Hindawi
Applied and Environmental Soil Science
Volume 2022, Article ID 1775330, 10 pages
https://doi.org/10.1155/2022/1775330

Research Article

Field-Based Biochar, Pumice, and Mycorrhizae Application on Dryland Agriculture in Reducing Soil Erosion

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Received 22 December 2021; Revised 4 July 2022; Accepted 11 July 2022; Published 12 August 2022

Academic Editor: Maman Turjaman

Biochar, pumice, and mycorrhizae applications using direct testing methods in the field have not been widely carried out. The application of biochar in this study was used as a conservation material to control runoff and erosion. The research was conducted using a field plot during the peak of the rainy season (March-April) of 2021. The study was conducted in areas where the soil material is dominated by clay (>40%) and steep slope angles (>60%). The cropping pattern at the research site is generally cassava in the dry season and corn in the rainy season. Four 1×10 m field plots with corn stands were prepared with biochar, pumice, mycorrhizae, and control treatments. Runoff and sediment measurements were carried out by calculating the volume of water and suspension in the storage tank. The effect of three treatments was observed and measured through some soil characteristics such as bulk density (BD), specific gravity (SG), porosity, organic matter content (OM), cation exchange capacity (CEC), and aggregate stability. The highest rainfall in March and April reached 441 mm/month, with the highest intensity reaching 150 mm/week. Under intense rainfall, biochar application provides better performance than pumice and mycorrhizae. Runoff reduction from biochar is the highest, with 51.67%. On the other hand, pumice and mycorrhizae show a lower effectivity in decreasing runoff with 40.15% and 37.92%, respectively. The effectivity on lowering runoff translates to each ameliorant's performance in reducing soil loss. Biochar decreases soil loss by 50.78%, while pumice and mycorrhizae decrease soil loss by 37.9% and 26.26%. The application of biochar reduced the rate of erosion by altering soil characteristics. Biochar application provides better soil characteristics by reducing BD and SG while at the same time increasing the porosity, OM, CEC, and aggregate stability. The changes provided by biochar can provide means to both soil conservation and increase in soil productivity.

1. Introduction

Land degradation is an environmental problem that globally occurs, which results in a decrease in land quality. Land degradation is an obstacle in developing sustainable land resources. The most common form of land degradation is erosion. The driving forces of erosion are rain, soil, relief, and vegetation. Rain kinetic energy has the ability to detach soil particles, which result in surface runoff and erosion [1]. The interaction between relief characteristics, amount of sunlight, rain, and wind direction influence vegetation and soil development. The combination of these factors provides complex interactions that affect the level of the erosion process [2]. Erosion occurs due to excessive surface runoff, causing the loss of the soil surface layer along with organic matter and nutrients in it [3]. Erosion will change soil characteristics such as particle size, bulk density, specific gravity, aggregate stability to the hydraulic conductivity of the soil [4, 5]. Changes in characteristics due to erosion can reduce soil quality, especially for agricultural ecosystems [6].

The development of erosion research starts from distribution, modeling, to conservation. Research related to the distribution of erosion has been carried out by Ritchie et al. [7]. Erosion modeling research has been conducted by Morgan [8]. Tesfahunegn et al. [9] conducted MMF modeling with GIS to estimate soil loss according to its spatial distribution. Zhu and Zhu [10] used multiple erosion plots with the aim is to analyze soil loss and runoff on sloping agricultural land and to test the effectiveness of conservation techniques applied in controlling erosion rates. The main advantage of using field plot erosion is that the results of the experiment could be directly applied in the area of research and other areas under similar environmental conditions. Erosion conservation efforts that are pretty effective are increasing the organic matter content to improve the quality of soil characteristics through increasing aggregate stability, hydraulic conductivity, and field capacity [11]. The improved quality of soil characteristics will reduce soil erosion and nutrient loss [12].

The application of biochar can improve soil aggregation due to its stable carbon composition. It is formed by decomposing organic materials in limited oxygen conditions through the pyrolysis process [13, 14]. Biochar is a suitable conservation medium because it can improve soil quality, store nutrients, increase soil microorganisms, and soil productivity [15, 16]. Several studies have revealed that biochar is quite effective in improving soil physicochemical properties, aggregate stability, nutrients, and plant productivity in subtropical and tropical regions [17, 18].

Research on erosion using biochar is generally carried out on a laboratory scale. The study was conducted using an experimental plot with less than 15% slope and artificial rain with an adjusted intensity. Jien and Wang [18] conducted a study with an artificial plot at a slope of 10%. Sadeghi et al. [19] experimented with a slope angle of 15%. Zhi-guo et al. [20] conducted an artificial experiment in an area with an annual rainfall of 750 mm and slope angles of 10% and 15%.

This research was conducted with field plots on land with a slope of >60% with extreme rainfall intensity above 150 mm/week. The research is located in the transition zone between the quaternary and tertiary volcanoes, which makes the soil material dominated by clay. There are 40 points of erosion occurrence that are known, including splash, rill and gully erosion. Foot slope of Sumbing Volcano has experienced massive erosion [21]. The erosion plot is located on a very heavily eroded slope so conservation effort is needed [22]. Field experiments is essential because field research can improve the accuracy of the data produced. The advantages of field experiments is that there is environment that cannot be imitated in the laboratory and where monitoring on large areas are not feasible [23]. Research on erosion using biochar in the field in extreme geomorphological and climatic conditions has not been widely carried out. The purpose of this study was to determine the effectiveness of biochar in controlling runoff and erosion rates.

2. Materials and Methods

2.1. Description of the Study Area. The research area is located on the south side of the Sumbing Volcano foot slope with coordinates 110°03′42″-110°04′08″ E and 7°33′13″-7°33′6″ S. Administratively, it is located in Kajoran District, Magelang Regency, Central Java Province (Figure 1). The study area has a tropical climate with two seasons, dry season (June-October) and wet season (November-May). During the wet season, the rainfall reaches more than 2500 mm/year [24].

The plot erosion is located in the transition zone of quaternary and tertiary volcanoes that have a hydrothermal

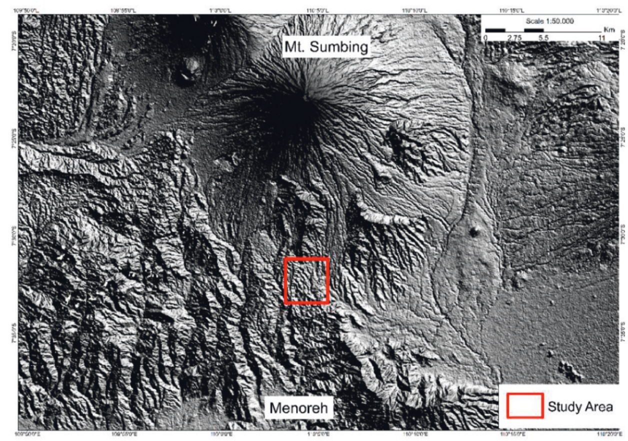


Figure 1: Study area location in the southern slope of Sumbing volcanoes.

weathering process (alteration) in the past. It provides unique characteristics in the study area. The alteration process works from below the surface because of very thick soil up to 2 m. The soil material with the dominance of clay, steep slopes, and high rainfall makes the soil easily eroded to landslides [25]. Soil characteristics at the research site are classified as *Typic Kandiudalfs.*

The erosion plot is on the west side of the slope with a slope aspect of 110,5° and a slope gradient of >60%. The slope gradient will affect the potential for surface runoff and the erosion intensity. The erosion plot is on a concave slope indicating that the erosion process has occurred intensively. The massive erosion happens because the concave slope makes flow concentration. The surface soil in the study area has >40% clay content. In detail, the alteration process makes the soil undergo advanced weathering and create rich clay. Soil formed through the alteration process has a clay content of >60% [26].

Aerial photo data were collected using a V-TOL drone for landscape analysis and DEM data. Photographs were taken during the barren period so that the condition of the land was empty without production plants. The barren period is usually occurs within October-November. This condition is very beneficial because it can produce detailed DEM data, especially where the installed erosion plot is.

2.2. Rainfall Measurement. Rainfall measurement was conducted during experiment and peak rainy season (March-April) 2021. Rainfall events were recorded by automatic weather stations installed at the study area. Rainfall data were downloaded continuously every week during observation. The automatic weather station was also recording temperatures, humidity, wind speed, and direction. All those climatic parameters play a significant role in performing soil characteristics which influence soil erodibility [27].

2.3. Biochar Materials. Bamboo leaves are used as the primary material for making biochar. Bamboo leaves are meant to utilize unused material, which is always available at the research site. The selection of bamboo leaves as biochar material also considers the spatial and temporal aspects. The availability of bamboo leaves is always excessive at the end of the dry season. In contrast, at the beginning of the rainy season, the land is still in a barren condition, so the application of biochar in this condition is entirely appropriate.

Biochar was made using the slow pyrolysis method at a temperature of 500°C. Scanning electron microscopy (SEM) test result was used for determining pyrolysis temperature. SEM result test provides an overview of the structure and shape of the biochar and provides information regarding the element content of the biochar. The physical properties of biochar are strongly influenced by the raw materials and the process of making biochar. The structure and pores of biochar are strongly influenced by the temperature and time of pyrolysis. Biochar pores will increase with the increase in pyrolysis temperature [28] and decrease when the pyrolysis temperature is above 500°C [29]. SEM test showed that the structure and pores of biochar had not been fully formed at 400°C and 450°C. Furthermore, biochar with a temperature of 500°C had the best pore structure, so it was used as a soil ameliorant (Figure 2).

The comparison materials were used to determine the effectiveness of the soil ameliorant. The other soil ameliorants were pumice and mycorrhizae. Pumice and mycorrhizae are good soil ameliorants, suitable for comparison [30, 31]. The pumice use is also based on the abundant pumice availability in Indonesia due to many composite-type volcanoes. The mycorrhizae refer to several studies showing mycorrhizae can improve soil characteristics and control erosion [32, 33]. Biochar and pumice were sieved with a diameter of <2 mm to make the size homogeneous.

2.4. Soil Characteristics Measurements. Soil characteristics were measured to determine the soil ameliorant effect on improving soil characteristics in reducing runoff and soil erosion. The measured parameters were soil texture, Bulk Density (BD), Specific Gravity (SG), porosity, organic matter content (OM), Cation Exchange Capacity (CEC), and aggregate stability. Those parameters can describe the intensity of the runoff and soil erosion processes on the different land types. Changes in soil characteristics were observed before and after applying soil ameliorants. Soil characteristics were measured both in the laboratory and field observation with each method. Soil texture was analyzed by pipette methods. BD was measured by collecting a known volume of soil using a metal ring pressed into the soil (intact core) and determining the weight after drying. The pycnometer bottle method was used to determine SG. Both parameters were interconnected, so that affected the values of soil porosity. The Walkley and Black method was used to measure the value of OM, while extraction NH_4OAc 1M, pH 7 was used to determine CEC. The aggregate stability measure with the mean weight diameter method determines the size distribution of aggregate [34]. All soil characteristics were analyzed by triple repetition.

2.5. Field Plot Experiments. The study was conducted using erosion plots which were applied in the field. Four erosion plots were constructed with 1 mx10 m equipped with sediment and runoff storage tanks (Figure 3). The length of the erosion plot is determined based on the slope arrangement. There are zones of erosion and deposition at 10 m intervals. The erosion zone is a material transport zone with the dominant process being erosion, while the deposition zone is a material accumulation zone, with the dominant process being sedimentation. Four erosion plots were created to compare the effectiveness of runoff and erosion control using biochar with other conservation materials. The study also uses rain observation data from three rain observation stations installed in the study area.

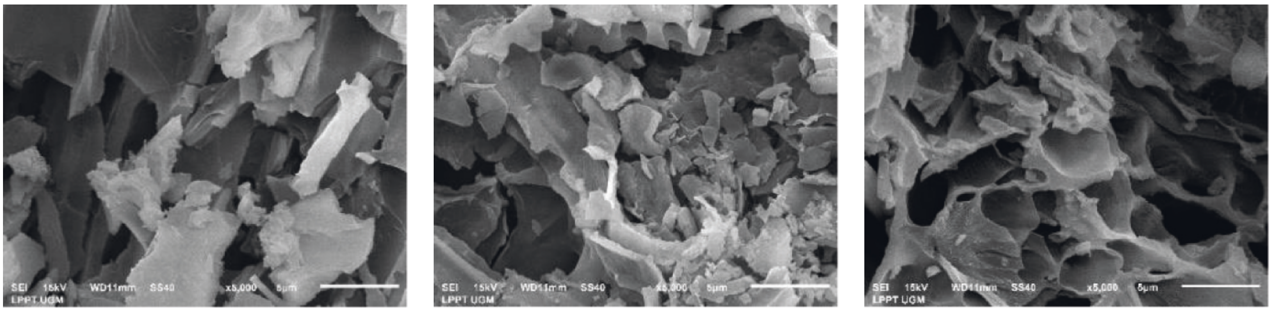
The application of biochar and pumice is carried out in the field with a composition of 10 tons/ha, which refers to several previous studies [19, 35] stating that this figure is an ideal composition from a technical and economic perspective. The distribution of biochar and pumice was adjusted to the morphological conditions of the erosion plot in the erosion zone. As much as 40% of the material was distributed in the upper erosion zone, while 40% was distributed in the middle erosion zone and 20% in the deposition zone. The application of biochar and pumice is mixed on the processing plane (20 cm). Biochar and pumice are incubated for two weeks to combine biochar properties with soil particles before erosion observations are made.

The mycorrhizae application was carried out after two weeks of biochar and pumice incubation period. Mycorrhizae application is carried out together with corn planting and placed around the corn root zone. Corn was planted in all erosion plots in the hope of being able to describe the fertility level of each erosion plot. Observations of runoff and erosion were carried out every week for two months of observation. Erosion and runoff measurements were carried out by calculating the suspension and runoff volume from the storage tank.

3. Results and Discussion

3.1. Rainfall Condition on the Study Area. Rainfall condition in the study area is driven by wind and topographical conditions, with the total rainfall during the observation being 465.6 mm with various daily rainfall intensities (Table 1). The interaction between rain and soil is affected by wind direction and speed. The direction of the rain determines the amount of kinetic energy of rain in contact with the soil, so it affects the level of soil erosivity [36]. The results of the observations showed that the wind at the plot erosion dominant moved in the 315°. Plot erosion is located with a slope that has an aspect of 110.5°, which is the opposite of the rain's direction. This indicates that the rain is moving toward the slopes so the erosion plot location has greater contact with rain, increasing potential for erosion due to rain. Areas with a slope facing opposite to the direction of rain are more prone to detachment of soil particles which can increase the occurrence of erosion processes [37]. The climatic data show that plot experiment is located on an erosion prone area.

All climatic parameters also affect the process of soil development. Temperature is the climate parameter that influences the occurrence of plant stress, where the hyphae will grow better [38]. Combinations of temperature and



(a) (b) (c)

Figure 2: SEM test results of bamboo leaf biochar. (a) Pyrolysis temperature 400°C. (b) Pyrolysis temperature 450°C. (c) Pyrolysis temperature 500°C.

Figure 3: The appearance of erosion plots in the field at preparatory conditions. (a) Erosion zone. (b) Deposition zone.

Table 1: Climate conditions in the study area.

Period	Rainfall (mm)	Wind direction (°)	Wind speed (m/s)	Temperature (°C)	Moisture (%)
Week 1	62.4	135	4.1	25	81.7
Week 2	150.9	315	3.7	23.5	88.6
Week 3	79.2	270	4.1	24.8	83.9
Week 4	9	315	3.4	25.2	84
Week 5	99.6	315	3.4	24.2	90.7
Week 6	24.9	315	3.1	25.2	86.4
Week 7	39.6	315	3.4	24.9	85.9
Total	465.6				

Source: analysis result.

moisture conditions can determine the conversion processes of mineral compounds in the soil such as the rate of weathering and the accumulation of soil-forming products, vegetation type, water erosion process, and soil microorganisms [39]. Microorganisms play an important role in soil aggregation. The quantity of microorganisms adjusts to the space or pores availability as living space. The presence of microorganisms influences the changes in BD, OM, and porosity that increases soil aggregation [40].

3.2. Runoff and Erosion. Observations were made during the peak rainy season (March-April) in 2021. The pores of biochar and pumice can increase active organic matter through soil microorganisms to increase soil aggregation. Increased soil aggregation will make the soil more resistant to erosion.

The erosion values are calculated from the sediment accommodated in the storage tank and analyzed in the laboratory. The largest runoff and erosion values were found in the control plot, with an erosion value of 32.8 kg and a

Table 2: Results of runoff and erosion measurements on each erosion plot.

Period	Rainfall (mm)	Control		Mycorrhizae		Pumice		Biochar	
		Runoff volume (liter)	Total erosion (kg)	Runoff volume (liter)	Total erosion (kg)	Runoff volume (liter)	Total erosion (kg)	Runoff volume (liter)	Total erosion (kg)
Week 1	62.4	10.20	0.16	7.65	0.12	7.65	0.12	6.38	0.09
Week 2	150.9	359.6	17.97	165.78	12.97	165.78	11.31	117.32	8.22
Week 3	79.2	102.02	5.69	51.01	2.85	43.36	1.88	34.43	1.68
Week 4	9	2.55	0.09	2.55	0.09	2.55	0.08	2.55	0.07
Week 5	99.6	165.78	7.08	165.78	6.96	165.78	6.06	153.03	5.49
Week 6	24.9	10.20	0.49	7.65	0.35	5.10	0.21	5.10	0.17
Week 7	39.6	35.71	1.33	25.50	0.87	20.40	0.71	12.75	0.41
Total	465.6	686.08	32.80	425.93	24.19	410.62	20.37	331.56	16.15

Source: analysis result.

runoff volume of 686.08 liters. Mycorrhizae plots resulted in 24.19 kg erosion and 425.93 liter runoff. The pumice plot produced 20.37 kg erosion and 410.62 liter runoff. However, the biochar plot resulted in 16.15 kg erosion and 331.56 liter runoff (Table 2). In detail, the difference in rainfall intensity and land cover in each plot affects the difference in runoff and sediment produced.

Biochar reduced soil loss by 50.78%, pumice by 37.9%, and mycorrhizae by 26.26%. Biochar was also able to reduce runoff by 51.67%, pumice by 40.15%, and mycorrhizae by 37.92%. The characteristics of the conservation material significantly affect the runoff and erosion values in each erosion plot. The presence of conservation materials can change the soil characteristics, so the control of runoff and erosion in each plot varies according to the quality of the soil characteristics in the erosion plot.

The result shows that mycorrhizae was least effective in comparison with others in reducing runoff and erosion. Soil erosion can decrease the amount of mycorrhizae. Raindrop splash can disintegrate soil aggregate and cause mycorrhizae in unprotected conditions, causing the role of mycorrhizae to be ineffective [32]. In addition, the erosion process also reduces the nutrient availability for mycorrhizae, that inhibit mycorrhizae hyphae growth [41]. The addition of mycorrhizae is temporally inappropriate. Mycorrhizae are given when wet season with high rainfall intensity. Mycorrhizae should be given during the dry season so that soil aggregation with mycorrhizae had formed.

Mycorrhizae grows better if the plant is under stress. Mycorrhizae hyphae help to fulfill nutrients and water intake for plants. Under temperature stress, the hyphae will be longer, thus increasing the water-holding capacity. It also promotes soil aggregation so it can reduce runoff and soil erosion [42–45]. The mycorrhizae application was conducted on plants with no stress in this study.

The addition of biochar and pumice has positive results in controlling runoff and erosion rates. The presence of biochar and pumice can increase the water-holding capacity and infiltration capacity in erosion plots, although it is more effective in biochar plots because its greater porosity. The porous nature of biochar can bind water and nutrients, thereby increasing the ability of the soil to catch water. The addition of biochar can reduce the surface runoff rate by 50% and increase the total water availability by up to 32% [19, 46].

3.3. Effect of Soil Ameliorant on Corn Plant Growth. Structure and pores in biochar and pumice are important aspects needed as a soil ameliorant. The presence of macro- and micropores can increase infiltration rate, soil aeration, and soil water storage. Improvements in soil characteristics are reflected in the growth of corn plants. There were apparent differences in corn growth in each erosion plot (Figure 4). The growth of corn plants can indicate an increase in soil fertility due to mycorrhizae, pumice, and biochar.

The growth of corn plants on biochar plots showed the best results. The growth of corn plants on biochar plots is faster so that the presence of corn plants can protect the soil from rain and reduce erosion [25]. Biochar is a porous material that can provide nutrients needed by plants. In addition, the porous nature of biochar can become a habitat for soil microorganisms that increase plant growth. The metabolic activity of soil microorganisms can break down nutrients bound by organic matter into available nutrients for plants [47].

Biochar is also better at retaining water than pumice, as evidenced in the runoff. The runoff data showed that biochar could supply enough plant available water. Based on the SEM test, the element component test, the elements composition required by plants in biochar is also more complete than pumice (Table 3). The data show biochar is a soil ameliorant material that can provide nutrients for plant needs. The soil Cation Exchange Capacity (CEC) also showed that the biochar plot had the highest value (Table4). The CEC value can describe the level of fertility in each erosion plot. The CEC increased in biochar plots because of the porous nature of biochar. That porosity is able to become a reservoir that binds cation elements. Biochar has an empty C bond due to pyrolysis. Therefore, biochar easily binds to cations in the soil, thereby increasing the soil CEC.

3.4. Effect of Biochar, Pumice, and Mycorrhiza on Change in Soil Characteristics. Soil in plot experiment has high clay content up to 40% (Table 5). In general, the transitional volcanic landscape has a thick soil and high clay content [48]. Soil with high clay content could drive runoff and soil erosion.

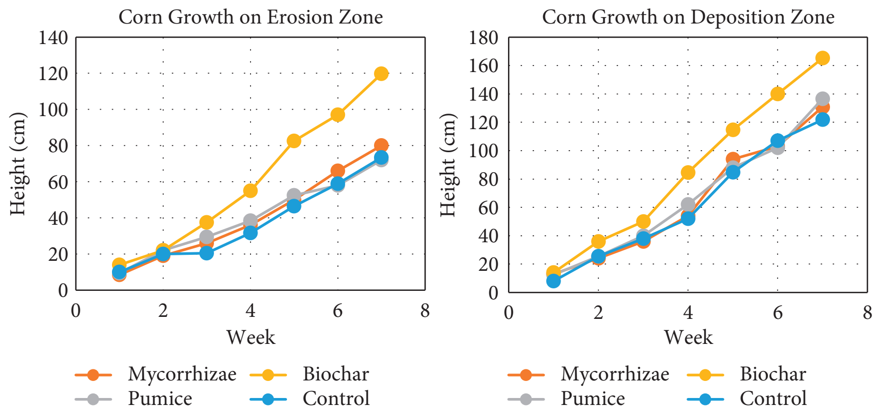


Figure 4: Corn growth graph on erosion and deposition zone.

Table 3: Test results of element components of biochar and pumice.

Element	Bamboo leaf biochar (500°C) (%)	Pumice (%)
C	45.83	13.44
N	16.36	0
O	23.88	43.93
Mg	0.64	0.51
Si	8.76	19.67
K	1.58	0.95
Ca	1.04	2.38
Cu	1.9	0
Na	0	2.01
Al	0	5.7
Fe	0	3.58
Re	0	7.82
Total	99.99	99.99

Source: analysis result.

The decrease in runoff and erosion values varies due to changes in soil characteristics and vegetation cover conditions in erosion plots. The addition of soil ameliorants in a short time are not able to change the soil texture. Changes in soil characteristics can be seen in the values of BD, SG, porosity, organic matter, and stability of soil aggregates (Tables 4 and 6). Changes in the value of different soil characteristics in each plot were due to the interaction between biochar, pumice, and mycorrhizae with the soil. Changes in soil characteristics are strongly influenced by the amount and soil ameliorant applied [49]. In addition, the incubation time also affects the magnitude of changes in soil properties due to the addition of soil ameliorants [50]. Furthermore, changes in soil characteristics are also influenced by the application of soil ameliorants. In this study, biochar and pumice were spread over the surface of the erosion plot. Mycorrhizae are spread only in the corn root zone.

The addition of soil ameliorants improves soil characteristics, thereby reducing runoff and erosion. Good quality of soil characteristics can increase the ability of the soil to absorb water and increase soil aggregation so that it is not easily transported by flow. Mycorrhizae, pumice, and biochar have different mechanisms in soil amendment. Mycorrhizae increased aggregation by binding to soil particles through the interaction of hyphae and soil. So the improvement of soil aggregation was influenced by the corn roots development and hyphae from mycorrhizae. Hyphae and roots play an essential role in forming soil particle bonds that increase the stability of soil aggregates [51]. Biochar and pumice enhance soil aggregation through their porous nature. This porous nature became a trap for soil particles which will bind to each other and increase soil aggregation. In addition, the pores nature were also capable of being a habitat for microorganisms. The presence of microorganisms becomes an active organic matter that can bind soil particles, increasing soil aggregation [52]. In general, biochar will increase the stability of soil aggregates in the long term [53].

Based on the observation, there are differences in the results of runoff and sediment in each plot. These differences illustrate the different forms of interaction between each soil ameliorant. Mycorrhizae are strongly influenced by hyphae and plant roots, so that their influence is only found around the root zone. Meanwhile, in biochar and pumice, the difference in interactions is due to pore size and surface area differences. The pore size in biochar is smaller than pumice, making the surface area larger than pumice (Figure 5). Biochar and pumice has an average pore diameter of 3,75 μm and 7,5 μm. These characteristics make biochar more effective in increasing soil aggregation and absorbing water. The presence of macro- and micropores can increase infiltration rate, soil aeration, storage, and provide nutrients needed for plants [54, 55].

In general, the result of biochar is better than pumice and mycorrhizae. However, the disadvantage of biochar is in the manufacturing process. The process of making biochar requires a lot of raw materials and the cost is quite expensive, so it is not effective when applied to a large area. Mycorrhizae can be applied easily, but the results are only around the root zone and are ineffective for areas outside the root zone. The use of pumice will be more effective because utilizing pumice can be done directly by smoothing its size.

Based on this research, for effectiveness, pumice can be inoculated with mycorrhizae. The combination of pumice and mycorrhizae is possible to produce a more effective result. The presence of mycorrhizae allows for accelerating

Table 4: Changes in soil characteristics before and after experiment.

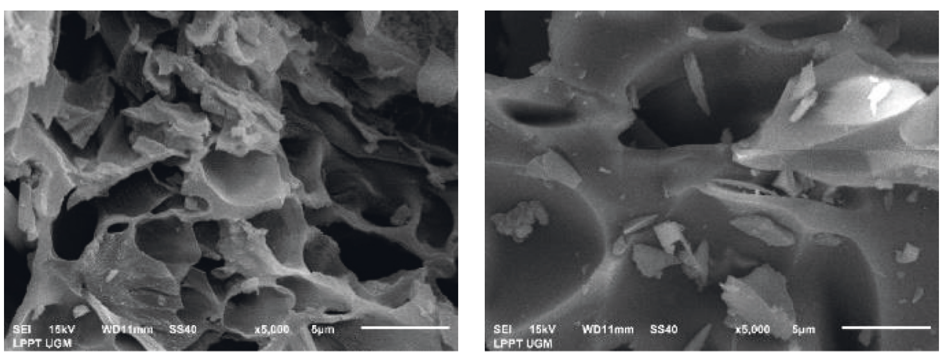
Erosion plot	Zone	Before experiment					After experiment				
		BD (g/cm^3)	SG	Porosity (%)	OM (%)	CEC (me/100 g)	BD (g/cm^3)	SG	Porosity (%)	OM (%)	CEC (me/100 g)
C	E	1.39	2.25	38.52	1.18	7.17	1.28	2.11	39.22	1.69	11.43
	D	1.40	2.23	37.49	1.38	7.08	1.28	2.09	38.49	1.83	11.33
M	E	1.38	2.25	38.55	0.96	7.13	1.25	2.09	40.15	1.90	12.24
	D	1.39	2.35	40.86	1.43	7.09	1.20	2.10	42.81	2.37	12.40
P	E	1.38	2.12	34.77	1.27	7.18	1.19	2.08	42.80	2.06	12.64
	D	1.39	2.20	37.04	1.34	7.22	1.18	2.10	44.05	2.10	12.75
B	E	1.39	2.14	35.24	1.15	7.17	1.17	2.07	43.26	2.33	14.40
	D	1.38	2.17	36.52	1.15	7.20	1.14	2.06	44.48	2.38	14.80

C: control; M: mycorrhizae; P: pumice; B: biochar; E: erosion; D: deposition. Source: analysis result.

Table 5: Soil texture at erosion plot locations.

Zone	Sand (%)	Clay (%)	Silt (%)
Erosion	8	54	38
Deposition	10	48	42

Source: analysis result.



(a) (b)

Figure 5: SEM test results of bamboo leaf biochar and pumice stone. (a) Biochar. (b) Pumice.

Table 6: Changes in aggregate stability values after experiment.

Erosion plot	Aggregate stability			
	Before experiment		After experiment	
Control (erosion zone)	51.85	Firm	56.38	Firm
Control (deposition zone)	159.07	Very strong	169.06	Very strong
Mycorrhizae (erosion zone)	51.85	Firm	56.92	Firm
Mycorrhizae (deposition zone)	158.88	Very strong	169.71	Very strong
Pumice (erosion zone)	51.68	Firm	59.50	Firm
Pumice (deposition zone)	158.28	Very strong	183.74	Very strong
Biochar (erosion zone)	51.63	Firm	73.10	Strong
Biochar (deposition zone)	159.01	Very strong	190.80	Very strong

Source: analysis.

the decomposition of pumice so that the nutrients contained in pumice become available for the plant. The combination of pumice and mycorrhizae needs to be done for further research.

3.5. Distribution of Characteristic Properties of Soil. Aggregate stability is an important parameter that describes the development of soil structure. Soil aggregate stability is a key parameter indicating soil resistance to erosion [56]. Changes in soil characteristics have the same pattern in each erosion plot. Better soil characteristics were found in the deposition zone (Tables 4 and 6). The deposition zone in all erosion plots had better values of bulk density, specific gravity, porosity, organic matter, and aggregate stability. The growth of corn plants also showed that plant growth was better in the deposition zone. The addition of soil ameliorants can reduce the erosion rate in the erosion zone and increase the sediment capture capacity in the deposition zone. These data prove that the slope arrangement significantly affects the ongoing geomorphological process.

Geomorphological processes that work in an area affect the quality of the soil characteristic. Soil characteristics in the deposition zone are better because it is a material accumulation zone from the erosion zone. However, in the erosion zone, the soil characteristics are not as good as the deposition zone because the geomorphological process is active. Hence, the soil is not well developed. Previous studies have also shown that the value of the quality of the soil characteristics in the deposition zone and its quality will decrease gradually to the top erosion zone [57]. In general, other factors such as land management also affect the quality of soil characteristics. Very intensive land management can reduce the value of physical properties to soil quality [58].

4. Conclusion

The addition of biochar was not only able to reduce erosion by 50.78% and runoff by 51.67% but also increased the growth of corn plants. These results indicate that biochar is a better conservation material in controlling runoff and erosion. The effect of giving biochar impacts changes in bulk density (BD), specific gravity (SG), porosity, organic matter content (OM), cation exchange capacity (CEC), and aggregate stability. The impact given is a decrease in the value of BD and SG, thereby increasing the porosity of the soil. The addition of biochar also increases organic matter, aggregate stability, and soil CEC, which positively impacts the growth of corn plants. The changes provided by biochar can effectively reduce the rate of runoff and erosion. The potential for biochar application is to prevent detachment of soil structure at the erosion zone and to increase the sediment capture at the deposition zone.

4.1. Research Limitation. This research was a preliminary study that has a significant contribution to reducing erosion. The focus of this research is on measuring the runoff volume and erosion, not on changes in soil characteristics. Therefore, this research still needs to be developed extensively in other areas with different characteristics of precipitation, soil, slope, and plants. This research is also the development of previous research based in the laboratory.

Data Availability

No supplementary data were used to support the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This paper is a part of thesis research titled "Aplikasi Biochar untuk Mengurangi Erosi pada Lereng Terjal dengan Kandungan Lempung dan Intensitas Hujan Tinggi" [59]. This research was part of the Transbulent (Transition of Natural Processes in the Built-Up Environments) research group. The authors would like to thank all members of the Transbulent research group for the valuable discussion and suggestions during this research. We would like to express our gratitude to Universitas Gadjah Mada for supporting the funding of this publication through the Rekognisi Tugas Akhir (RTA) project. The research was conducted by all three involved researchers. The second and the third researcher had a personal budget to support the research both in the field and in the laboratory.

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