PHYSIOLOGICAL RESPONSE OF PALM PLANTS (Arenga pinnata (Wurmb.) Merr.) AT VARIOUS ALTITUDES AND BIOCHAR APPLICATION

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Abstract. This research aims to determine the influence of height factors and the provision of biochar on the yield of sugar palm sap. The research was carried out in areas where sugar palm plants grow which include river basins and hills in Semaya Hamlet, Sunyalangu Village, Karanglewas District, Banyumas Regency and the Food Technology Laboratory, Jenderal Soedirman University with a split plot experimental design with 2 factors each. 3 levels each. The first factor, altitude, is 250 < x ≤ 450 m above sea level (K0), 450 < x≤ 650 (K1), and > 650 m above sea level (K2). The second factor is the administration of various doses of biochar consisting of 0 g biochar (B0), 750 g biochar (B1), and 1,500 g biochar (B2). The variables observed are the volume of sap per day, sugar content in Brix degrees, pH of the sap, sugar sucrose, and reducing sugar. The experimental data obtained were analysed using analysis of variance (ANOVA) at the 5% level and continued with the DMRT test (Duncan Multiple Range Test). The research results obtained were that the altitude factor had a significant effect on the volume of sap per day, sugar content in degrees Brix, and viscosity of the sap. Meanwhile, administering various doses of biochar affected the variable volume of sap per day. There was no interaction between the altitude factor and the provision of biochar on all observation variables.

Keywords: sugar palm sap, altitude, biochar, degrees brix

A. Introduction

Aren (Arenga pinnata) belongs to the Arecaceae (areca nut) family, and is a closed-seed plant (Angiospermae) which means the fruit seeds are wrapped in fruit flesh. Aren plants are widely found from the east coast of India to Southeast Asia. In Indonesia, aren grows in 29 provinces with an area of 63,244 ha. Aren grows in areas with relatively high and even rainfall throughout the year. 10 provinces have aren plants with large areas, namely Aceh, North Sumatra, Bengkulu, Banten, West Java, Central Java, South Kalimantan, North Sulawesi, South Sulawesi, Southeast Sulawesi, and West Sulawesi (6). Aren, commonly called enau, is a palm family with high economic value potential. The aren plant is a palm plant with high fructose and sucrose content. Therefore, the flowers of the aren plant are usually tapped for sap to be used. This plant can be used as a plant that produces sap, a source of renewable energy, a source of carbohydrates, a mixture of food and drinks (sugar palm), building materials (stems) and as a conservation plant for critical land (8).

Sugar palm plant production in 2021 reached 107,415 tons, decreasing in 2022 to 106,867 tons. (6). Fluctuating production occurs because farmers tend to let sugar palm plants grow wild without intensive maintenance. (13). In addition, according to (23), several challenges can cause fluctuating production, including minimal technological input, production management,

processing, and marketing (17). Dissemination is still limited to a small number of farmers and the availability of superior seeds. Increasing the production of sugar palm plants can be done by increasing technological inputs such as providing soil conditioners. Soil conditioners are useful for increasing the soil's ability to bind nutrients, especially basic cations so that fertilization becomes efficient. (17).

In this study, a soil conditioner of the biochar type made from empty oil palm bunches was used. Biochar is a solid product of pyrolysis of organic material that is intrinsically resistant to microbial decomposition so that it can potentially remain in the soil for hundreds of years. (21). The provision of a biochar mixture can increase the ability to absorb water. The provision of biochar can increase the pH value of the soil because biochar has a high pH so if mixed with the soil, the pH of the soil will be higher than before. If the results of water absorption and pH increase, soil retention will also increase because the soil can maintain water content and nutrients (1).

The objectives of this study were to determine the effect of altitude on the yield of aren palm sap, 2) to determine the effect of biochar administration on the yield of aren palm sap, 3) and to determine the effect of the interaction between altitude and biochar administration on the yield of aren palm sap.

B. Methods

The research was conducted in the area where the sugar palm grows, which includes the river basin and hills in Semaya Hamlet, Sunyalangu Village, Karanglewas District, Banyumas Regency and the Food Technology Laboratory, Jenderal Soedirman University. The materials used in this study were sugar palm plants in Sunyalangu Village, biochar, acetone, distilled water, anhydrous glucose, Nelson's reagent, arsenomolybdate reagent, 25% HCl, and 15% NaOH. The tools used in this study included hoes, pH meters, altimeters, Global Positioning System (GPS), lux meters, latex gloves, test tubes, test tube racks, scissors, mortars and pestles, digital scales, droppers, 2 ml volume pipettes, 10 ml volume pipettes, 10 ml measuring cups, 100 ml measuring cups, 5 litres measuring cups, 100 ml beakers, 500 ml beakers, boiling flasks, 250 ml Erlenmeyer flasks, spray bottles, spectrophotometers, water baths, vortexes, and stationery.

The experimental design used was a split plot with 2 factors of 3 levels each. The first factor was the altitude, namely $250 < x \leq 450$ masl (K0), $450 < x \leq 650$ (K1), and > 650 m asl (K2). The second factor was the provision of various doses of biochar consisting of 0 g biochar (B0), 750 g biochar (B1), and 1,500 g biochar (B2).

The variables observed were the volume of sap per day, sugar content in degrees Brix, sap pH, sucrose sugar, reducing sugar, sap viscosity, and sap colour. The experimental data obtained were analysed using analysis of variance (ANOVA) at the 5% level, followed by the Duncan Multiple Range Test (DMRT) at the 5% level.

C. Results And Discussion

1. The volume of sap per day (litre)

Table 1 shows that the altitude factor and biochar administration significantly affect the volume of sap per day. There is no interaction between the altitude factor and the biochar administration factor on the variable of sap volume per day. The highest average sap volume per day in the altitude factor is at an altitude of $450 < x \leq 650$ m above sea level, which is 15.17 litres in the 8th week of observation. The highest average sap volume per day in the biochar administration factor with a dose of 1500 g/plant is 14.27 litres.

The altitude factor has a significant effect on the volume of sap per day because it is related to the microclimate that affects the sugar palm plant. Temperature, humidity, and light intensity are limiting factors for the sugar palm plant in producing sap. Light intensity and temperature

greatly affect the rate of photosynthesis which plays a role in producing photosynthate. Photosynthate is the source of sap production in the sugar palm plant (7). The rate of photosynthesis at an altitude of 250 < x ≤ 450 m above sea level and > 650 m above sea level tends to be lower than at an altitude of 450 < x ≤ 650 m above sea level.

Table 1. The effect of altitude and biochar application on the volume of sap per day (liter)

Treatment	Week								
	Before Application of Biochar	2	4	6	8	10	12	14	16
Altitude									
K0	7,29 **b**	7,61 **B**	8,08 **b**	7,36 **b**	10,02 **b**	8,46 **b**	9,03 **b**	9,67 **b**	9,78 **B**
K1	12,67 **a**	12,82 **A**	13,64 **a**	12,5 **a**	15,17 **a**	13,18 **a**	13,73 **a**	13,84 **a**	13,98 **a**
K2	5,72 **b**	5,77 **C**	6,46 **c**	6,23 **b**	7,15 **c**	7,03 **c**	7,21 **c**	7,6 **c**	7,44 **C**
Biochar									
B0	6,93 **b**	7,22	7,68 **b**	6,95 **b**	7,59 **b**	7,37 **b**	7,22 **b**	7,14 **b**	7,10 **B**
B1	7,93 **ab**	8,37	9,04 **ab**	8,54 **ab**	10,6 **ab**	8,24 **ab**	9,18 **ab**	9,72 **ab**	9,84 **Ab**
B2	10,82 **a**	10,61	11,46 **a**	10,6 **a**	14,14 **a**	13,06 **a**	13,57 **a**	14,15 **a**	14,27 **a**

Description: Numbers followed by different letters on the same variable and treatment indicate a significant effect on the 5% DMRT test. K0 = 250 < x ≤ 450 m above sea level, K1 = 450 < x ≤ 650 m above sea level, K2 = x > 650 m above sea level, B0 = 0 g/plant, B1 = 750 g/plant, B2 = 1500 g/plant.

At an altitude of <450 m above sea level and >650 m above sea level, the rate of photosynthesis is low. At an altitude of <450 m above sea level, the rate of photosynthesis decreases due to the rapid photooxidation of chlorophyll due to high temperatures, thus damaging the chlorophyll (9). Sugar palm plants at an altitude of > 650 m above sea level have a low photosynthesis rate. This is caused by the intensity of sunlight and low temperatures. Sunlight is a source of energy in the photosynthesis process so if the intensity of sunlight decreases, it will also decrease the rate of photosynthesis. In addition, chlorophyll at low light intensity will also have a small content in the leaves so it will decrease the rate of photosynthesis (12).

2. Sugar level (°brix)

The biochar administration factor has a significant effect on the volume of sap per day. Biochar can increase the physiological processes that occur in sugar palm plants so that it can increase the volume of sap. Biochar can increase the total chlorophyll content in plants. Research conducted by (19) showed that the provision of biochar can increase the amount of chlorophyll. Increasing chlorophyll levels will increase the rate of photosynthesis. Increasing the rate of photosynthesis will increase the amount of photosynthate produced by plants. The photosynthate becomes sap that flows through the phloem that is cut on the male flower stalk.

Table 2. The effect of altitude and biochar application on the sugar level (°brix)

Treatment	Week								
	Before Application of Biochar	2	4	6	8	10	12	14	16
					Altitude				
K0	13,38	13,73	13,51	13,27	13,64	13,96 **ab**	13,66 **ab**	13,42 **ab**	13,31
K1	13,40	12,98	13,18	12,80	13,09	14,29 **a**	13,89 **a**	13,82 **a**	13,24
K2	13,27	12,96	13,44	12,84	13,40	12,83 **b**	13,40 **b**	13,22 **b**	13,38
					Biochar				
B0	13,60	13,87	13,80	13,51	14,11	13,86	13,74	13,96	13,56
B1	13,64	13,24	13,58	12,96	13,67	13,54	13,69	13,51	13,16
B2	12,80	12,56	12,76	12,44	12,36	13,68	13,51	13,00	13,22

Description: Numbers followed by different letters on the same variable and treatment indicate a significant effect on the 5% DMRT test. K0 = 250 < x ≤ 450 m above sea level, K1 = 450 < x ≤ 650 m above sea level, K2 = x > 650 m above sea level, B0 = 0 g/plant, B1 = 750 g/plant, B2 = 1500 g/plant.

Table 2 shows that the altitude factor has a significant effect on sugar content (°brix) and the biochar provision factor has no significant effect on sugar content (°brix). There is no interaction between the altitude factor and the biochar provision factor on the sugar content variable (°brix). The highest average sugar content (°brix) of the altitude factor is at an altitude of 450 < x≤ 650 m above sea level with a value of 14.29%.

The altitude factor has a significant effect on sugar levels (brix) occurring in the 10th, 12th, and 14th weeks of observation. This is because the weather factor that often changes causes the sugar levels (brix) in the sap to fluctuate. The intensity of sunlight and environmental temperature play a major role in the synthesis of sugar in the sap. These changes greatly affect the sugar levels (brix) of the sap (16). These weather changes are related to the photosynthesis process that occurs in the sugar palm plant. According to Konan et al. (11), the sugar content of sap is also influenced by the microclimate of the plant, because environmental or soil conditions and climate can affect the absorption of water and minerals in the photosynthesis system which leads to the production of plant carbohydrates.

Weather that changes from hot to rainy and rainy to hot will cause changes in sunlight intensity and environmental temperature, thereby reducing the rate of photosynthesis. Fluctuating sunlight intensity and temperature will interfere with the rate of photosynthesis. Research conducted by (19) shows that temperatures that are too high or too low will reduce the rate of photosynthesis. Increasing or decreasing temperature from the optimum point will affect the rate of plant photosynthesis.

a. pH of sap

The results of the analysis of variance in Table 3 show that the altitude factor and the provision of biochar have no significant effect on the sap's pH variable. There is no interaction between the altitude factor and the biochar provision factor.

Table 3. The effect of altitude and biochar application on the pH of sap

Treatment	Week							
	Before Application of Biochar	1	2	3	4	5	6	7	8
				Altitude					
K0	6,67	6,78	6,78	6,78	6,33	6,89	6,56	6,78	6,56
K1	6,78	6,78	6,33	6,33	6,33	7,11	7,11	7,00	6,56
K2	6,33	6,56	6,44	6,56	6,67	5,89	6,67	6,56	6,67
				Biochar					
B0	6,56	6,78	6,44	6,44	6,33	6,44	7,11	7,11	6,67
B1	6,22	6,67	6,56	6,56	6,44	6,67	6,44	6,67	6,22
B2	7,00	6,67	6,56	6,67	6,56	6,78	6,78	6,56	6,89

Description: Numbers followed by different letters on the same variable and treatment indicate a significant effect on the 5% DMRT test. K0 = 250 < x ≤ 450 m above sea level, K1 = 450 < x ≤ 650 m above sea level, K2 = x > 650 m above sea level, B0 = 0 g/plant, B1 = 750 g/plant, B2 = 1500 g/plant.

The sap that has just come out of the tapped flower bunches has a neutral pH of around 7, but the influence of environmental conditions can cause the sap to be easily contaminated and undergo fermentation so that the sap turns acidic (the pH decreases). (12). Changes in the pH of the sap are greatly influenced by the fermentation process caused by microorganisms in the sap that can convert glucose into ethanol and then into acid. High environmental temperatures can trigger the growth of bacteria in the aren sap. The higher the sugar with high glucose or inverted sugar content will be difficult to harden and has a short shelf life because it melts easily 10).

D. Conclusion

Factors of various altitudes only affect the variables of daily sap volume, sugar content, and sap viscosity. At an altitude of 450 < x ≤ 650 m above sea level, it can provide the greatest influence on the variables of daily sap volume and sugar content. The factor of giving various doses of biochar only affects the variable of sap volume per day. At a dose of 1500 g/plant, it can have the greatest influence on this variable. There is no interaction between the altitude factor and the provision of biochar on all observation variables.

E. Acknowledgement

Thank you to the UNSOED Institute for Research and Community Service (LPPM) for the cost of research through the Unsoed BLU funds for 2024

F. References

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