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Bioremediation of Cement Mining Waste as a Medium for Growth and Production of Chilies with Mycorrhiza and Biohumate Application

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Abstract
Cement mining by exploiting Maros karst, South Sulawesi, produces waste in the form of gypsum, which still has the potential to be used in bioremediation as a planting medium for plant commodities. The research aims to determine the growth of chili plants on former cement mining media treated with mycorrhiza and biohumic—the biohumate used from an extract of cocoa pod husk. The research was structured using an experimental method with 5 treatments, namely primary media in the form of soil + manure as a control, gypsum 30 g/polybag, gypsum 60 g/polybag, gypsum 30 g/polybag+mycorrhiza, gypsum 60 g/polybag+mycorrhiza. The treatment was then divided into 2, with biohumic and without biohumic. The research showed that all observed parameters had higher values in the biohumic treatment than without biohumic. Treatment with 30 g gypsum/polybag + mycorrhiza can improve the physical properties of the soil by changing the percentage composition of soil fractions. It can also increase P_2O_2 and K_2O levels and provide the best growth for chili plants. It is possible to utilize waste from cement mines to produce horticultural commodities by bioremediation with mycorrhiza and biohumate.

Keywords— Biohumic, horticulture, Karst, manure, plant nutrient.

Introduction

The cement industry is essential in Indonesia, including PT Semen Bosowa, which established cement packaging terminal facilities and a Packing Factory port in Siawung Village, Barru Regency, South Sulawesi (Ainun, 2020). Cement mining exploits karst areas in Maros Regency, South Sulawesi. In the packaging process, gypsum waste is expected to be used as a growing medium for plants. Gypsum in karst areas can form because evaporation is not too intensive. It can affect the evaporation process that occurs. Gypsum is formed when water evaporates, reducing the volume to 20% of its initial volume. Gypsum is formed under various conditions, varying in purity and thickness.It was a salt that precipitates due to the evaporation process of seawater, followed by anhydrite and halite when salinity increases (Yahya, 1982). Increasing the vitality and viability of plants on ex-cement mining land requires appropriate silvicultural techniques, selecting suitable plant types, high energy input such as phosphate saturation, and complete fertilization and organic matter management. However, these techniques require high costs to rebuild the land into productive land. It can also have negative impacts in the future; for example, the continuous use of chemical fertilizers can damage the environment and soil (Fadli M, 2016; Asmarahman, 2008). Mycorrhiza and biohumate are alternatives for utilizing by-products in the form of ex-mining land, especially for cultivating chili plants.

Chili (*Capsicum frutescens*) is one of the important horticulture commodities that is cultivated commercially. Chili has complete nutritional content and high economic value for

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household consumption and the food industry (Jannah, 2010). According to Prajnanta (2007), chilies provide color and taste that can stimulate appetite, contain lots of vitamins, and can also be used as medicines, ingredients in food mixtures, and animal husbandry. This research aims to determine how much cement mining waste can be used for growth and chili plant production. This research applied gypsum to the planting medium by adding mycorrhiza and humic acid to bioremediate cement mining waste.

Literature Review

Bioremediation is the use of biological processes to control pollution or pollutants. Pollutants include heavy metals, petroleum hydrocarbons, and halogenated organic compounds such as pesticides and herbicides. Bioremediation is an alternative technology for overcoming environmental problems by utilizing microorganisms such as yeast, fungi, algae, and bacteria, which function as bioremediation agents. Bioremediation aims to break down or degrade pollutant substances into materials that are less toxic or non-toxic (Lumbanraja, 2014).

Bioremediation is a development in environmental biotechnology that utilizes biological processes to control pollution and is quite interesting. Apart from being cost-effective, it can also be done in situ directly on the spot, and the process is natural (Erman, 2006). The rate of microbial degradation of heavy metals depends on several factors, namely microbial activity, nutrition, degree of acidity, and environmental factors (Susanto, 2002). One of the bioremediation agents is mycorrhiza.

Mycorrhizae can increase the nutrient transfer rate to host plant roots and increase resistance to biotic and abiotic stresses (Smith & Read, 2008). In polluted conditions, mycorrhizae can play a role in helping maintain plant growth stability (Khan, 2005). Mycorrhiza and humic acid can also be used in ex-cement mining media. Several reports show the potential of humic acid to help improve soil health, significantly increasing carbon storage in soils poor in organic C content (Ahmad et al., 2015; Yeo et al., 2015; Hartz & Bottoms, 2010) and the growth of soil microorganisms (Tikhonov et al., 2010; Canellas & Olivares, 2014). Mycorrhiza increases the absorption of ions with low mobility levels, such as phosphate (PO43-) and ammonium (NH4+). Other relatively immobile soil nutrients include Cu, S, B, and Zn (Suharno & Santosa, 2005). Mycorrhiza also increases the surface area in contact with the soil so that the root absorption area increases up to 47 times. It facilitates the activity of the nutrients contained in the soil.

Research Method

This research was structured by treating soil and ex-mining waste (gypsum). The treatment is basic media (soil + manure); basic media+gypsum 30 g; basic media+gypsum 60 g; basic media+gypsum 30 g+Mycorrhiza; basic media+gypsum 60 g+mycorrhiza; and basic media + mycorrhiza. Gypsum sampling (cement waste soil) at the Garongkong cement packing port in Siwung Village, Barru District, Barru Regency, South Sulawesi. Soil samples were put into sacks and transported to the research location. The research was carried out at the Faculty of Agriculture, Animal Husbandry and Fisheries Screen House, Universitas Muhammadiyah Parepare.

Before planting, an initial soil sample analysis is carried out. Soil samples were taken in limestone soil from a former cement mine and then air-dried. According to the treatment, ex-mining soil is mixed with planting media containing soil and manure. Mycorrhiza application is carried out when planting shallots by inserting 15 g of mycorrhiza into each planting hole. Biohumate, which comes from acid-base extraction of cocoa pod husk compost, is carried out by dissolving 5 ml of biohumate with 1 liter of water. Biohumate is applied by spraying it on plants every week.

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Results and Discussion

Analysis of soil texture and nutrients carried out in the gypsum and mycorrhiza treatments is shown in Table 1.

Table 1. Soil texture and soil nutrient content before and after application of gypsum and mycorrhiza

Treatment application	Texture (%)			pH(1:2.5)		N	Olsen/Bray (ppm)	
	Sand	Dust	Clay	H_2O	KCl	(%)	P_2O_2	K_2O
Preliminary analysis	49	49	2	7.06	6.34	0.09	75	489
Control	38	59	3	7.95	6.94	0.14	170	201
Gypsum 30 g/polybag	29	65	6	6.6	5.31	0.14	149	96
Gypsum 60 g/polybag	23	64	13	6.18	5.45	0.14	92	121
Gypsum 30 g/polybag + mycorrhiza	42	58	0	7.68	6.92	0.15	253	219
Gypsum 60 g /polybag + mycorrhiza	31	65	4	6.57	5.64	0.14	88	103

Table 1 shows the initial analysis of the soil used as a planting medium, with a sand and dust texture reaching almost 50% each. After being given control treatment, namely the addition of manure, there was a change in the percentage composition of the soil fraction. It also occurs when administering gypsum and mycorrhiza. There was a decrease in the percentage of sand fraction in all treatments. Sand has disadvantages as a planting medium, with its porosity being able to transmit excess water. However, sand media is poor in nutrients but contains minerals that plants need. Disadvantages of sand media include the relatively small cumulative surface area and the deficient ability to store water so that the media dries more quickly (Wiryanto, 2007). Providing gypsum and mycorrhiza can improve the physical properties of the soil by increasing the percentage of other soil fractions in the form of dust and clay, so that the media is good for plant growth. According to Hanafiah (2012), dust has a larger surface area than sand, which can hold water and nutrients available to plants.

When given mycorrhiza and gypsum, the performance of chili plants can be seen in Figure 1.

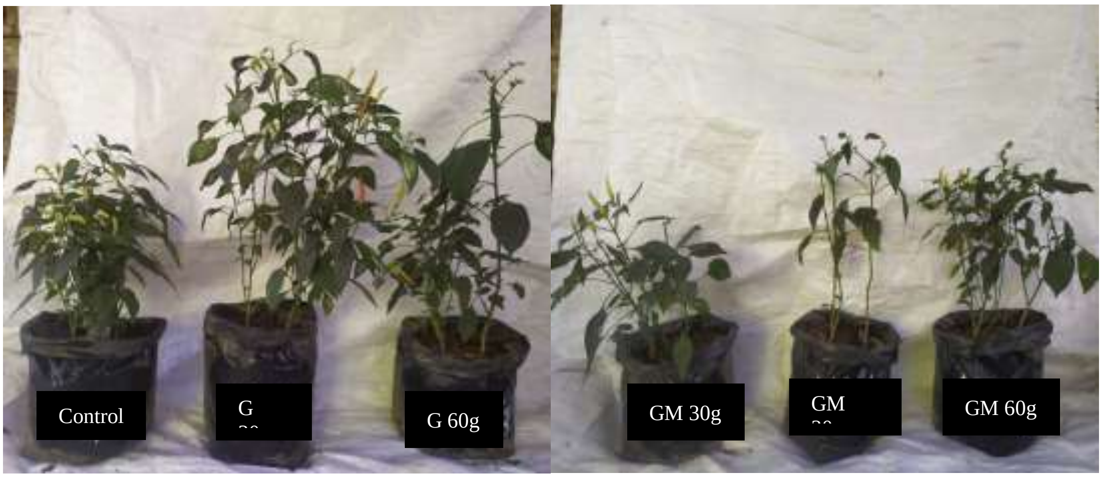

Figure 1. Performance of chili plants given gypsum (cement mining waste) and mycorrhiza.

Journal of Agriculture

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Figure 1 shows that chili plants grew exceptionally well in the control (land treated with manure) but not taller than other treatments. Chili plants grow better on media given 30 g of gypsum. The performance and growth of chili plants turned out to be better after applying biohumate. It is shown in Table 1.

Table 1. Growth of chili plants when given gypsum and mycorrhiza in cement mining waste planting media

Biohumic	Planting treatment	Plant height	Number of leaves	Stem diameter
Without Biohumic	Control (soil + manure)	27.00	29.33	3.57
	Gypsum 30 g /polybag	26.33	24.67	3.43
	Gypsum 60 g /polybag	24.00	30.33	3.70
	Gypsum 30 g/polybag + mycorrhiza	31.67	22.67	3.77
	Gypsum 60 g /polybag + mycorrhiza	25.00	14.33	3.10
	Mycorrhiza	24.00	18.67	3.50
With Biohumic	Control (soil + manure)	35.33	41.67	5.67
	Gypsum 30 g /polybag	25.00	31.00	4.50
	Gypsum 60 g /polybag	34.33	25.33	4.30
	Gypsum 30 g /polybag + mycorrhiza	36.33	32.33	4.83
	Gypsum 60 g /polybag + mycorrhiza	29.33	27.67	4.87
	Mycorrhiza	31.33	47.00	4.83

The highest plants were treated with 30 g of gypsum+mycorrhiza without and with biohumic. However, the results were higher with biohumic, namely 36.33 cm. Biohumate can have a direct and indirect effect. The direct effect is that it can improve plant metabolic processes, such as increasing the rate of plant photosynthesis (Heil, 2005), due to increasing chlorophyll content in leaves (Ferrara & Brunetti, 2010). Indirectly, namely improving soil fertility status regarding physical, chemical, and biological soil properties (Tan, 1992). As soil fertility status increases, plant nutrient uptake will increase, so plant growth and production will be more optimal.

The control treatment in the number of leaves parameter, namely the application of chicken manure to the media, gave the highest value. The control did not contain cement mining waste; chicken manure also affected plant height and number of branches. The manure could improve the physical properties of the soil so that plant root growth was better than others (Surtinah, 2007). Utilization of cement mining waste with the addition of mycorrhiza can increase the absorption of nutrients and water that plants need in the growth process. Mycorrhiza can help increase nutrient and water uptake (biofertilizer), protect plants from root pathogens and toxic elements, and increase plant resistance to drought (bioprotector) (Herlina et al., 2017). This research shows that mycorrhiza and biohumate can increase the utilization of cement mining waste for application to horticultural commodities, especially for chilies.

Journal of Agriculture

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Conclusion

Adding biohumate from cocoa husk extract at 5 ml/L of water combined with mycorrhiza at 15 g/plant can increase the ability of cement mine waste to be used as a medium for growth chili plants.

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Journal of Agriculture

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