants were planted in the soil mixed with star fruit waste compost with different dosage levels. The growth of mustard (Brassica rapa L.) was observed for 4 weeks and the results are shown in Table 3. The different treatments led to various results in all parameters. The plant height was measured from the ground to the highest shoot of mustard. From the plant height parameter at 4 WAP, it is shown that the addition of 40 to/ha (equal to 80 g/polybag) resulted in an average plant height of 14.78 cm.

Nutrients given to mustard by compost resulted in good growth compared to 0 ton/ha treatment. According to Maulana & Sumiasih (2022), the use of starfruit waste compost had an effect due to the presence of nitrogen in the compost to increase mustard growth. Furthermore, the compost was mixed with the soil a week before transplanting, so that the soil absorbs nutrients for plants. This is in accordance with Ismayanti et al. (2020)

Leaf width was a parameter to determine growth in leaves. The increase in leaf width is influenced by the absorption of nutrients available in the soil. If the nutrient content is available and adsorbed by the plant, then photosynthate and protein will increase and result in a wider leaf (Jatra et al. 2021). The results of the leaf width parameters were significantly different with an error rate of 5%. The dose of starfruit waste compost at 30 tons/ha resulted in a leaf width of 5.42 cm. However, the optimum dosage was 20 tons/ha since the result (5.17 cm) was not significantly different from the 30 tons/ha treatment. If too much compost is applied, it would disturb the growth in the vegetative phase. Thus, optimization is needed to avoid nutrient toxicity in plants. Nitrogen is responsible for converting carbohydrates into proteins, which are then used as protoplasm to increase leaf growth and widening (Handayani & Elfarisna 2021).

Table 3. Observation results at 4 WAP (weeks after planting)

Treatment	Plant height (cm)	Leaf width (cm)	Number of leaves	Yield (g)
d0 (0 ton/ha)	13.93	4.72 bc	8.50	9.26
d1 (10 ton/ha)	13.48	4.59 c	8.00	7.79
d2 (20 ton/ha)	14.53	5.17 ab	9.00	9.74
d3 (30 ton/ha)	14.37	5.42 a	8.92	10.23
d4 (40 ton/ha)	14.78	5.31 a	9.00	10.09

Notes: d1: 10 ton/ha, d2: 20 ton/ha, d3: 30 ton/ha, d4: 40 ton/ha. Numbers followed by the same letter showed no significant difference using Duncan's multiple range test (DMRT) with $\alpha = 5\%$.

The number of leaves was analyzed using the STAR application to see the effect of various doses of compost. The observation results at 4 weeks showed that the number of leaves was not significantly different across treatments. This was because the nutrients available in the starfruit waste compost were sufficient for the development of leaves. According to Latarang & Syakur (2006), the addition of compost helps the plant to be able to get nutrients so that the number of leaves reached optimal results. The formation of leaves in leafy vegetables in the development phase is determined by the number and size of cells which are influenced by the availability of nutrients in the compost.

Harvested yields in this study were not significantly different across various treatments given. Excessive use of compost would result in abnormal conditions such as wetter mustard tissue, delayed production period, and shortened vegetative phase. If these conditions occurred, it would affect the yield of the harvested mustard (Roidi 2016). The mechanism of action of compost in plants is by releasing organic substances which are then absorbed by normal root hairs, and accumulation of compost in the rhizosphere (Habibi et al. 2017).

Leaf Color

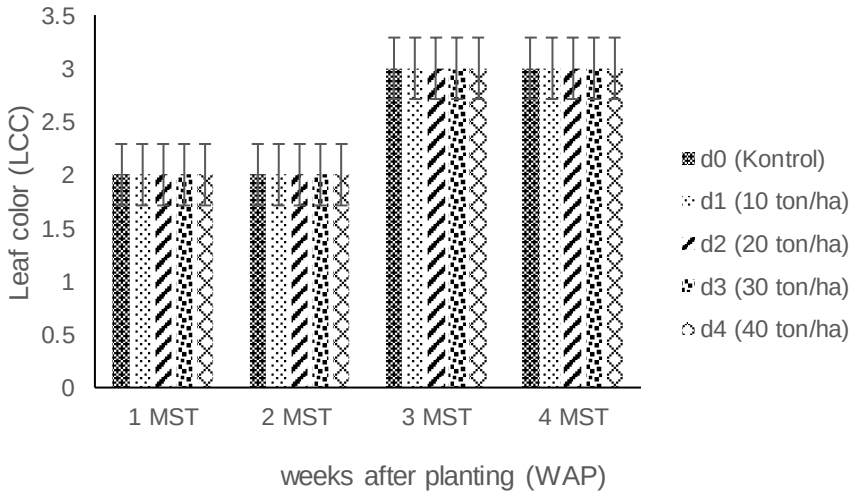

Figure 2: Leaf Color Of Mustard With Star Fruit Compost As Treatments

The measurement for leaf color was conducted using Leaf Color Chart (LCC) to see the function of nitrogen (N) in plant leaves. The use of starfruit waste compost had no significant effect on leaf color, which can be seen in Figure 2. For mustard leaves, a score of 3 showed that mustard had sufficient N nutrients and also had no chlorosis symptoms in the leaves. When there is a lack of N nutrients, the chlorophyll content in the leaves would be lost and the leaves would be yellowish green. Leaves have a function to carry out photosynthesis to get the energy from the sun (Vivonda et al. 2016).

Root Weight

The analysis of variance results through the calculation of the STAR application showed that the highest root weight was at 30 tons/ha compost, although there was no significant effect on the 5% error level. The ability of roots to absorb water is directly related to the value of root weight (Salisbury & Ross 1995). The appropriate application of compost would make the root grow better, as shown by the various weights of mustard roots with the treatment of starfruit waste compost dosage. The differentiation process in mustard proves that there is a growth process in root weight (Munthe et al. 2018).

Table 4. The Effect of Compost on Mustard Root Weight

Treatment	Root weight (g)
Dosis Pupuk kompos	
d0 (control)	0.56
d1 (10 tons/ha)	0.59
d2 (20 tons/ha)	0.47
d3 (30 tons/ha)	0.60
d4 (40 tons/ha)	0.48

Notes: d1: 10 tons/ha, d2: 20 tons/ha, d3: 30 tons/ha, d4: 40 tons/ha. The results showed no significant difference using Duncan's multiple range test (DMRT) with $\alpha = 5\%$.

Root Length

Plant root length is a parameter to estimate the ability of the root to absorb nutrients from the soil. When plants have longer roots, they will have a better yield. The results from this research showed that there was no significant difference in root length across all star fruit compost treatments. However, the mustard plants had enough nutrients and the roots were well developed.

Table 5: The effect of Compost on Mustard Root Length

Treatment	Root length (cm)
Compost Fertilizer Dosage	
d0 (Control)	7.76
d1 (10 tons/ha)	8.00
d2 (20 tons/ha)	7.13
d3 (30 tons/ha)	8.23
d4 (40 tons/ha)	7.99

Notes: d1: 10 tons/ha, d2: 20 tons/ha, d3: 30 tons/ha, d4: 40 tons/ha. The results showed no significant difference using *Duncan's multiple range test* (DMRT) with α = 5%.

Conclusion

Nutrients in the star fruit waste compost showed good results for compost criteria according to SNI 19-7030-2004 standard. The star fruit compost was ready to use and effective in the 3rd month. The results of observations of the potential use of star fruit waste compost for mustard showed that some of the parameters had no significant difference. There was a significant difference in leaf width, with the dose level of 30 tons/ha resulting in the highest leaf width. However, the effective compost dose was 20 tons/ha (equivalent to 40 g/polybag). Sustainable agriculture at Attaqie Farm was fairly well run because Attaqie Farm was able to utilize waste from one system to another in its ecology.

Acknowledgment

The author would like to express gratitude to the Ministry of Education and Culture through the University Excellence Applied Research Grants, Trilogi University, and Attaqie Farm Tuban East Java which have facilitated the research.

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