

Original Research Article

Usage of Seaweed Base Organic Fertilizer as Yield Booster at Volcanic Soil: Effect on Soil Quality and Yield of Patchouli (*Pogostemon Cablin*)

Sures Narayasamy^{1*}, Mohamadu Boyie Jalloh²

¹Department of Agrotechnology and Bioindustry, Politeknik Sandakan Sabah, Jalan Sungai Batang, 90000, Sandakan Sabah, Malaysia, sures@pss.edu.my

²Department of Crop Production, Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Locked 3, 90509 Sandakan Sabah, Malaysia, m.boyiej@gmail.com

*Corresponding author: Sures Narayasamy, Department of Agrotechnology and Bioindustry, Politeknik Sandakan Sabah, Jalan Sungai Batang, 90000, Sandakan Sabah, Malaysia, sures@pss.edu.my

Abstract: Patchouli (*Pogostemon cablin Benth.*) is a bushy herb and native to tropical region of Asia, and now cultivated for its essential oil which usually used in perfume productions. It is also widely been used throughout the world to treat skin conditions, relieving depression, controlling appetite, and antifungal agents. It is cultivating commercially in Tawau, Sabah for export purposes and the average oil production is up to 26–29 mt per acre in 2016. As they enter the second and third harvesting cycle, the production starts to decline and reach 2.6 mt of oil per acre. This drop-in yield is thought to be either due to soil variabilities, low nutrient levels in volcanic soil, and diseases. Soil nutrient analysis and leaf coloration patterns are studied before conducting the study. Seaweed extract, banana peel, the mixture of Seaweed extract and banana peel, and pre-formulated 12-12-12 (N-P-K) organic fertilizer (PFF) fertilizer treatments were engaged in the Patchouli plot field experiment. Besides, the agronomical practice for the cultivation of Patchouli is well documented. The pre-study showed that the study plot has a very low conductivity level, a very low organic Carbon level and low Cation Exchange Capacity (CEC) level. Meanwhile, there were no diseases or nematode occurrences in the area. Plant height, soil pH, and soil conductivity were studied with all the four treatments that have shown a positive significant impact compared with standard estate practice. The treatments using seaweed and seaweed mixture had the highest significant level with a slight reduction in soil pH. Whereas plant height data analysis showed that the seaweed mixture was significantly different compared with other treatments at a 0.05 level. Hence, we recommend the Patchouli plantation to use organic fertilizers including the mixture of seaweed since it is cheap and easily available in Sabah.

Keywords: Seaweed extract; banana peel; soil pH; soil CEC and organic fertilizer.

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1. Introduction

Volcanic soils cover 1% of the Earth's surface yet support 10% of the world's population, including some of the highest human population densities. This is usually attributed to their high natural fertility. However,, this is true only in part. Such soils represent the surface areas of our planet that are being replenished with new minerals escaping from the interior of the Earth (Neall, 2009). The land around volcanoes is intermittently attacked by pyroclastic flows, volcanic ash deposition, lahar deposition, and others. This volcanic ejecta or tephra contains various silicates and other minerals of different sizes such as volcanic glass, feldspars, quartz, hornblende, hypersthene, augite, magnetites, biotites, and apatites. After tephra deposition, soil formation starts, the tephra element and mineralogical composition changes, and volcanic ash soils or andisols having unique properties are formed. Many plant nutrient elements are provided to the soil environment during soil formation (Nanzyo, 2002). Volcanic soils are considered fertile soils and suitable for agriculture activities as it contains carbon and minerals, yet it is not as fertile as claimed previously. Volcanic soils are lacking in micronutrients such as Copper (Cu), Zinc (Zn), and Carbon Monoxide (CO). This is due to the availability of these micronutrients in volcanic ash and on their release rates by chemical weathering (Shoji & Takahashi, 2002) Moreover, the percentage of readily mineralizable organic nitrogen (N) in the pool of organic N is rather small in volcanic ash soils. The previous study done by Moritsuka and Saito (2019) comparing the N mineralization potential (NO) to the pool of total organic nitrogen (N) between volcanic ash soils and non-volcanic soils from north-eastern Japan, showed that the percentage of mineralizable of volcanic ash soils is less than that of non-volcanic soils. According to (Kim & Stoecker, 2006), the use of chemical fertilizers has increased significantly to increase the agricultural productivity, and one of the purposes of using chemical fertilizers is to help nutrient-deficient volcanic soils. Liquid organic base fertilizers are an alternative fertilizer that can be used to reduce the usage of chemical fertilizers since chemical fertilizers can cause pollution and degeneration the soil quality (Lin, *et al.*, 2019). Therefore, the use of organic fertilizer is a good solution to avoid harmful effects and risks either to the environment or to humans (Chandini, *et al.*, 2019).

Other than that, excessive usage of chemical fertilizers in agriculture, resulting in many environmental pollutions due to the heavy metal contents such as cadmium and chromium (Savci, 2012). While chemical fertilizers have been claimed as the most important contributor to the increase in agricultural productivity, it will negatively affect both the environment and humans (Kashi & Olfati, 2012). Chemical fertilizers cause water pollution, soil pollution, air pollution, and bring health issues (Iberdrola, 2020). Nitrogen in agricultural areas reaches the water environment in three ways such as drainage, leaching, and flow. The second effect is the effect on soil pollution. According to previous research, the impact of chemical fertilizers on land is not very clear. However, the effects of chemical fertilizers suggest that the emergence of pollution, reduced soil fertility, and soil degradation reactions occur in the soil. The third effect is affecting air pollution where chemical fertilizers too much

applied, it causes air pollution by nitrogen oxides (NO, N₂O, NO₂) emissions (Savci, 2012) According to (Sharma & Singhvi, 2017), agrochemicals or chemical fertilizers are cause serious hazards to humans that cause endocrine, immune systems, may promote the development of cancer, and causes the escalation of deadly the disease like chronic kidney disease. Therefore, we should consider using organic fertilizer since it is can produce healthy vegetables and plants for consumption. Fruit peels are the best-known source of macronutrients and micronutrients. These are the cheapest and harmless materials are used for plant growth (Jariwala & Syed, 2016). Furthermore, food waste is an inevitable problem everywhere, restaurants, residential houses, food service providers, and so on. Food waste is an issue that is mostly neglected or disseminated. Although, it is a concern for many farmers, not everyone is ready to take it seriously. Food waste usually occurs at the retail and consumer levels in the food value chain. This is due to negligence or conscious decision to remove food. According to Hussein (2019), the banana peel extract enhances the seed germination rate of tomato and fenugreek to 97%.

Seaweed is macroscopic algae which form an essential element of marine renewable resources. These nutrient-rich algae have washed up on seashores throughout the world that can be dried for simple transportation, or integrated wet into compost. It is also an excellent supply of plant nutrients, such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) (Gardening Channel, 2020). Seaweed also contains all the 19 essential elements needed for plant growths as well as the trace elements (Andrew, *et al.*, 2015) (Nedumaran, 2017). Seaweed extract is widely used in agriculture especially in the horticulture industry. When applied to fruit, vegetable, and flower crop, it improves the nutrient uptake, expands resistant towards diseases and insects, and increase seed germination rate (McHugh, 2003). Moreover, seaweed also acts as a bio stimulant to surge the yield and growth of vegetables and leafy trees (Mohanty *et al.*, 2013).

The objectives of the study were to used seaweed as an alternative organic fertilizer at Patchouli plantation in the volcanic area, and to reuse the banana peels as fertilizer which will reduce agricultural waste. The parameters studied were soil pH and plant height with all the parameters were analyzed using SPSS v24 at α 0.05 significant level.

2. Materials and Methods

2.1. Seaweed Extract Preparation

The organic seaweed and banana extract plant booster were developed using the method recommended by Bhosle *et al.*, (1975). in which chopped seaweed was boiled with distilled water and then filtered. The ratio of seaweed and distill water for boiling is 1:1 (1 kg seaweed: 1 liter water). The filtrate was taken as a 100% concentration of the seaweed extract. Finally, the seaweed extracts were stored in a covered tank to avoid contamination (Figure 1).

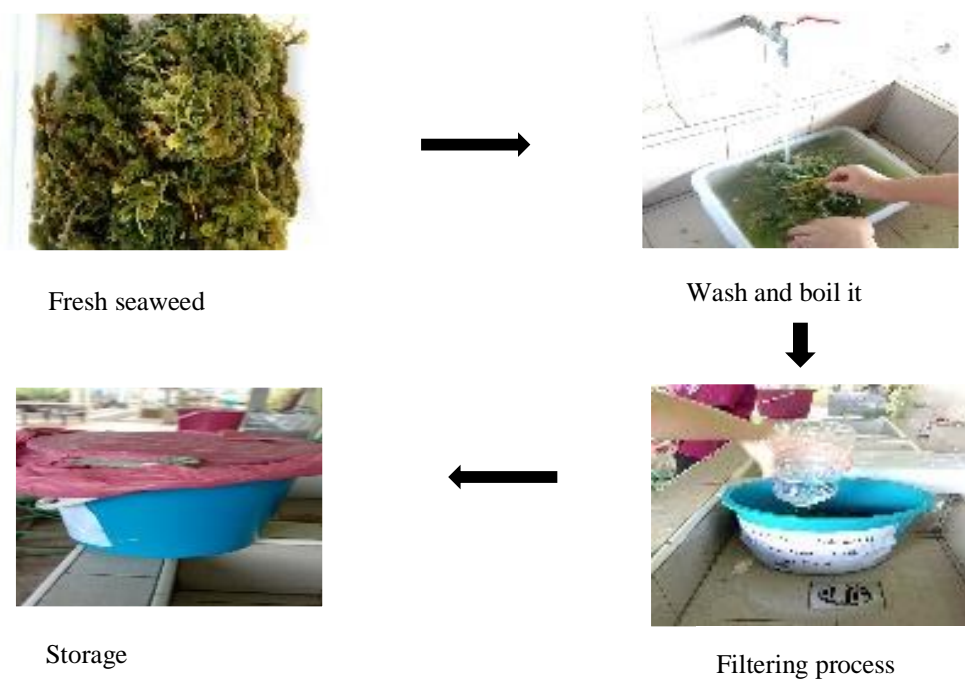
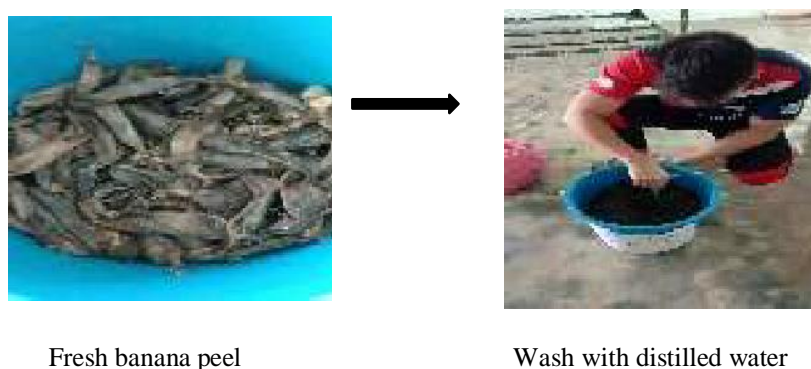


Figure 1. The seaweed extract preparation process.

2.2. Banana Peel Preparation

Meanwhile, the banana peel extract was prepared to wash the peel using distilled water followed by mash/grind it is using the grinder to prepare a banana peel puri. The puri can store in the refrigerator for more than 2 months while it can keep much longer in cold storage. It was prepared in such a way that we can mix it in distilled water when needed (Figure 2).



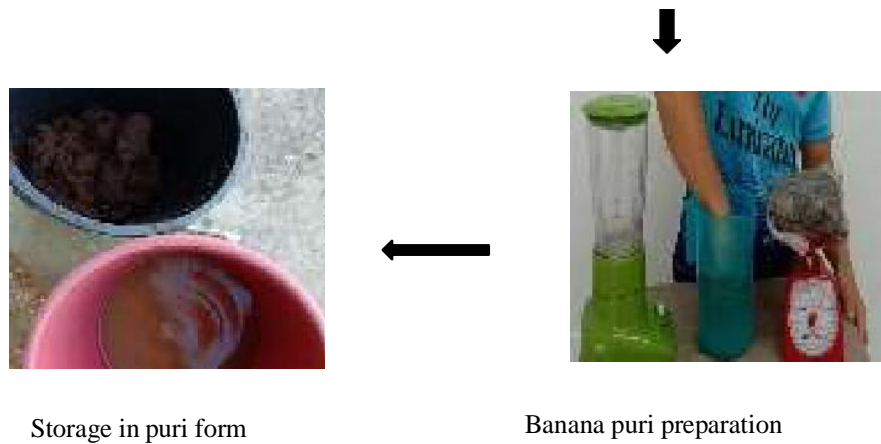


Figure 2. The banana peel extract preparation process.

2.3. Nutrient Analyst of Seaweed and Banana Peel Extract

The extracts were analyzed for nitrogen (N) and phosphorus (P) contents before diluting it with distilled water using La Motte SMART3 colorimeter. The reading of the colorimeter was recorded to determine the level of N and P in both the extracts.

2.4. Testing at Patchouli Plot

After the nutrient test both the extracts were diluted using distilled water (Figure 3) at the rate of 10% since it contains a very high level of N and P. The prepared organic seaweed and banana peel extract were tested on patchouli shrubs that cultivated in volcanic soil (Figure 4). A total of 4 treatments involved in this study with the first plot applied with seaweed extract alone (100 ml), the second plot tested with banana extract alone (100 ml), the third plot tested with both seaweed and banana (1:1) (50 ml:50 ml) and the last plot was treatment with commercial organic fertilizer (100 g) at the frequency of 30 days for 3 rounds before data collection. Experimental design used for the study were RCBD with each plot covers an area of 16m x 10m with an average of 30 Patchouli plants per plot. Each treatment has 5 replicates for plant height and 4 replicates for soil pH. All the plant boosters were supplied via hand spraying methods (Figure 5). Randomized samplings were done each time before application.



Figure 3. Extract of seaweed and banana peel after dilution



Figure 4. The Patchouli plot.



Figure 5. Hand spraying and tagging of Patchouli plant.

3. Results

3.1 Plant Height

A total of 4 treatments were conducted with the difference in plant height, before and after treatment was recorded after 90 days.

Table 1. The patchouli plant height before treatments and after treatments with 5 replicates.

<i>Highest of Plant (Cm)</i>												
<i>R</i>	<i>PLOT A (S)</i>			<i>PLOT B (B)</i>			<i>PLOT C (B+S)</i>			<i>PLOT D (O)</i>		
	<i>bfr</i>	<i>after</i>	<i>dif</i>	<i>bfr</i>	<i>after</i>	<i>dif</i>	<i>bfr</i>	<i>after</i>	<i>dif</i>	<i>bfr</i>	<i>after</i>	<i>dif</i>
1	40.5	43.7	3.2	30.5	31.6	1.1	27.6	28.9	1.3	45.5	47	1.5
2	37	40.1	3.1	33.5	34.1	0.6	46	49.2	3.2	42	42.4	0.4
3	37	38.1	1.1	35.5	35.6	0.1	50	51.3	1.3	41	41.5	0.5
4	21	23.2	2.2	47.3	47.9	0.6	38	39.3	1.3	26.3	27	0.7
5	36.5	36.9	0.4	22.5	24	1.5	22	25.7	3.7	28	28.3	0.3
<i>Ave</i>	34.4	36.4	2	33.86	34.64	0.78	36.72	38.88	2.16	36.56	37.24	0.68

The average height of the selected patchouli plants was 35.39 cm before treatment, and it increased to 36.79 cm within 1 month after the initial treatment. The Patchouli plants treated with the mixture of seaweed and banana show the highest difference in average plant height with 2.16 cm while the treatment with standard organic fertilizer shows a slight increase in plant height with 0.68 cm from the initial height (Table 1). The result obtained was similar to the study done by (Isleib, 2016) where liquid fertilizers are easy to blend in soil, and uniformity of application can be obtained with it compared with granular fertilizers.

3.2. Soil pH

The treatments with seaweed, banana peel, and the mixture of both seaweed and banana peel have increased slightly over the 1 month with the treatment with banana peel have the highest shift in the pH value up to 1.2. meanwhile, both the treatments with seaweed and mixture of seaweed and banana peel have increased the volcanic soil pH value at an average rate of 0.25 and 0.2875 respectively (Chart 1). This is due to the pH value of the fertilizers itself with pH value seaweed is 6.7 while the pH value of the banana peels was 9.8. This is similar to the study done by Ji (2017) about the effects of liquid organic fertilizers on plant growth and rhizosphere soil characteristics of Chrysanthemum shows that the initial pH value of seaweed extract was 7.1 and the pH value of plant decomposition were 10.4. This is similar to the pH value of the seaweed and banana peel of the treatments. The soil pH of the plot treated with organic NPK shows contrast results as the Nitrogen and Carbon in that fertilizers makes the soil acidic. This finding and statement supported by McCauley *et al.* (2017) where nitrogen base fertilizers such urea (46-0-0) and ammonium phosphates (11-52-0 or 18-46-0) can slowly lower pH of basic soils.

Chart 1. The soil pH value before and after treatments by seaweed, banana peel, the mixture of banana peel and seaweed and organic NPK fertilizer

TREATMENTS		before	after	dif
PLOT A (Seaweed)	R1	5.4	5.6	0.2
	R2	5.1	5.3	0.2
	R3	5.15	5.45	0.3
	R4	5	5.3	0.3
PLOT B (Banana peel)	R1	5.4	6.6	1.2
	R2	4.9	5.7	0.8
	R3	5.05	5.95	0.9
	R4	4.65	5.75	1.1
PLOT C (banana peel + seaweed)	R1	5.6	5.7	0.1
	R2	5.45	5.75	0.3
	R3	5.7	5.8	0.1
	R4	5.15	5.8	0.65
PLOT D (Organic NPK)	R1	5.4	4.9	-0.5

R2	5.7	4.9	-0.8
R3	5.4	5.1	-0.3
R4	5.85	5.5	-0.35

4. Discussion

Moreover, the statistical analysis also showed that the treatment with the mixture of seaweed and banana were significantly different compared to the treatment with banana and organic pellet fertilizer at significant level $\alpha = 0.05$. Meanwhile, statistically, there are no significant differences between the other treatments as well (Table 2). This is because of the high amount of carbon and nitrogen with trace elements in the seaweed that easily bind with soil. The volcanic soil at Merotai, Tawau is low in Carbon and CEC that makes it difficult to supply nutrients to the Patchouli plants. With the application of seaweed, the carbon content in the soil improves slightly that allow the Patchouli plant uptake nutrients. The result obtained was supported by a study done by Andrew (2015) about seaweed compost for agricultural crop production in which the yield is affected by C: N ratio. Moreover, our findings are similar to study done by Angela, on effects of seaweed on soil quality and yield of sweet corn in 2013 shows that the carbon in soil increases from 492 mg C/kg to 608 mg C/kg after the soil treated with seaweed-based fertilizers. This shows that with the application of seaweed and banana extracts, the carbon level of the soil increases and allowed the nutrients available to the patchouli plant.

Although the volcanic soil pH varied significantly between the treatments (Table 3), two-way ANOVA analysis showed that there are significant differences between the treatment except for the treatment between seaweed, mixture of seaweed and banana peel where the p-value is higher than alpha (0.05).

Table 2. A *t*-test of two samples assuming equal variances analysis of the patchouli plant height.

	Plot A (S)	Plot B (B)	Plot A (S)	Plot C (B+S)	Plot A (S)	Plot D (O)	Plot B (B)	Plot C (B+S)	Plot B (B)	Plot D (O)	Plot C (B+S)	Plot D (O)
Mean	2	0.78	2	2.16	2	0.68	0.78	2.16	0.78	0.68	2.16	0.68
Variance	1.515	0.29	1.515	1.42	1.515	0.23	0.287	1.42	0.287	0.23	1.418	0.23
Observations	5	5	5	5	5	5	5	5	5	5	5	5
Pooled Variance	0.901		1.4665		0.8735		0.8525		0.2595		0.825	
df	8		8		8		8		8		8	
t Stat	2.0322		-0.20891		2.23312		-2.36321		0.31039		2.5763493	
P(T<=t) one- tail	0.0383		0.41987		0.02801		0.02286		0.38210		0.0164010	
t Critical one- tail	1.859548		1.859548		1.859548		1.859548		1.859548		1.859548038	
P(T<=t) two- tail	0.076595		0.8397435		0.0560234		0.0457287		0.7642001		0.032802021	
t Critical two-tail	2.306004		2.3060041		2.3060041		2.3060041		2.3060041		2.306004135	

**P* (two tail) value is higher than alpha 0.05 shows that there are no significant differences between the treatments.

Table 3. Two way ANOVA analysis assuming equal variances analysis of the difference in soil pH.

	PLOT A (S)	PLOT B (B)	PLOT A (S)	PLOT C (B+S)	PLOT A (S)	PLOT D (O)	PLOT B (B)	PLOT C (B+S)	PLOT B (B)	PLOT D (O)	PLOT C (B+S)	PLOT D (O)
Mean	0.25	1	0.25	0.2875	0.25	-0.4875	1	0.2875	1	-0.4875	0.2875	-0.4875
Variance	0.0033	0.0333	0.0033	0.0673	0.0033	0.0506	0.0333	0.0673	0.0333	0.0506	0.0673	0.0506
Observations	4	4	4	4	4	4	4	4	4	4	4	4
Pooled Variance	0.0183		0.0353		0.0270		0.0503		0.0420		0.0590	
df	6		6		6		6		6		6	
t Stat	-7.8335		-0.2822		6.3498		4.4922		10.2673		4.5138	
P(T<=t) one- tail	0.0001		0.3936		0.0004		0.0021		0.0000		0.0020	
t Critical one- tail	1.9432		1.9432		1.9432		1.9432		1.9432		1.9432	
P(T<=t) two- tail	0.0002		0.7873		0.0007		0.0041		0.0000		0.0040	
t Critical two- tail	2.4469		2.4469		2.4469		2.4469		2.4469		2.4469	

5. Conclusion

The results show that the mixture of seaweed and banana works well as plant booster as they increase the plant height and improve volcanic soil pH at a significant rate compared with other treatments. Meanwhile, the organic NPK fertilizers have minor effects on the plant height and reduce the soil pH within the treatment period. Prolong application of organic NPK in the same area will significantly drop the volcanic soil pH at a vigorous rate. This is due to the nitrogen sources in the fertilizer (Ji *et al.*, 2017). Therefore, it is recommended that seaweed extract is a good source of plant booster as it improve the plant height without deteriorate the soil quality. At the same time utilizing readily available resources as fertilizer will improve the Gross Domestic product (GDP) of Malaysia and will increase job opportunities to the surrounding community.

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