Growth and Yield of Sweet Sorghum (Sorgum bicolor L. Moench) Planted in Tidal Soil Applied with Dolomite and Vermicompost

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Research Paper

Growth and Yield of Sweet Sorghum (*Sorghum bicolor* L. Moench) Planted in Tidal Soil Applied with Dolomite and Vermicompost

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Abstract

Sorghum (*Sorghum bicolor* L. Moench) plant is native to tropical and subtropical countries with high suitability for planting on marginal land. Therefore, this research aimed to determine the use of dolomite and vermicompost in tidal swamp soil for the growth and yield of sweet sorghum plants at the Experimental Garden and the Chemistry, Biology and Soil Fertility Laboratory, Department of Soil Science, Faculty of Agriculture, Sriwijaya University. A factorial randomized complete block design (FRCBD) consisting of two factors was used. The first factor was dolomite namely 0 ton.ha^{-1}, 6 ton.ha^{-1}, 9 ton.ha^{-1}, and 12 ton.ha^{-1}, while second factor was vermicompost including 0 ton.ha^{-1}, 3 ton.ha^{-1}, 6 ton.ha^{-1}, and 9 ton.ha^{-1}. The results showed that the application of Dolomite had a very significant effect on soil pH, N-total, P-available, and potassium exchangeability. In addition, dolomite increased plant height, number of leaves, chlorophyll content, fresh and dry weight shoot, number of grains, and weight of 1000 grains.

Keywords
Dolomite, Sorghum, Tidal swamp, Vermicompost

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) plants are native to tropical and subtropical countries in the southeastern Pacific and Australasia, namely Australia, New Zealand and Papua. This plant is tolerant to drought and does not require a lot of water during the growth period. In addition, sorghum is considered suitable for growing on marginal land and is tolerant to environmental stress. A superior variety is the Bioguma 3 agritan cultivar, which can also produce ratoons and can grow to a height of 254 cm (Lestari, 2019). Bioguma 3 agritan variety has a 50% flowering age of around 61 days and a harvest age between 91 and 105 days. Efforts need to be made to develop swamp land to keep pace with population growth. On a national scale, swamp land plays a role in agricultural development efforts, especially in support of national food security. Indonesia has tidal swamp land covering an area of 20.1 million ha with a potential land typology of 2.1 million ha, acid sulfate 6.7 million ha, peat 10.9 million ha, and saline area of 0.4 million ha. In the future use of tidal swamp land, development is needed to increase agricultural production (Susilo et al., 2019). Peat soil has a low pH level, high cation exchange capacity, low base saturation, low K, Ca, Mg, P content and also low micronutrient content (such as Cu, Zn, Mn and B). Addition of nutrients to peat soil can increase plant growth and development (Baharuddin and Sutriana, 2019). Vermicompost is an organic fertilizer that comes from a mixture of earthworm faeces and organic materials subjected to a composting process using worms (Dhani et al., 2014). The provision of 4 tons/hectare of vermicompost increases sweet corn yields (Dailami et al., 2015). In addition, the application of dolomite can increase soil pH in swamp land and improve other chemical properties (Paripurna et al., 2017). According to Susilo et al. (2019), optimal soil pH for growing sorghum is 6.0 − 7.5. In swamp soil, the pH is usually below 5 and the low pH can reduce sorghum yields by 10%. Therefore, this research aimed to determine the efficiency of dolomite application in improving soil chemical properties, adding vermicompost fertilizer to increase sorghum production in swampy soil and observing the interaction.

2. EXPERIMENTAL SECTION

2.1 Material and Method

This research was carried out in 2020 at the Experimental Garden, Faculty of Agriculture, Sriwijaya University and soil analysis was performed at the Chemistry, Biology and Soil Fertility Laboratory, Soil Science Department, Faculty of Agriculture, Sriwijaya University. A factorial randomized complete block design (FRCBD) consisting of two factors with 4 treatment levels was used. The first factor was dolomite namely 0 ton.ha^{-1}, 6 ton.ha^{-1}, 9 ton.ha^{-1}, and 12 ton.ha^{-1} while the second factor was Vermicompost including 0 ton.ha^{-1}, 3 ton.ha^{-1}, 6 ton.ha^{-1}, and 9 ton.ha^{-1}.

Sorghum planting is carried out one week after the media has been treated. Planting is conducted in a single method by making 3 holes + 3 cm deep and leaving a distance between one hole and another. Subsequently, 3 seeds are inserted into the soil/planting hole, and covered by the soil. Vermicompost and dolomite treatment was carried out one week before planting. Additionally, fertilization was given based on the results of calculating the need for vermicompost and dolomite. Each treatment received basic fertilizer N 100 kg.ha^{-1}, P_2O_5 100 kg.ha^{-1} and K_2O_5 50 kg.ha^{-1}. N and P were given in two stages, namely 40% at planting and 70% at 30 days after planting (DAP). Meanwhile, K is given at the beginning of planting 100%.

2.2 Data Analysis

Data analysis uses ANOVA by comparing the calculated F value with the F table. The treatment has no siqnificant effect when the calculated F is smaller than the F table of 5%. In addition, the treatment has siqnificant and very siqnificant effect when the calculated F is greater than the F table of 5% and 1%, respectively. The Least Significant Difference (LSD) test is carried out when the treatment is having siqnificant effect.

3. RESULT AND DISCUSSION

3.1 Soil Characteristics Analysis

Laboratory analysis showed initial soil characteristics, as reported in Table 1. The soil pH analysis was reported in acidic criteria with value of 3.27, where this soil was used as a planting medium for sorghum growth.

Table 1. Initial Soil Characteristics was used for Sorghum Growth

Variable	Unit	Result	Criteria*
pH	-	3.27	Acidic
N-total	g kg^{-1}	0.18	low
P-available (Bray 1)	mg kg^{-1}	13.5	high
Potasium Levels	cmol kg^{-1}	0.26	low

*)Soil Reserach Institute, 2009

The soil analysis before adding dolomite showed a pH of 3.27. Under conditions of pH < 4, the solubility of Fe and Mn increases, which can form Ferrous ions (Fe^{2+}) and manganese ions (Mn^{2+}) under anaerobic conditions (Napsiah and Ningsih, 2013). Low total N levels occur because N is dynamic and easily evaporates due to the combustion process (Onwuka et al., 2017; Nurmegawati et al., 2012) The high available P content is useful in providing P elements for plant needs (Manurung et al., 2017). High soil acidity can inhibit the soil nitrification process because pH drives the rate of nitrification. According to Li et al. (2020), the nitrification process is significantly greater in soil with a high pH.

Table 2. Nutrient Content in Vermicompost

Variable		Result	Criteria*	
			Min	Max
pH	-	5.64	6.80	7.49
C-Organic	%	19.1	20.00	58
Organic matter	%	32.9	20.00	58
N	%	0.61	0.40	-
P	%	0.11	0.10	-
K	%	0.12	0.20	-
C/N ratio	-	31.31	10.00	20

*Compost quality standards (SNI: 19-7030-2004).

Table 3. F Value Test on the Soil after Harvesting

Variable	F value		
	Dolomite	Vermicompost	Interaction
pH	12.08**	1.82 ns	2.72 *
N-Total	11.02**	0.59 ns	0.97 ns
P-available	3.34*	0.33 ns	0.34 ns
Potassium levels	6.63**	0.95 ns	1.12 ns
F Table 5%	2.92	2.92	2.21
F Table 1%	4.51	4.51	3.06

**showed significantly different
ns showed not significantly different

The application of dolomite had a significant effect on soil pH, total N, available P and soil Pottasium levels. This can increase soil pH but affects nitrogen uptake. In this research, high doses showed low total N, as reported in Table 4. Soil P-bray at the start of the research was 13.5 mg kg^{-1} (classified as high) and increased drastically. The Pottasium levels concentration in the soil decreased with the high dose of dolomite administered. An important factor causing high P-availability is the provision of basic fertilizer before planting.

Vermicompost contains growth regulators such as gibberellin, cytokinin and auxin, as well as the nutrients N, P, K, Mg and Ca and *Azotobacter* sp (Setiawan et al., 2015). However, the application of dolomite fertilizer had a significant effect compared to vermicompost. Liming can increase P availability by stimulating soil organic phosphorus mineralization explained by increasing pH. The accumulation of P elements occurs due to immobility and reduced avail-

Table 4. Effect of Dolomite on pH, N-total, and K-exchangeability after Harvesting Sorghum

Dolomite	pH	N-total (%)	P-available (mg kg^{-1})	Pottasium levels ($cmol/kg$)
0 ton/ha	3.80a	0.25c	49.49a	0.38b
3 ton/ha	4.46 ab	0.23bc	52.46ab	0.28a
6 ton/ha	4.83bc	0.22ab	54.25b	0.27a
12 ton/ha	5.11c	0.20a	59.63c	0.27a
LSD	1.1	0.03	4.02	0.09

Means followed by the different small letters within each column are significantly different at LSD 5 %

ability (Yuniarti et al., 2020). The provision of dolomite increases the pH of the planting medium needed by plants. The application can increase soil pH in influencing nitrogen uptake to reduce total soil nitrogen (Tando and Edi, 2019). The concentration of K-exchangeable decreased with the high dose of dolomite applied. Han et al. (2019) stated that the decrease in K-exchangeable could be attributed to the entry of divalent cations. In addition, decreasing soil acidity can retain organic acids produced by K-solubilizing bacteria and inhibit the release of K^+ from minerals. The results of diversity analysis showed that dolomite treatment had a significant effect on chlorophyll levels, plant height and number of leaves Table 5. The high levels of chlorophyll in sorghum plants are directly proportional to the dose. The provision of dolomite also has a good effect on plant growth. The application can neutralize organic acids which cause the unavailability of nutrients. The availability of nitrogen can also be increased to enhance plant vegetative growth, a constituent of leaf chlorophyll and healthy leaf growth.

Table 5. Effect of Dolomite on Chlorophyll Content, Plant Height and Number of Leaves on Sorghum

Dolomite	Chlorophyll	Height (cm)	Number of leaves
0 ton/ha	20.99a	22.50a	5.00a
3 ton/ha	25.70 ab	27.50ab	6.17ab
6 ton/ha	27.63ab	27.50ab	6.67 b
12 ton/ha	27.73b	29.17b	6.83b
LSD	5.49	6.59	1.49

Means followed by the different small letters within each column are significantly different at LSD 5 %

The application of dolomite affects the growth variables of sorghum plants, including height, number of leaves and amount of chlorophyll. The increase in chlorophyll levels is directly proportional to the dose of dolomite. (Septina et al., 2020) stated that the Mg content affects several proteins in the leaves. The addition of dolomite is useful as a soil amendment in neutralizing Al, and increasing Mg and Ca (Suntoro. et al., 2028). In addition, the application of dolomite also affects reducing hydrogen ions and increasing the availability of N by enhancing the rate of decomposition. Nitrogen functions in tissue development thereby increasing plant growth (Fatirahma and Kastono, 2020). The application of dolomite can neutralize organic acids which cause the unavailability of nutrients. Mwende and Esther (2015) stated that soil with a low pH had high Al and Fe levels, which caused poisoning for plants. Liming can increase the growth response by improving Al toxicity. In addition, the administration attracts H^+ ions from exchange to form H_20. Research conducted by (Vishwakarma et al., 2012) stated that the addition reduced hydrogen ions and increased pH, N availability and rate of decomposition of organic matter. According to Saputri et al. (2018), N functions to increase plant vegetative growth and leaf chlorophyll as well as promote healthy leaf growth. This is because plants cannot use nutrients N, P, and K in acidic soil. High soil acidity causes low panicle yields because Al can interfere with the absorption and use of water. Dolomite reduces the level of Al poisoning which inhibits plant growth. Therefore, increasing the dose of dolomite significantly enhanced the fresh weight of the seeds and fruit set Table 6.

Table 6. Effect of Dolomite on Fresh and Dry Weight of Sorghum Grains and Shoot of Sorghum

Dolomite	FW Spikelet (g)	DW Spikelet (g)	Shoot FW(g)	Shoot root DW (g)
0 ton/ha	18.62a	10, 06a	56.80a	29.06a
3 ton/ha	35.52b	18.07b	99.50b	51.41bc
6 ton/ha	38.87b	20.67b	125.83bc	62.65c
12 ton/ha	49.38c	29.57c	135.58c	70.65c
LSD	10.49	6.46	33.74	19.23

Table 7. Number of Grains and Weight of 1000 Grains of Sorghum Affected by Dolomite Application

Dolomite	Number of grains	Weight of 1000 grains (g)
0 ton/ha	253.08a	136.05a
3 ton/ha	432.83	137.00a
6 ton/ha	523.75b	147.30ab
12 ton/ha	773.67b	155.05b
LSD	253.39	13.64

Means followed by the different small letters within each column are significantly different at LSD 5 %

Nutrient P plays an important role in the formation of seeds in plants. This is very related because P has an important role in the formation of seed protein. The application of dolomite increases the availability of P in the soil. Therefore, in this research increasing the dose of dolomite significantly enhances the number and weight of seeds (Table 7), as well as increasing plant yield per hectare Figure 1.

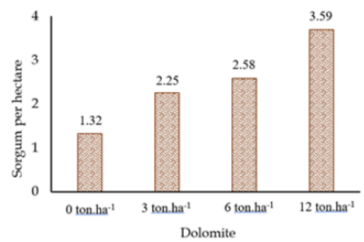

Figure 1. Sorghum Yield per Hectare Influenced by Dolomite Application

High soil acidity causes a decrease in the number of panicles. This is because Al can interfere with the absorption and use of water. Nutrient P plays an important role in the formation of seeds because the P element can enhance growth and ripening (Sholikah et al., 2013). The provision of dolomite increases plant efficiency in absorbing available phosphate in the soil and reduces Al toxicity. Mwende and Esther (2015) explained that the decrease in crop yields was associated with a lack of micronutrients due to high pH, Al poisoning, and low P uptake in acidic soil. Meanwhile, phosphorus has an important role in the formation of seed protein, as an energy source and stimulates the process of plant root development (Pradana et al., 2015). High soil acidity results in low yields from sorghum panicles and the weight of grain is directly proportional to the dose of dolomite applied. This is because dolomite reduces the level of Al toxicity in line with (Noza et al., 2014) where the increase in soil pH is due to the application. In seed formation, the element P has an important role as an energy source and stimulates the process of plant root development (Pradana et al., 2015). Grain production data per hectare was obtained by converting dry weight per panicle. Based on the description, the average yield of Bioguma 3 sweet sorghum is 6.98 tons ha^{-1}. The highest yield was obtained at a dolomite dosage of 12 tons/ha, and the result was 3.69 tons per hectare. Subagio et al. (2013) stated that soil with a pH of 4.42 reduced yields by 10-30%. Aluminium poisoning in cereal plants could also reduce yields by 28-63% (Fauzi et al., 2020).

4. Conclusion

The application of dolomite was reported to have a significant effect on soil pH, N-total, P-available, Potassium level, chlorophyll content, increase in plant height, number of leaves, fresh and dry weight of panicle, fresh and dry weight of shoot, number of grains, weight of 1000 grains. The application of vermicompost had a real influence on soil pH after harvest and plant height.

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