Application of ameliorant for improving soil quality and chili productivity on degraded acidic upland

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Abstract. Development of agricultural commodities, including for horticulture crops, must lead to suboptimal lands and often already degraded. The study aims to study the effectiveness of organic ameliorant in improving soil quality on degraded acidic upland and its impact on the productivity of chili plants. The study was conducted on acidic upland in Tamanbogo, East Lampung, using a randomized block design with six treatments and three replications. The treatment used 3 ameliorants namely compost, biochar KK-50, Biochar KK-20 with a dose of 20 t ha\(^{-1}\), each combined with and without mulch, the control treatment was without mulch and ameliorant. The results showed that the amelioration treatment had a significant effect on improving soil physical properties, indicated by the average BD values which was significantly lower and the soil porosity was significantly higher. The treatment of biochar also results in significantly higher aeration pores than control treatment. The average soil pH in the control treatment <5, while the average pH in the biochar treatment >5. The average potential soil K content at the biochar treatment was significantly higher. Amelioration treatment has a significant effect on the growth of chili plants. The average chili production in the amelioration treatment was relatively higher than control.

1. Introduction

Indonesia production of horticultural main commodities during the 2000s showed a fluctuating pattern. The smallest growth rate among them occurs in chili, which the growth is about below 4.13% per year [1], hence, every year there are always price fluctuations and have a share of Indonesia's inflation. To meet the needs of this commodity, additional areas are needed for the development of chili plants. Because the availability of fertile soil has become increasingly limited, development of agricultural commodities including for horticulture crops such as chili must lead to suboptimal (marginal) lands, and the available land is often already degraded [2]. One potential suboptimal land to be developed, both in terms of area and environmental risk, is acidic upland [3 and 4].

The total area of acidic upland soil is around 108.8 million ha or 60% of Indonesia total land area, which has the potential to develop agriculture at around 62.6 million ha. However, less than 50% of the total potential land is available [4]. The main characteristic of acidic upland is the low soil pH (<5.5). Cat-ion exchangeable and soil CECs are classified as low, Fe and Mn content is often in conditions that can be toxic for plants. Low level soil fertility caused soil become poor in biotic elements [3, 5, 6].

The deterioration of soil carbon content is a form of land degradation that is often found on acidic upland soil. Monitoring status of C organic matter in agricultural areas on acidic upland showed an...
average content of C organic <2% [7-9]. Naturally, soil organic matter decrease in a fast way in the tropics, can reach 30-60% within 10 years [10]. The intensity of landuse influences the dynamics of carbon stocks in the soil [11-17]. Carbon loss from soil generally occurs in the form of CO₂, dissolved carbon and erosion [11, 18, 19].

Turnover of soil organic matter as a restoration in soil generally carried out by compost application, which is limited of its availability. Recalcitrant charred organic matter (biochar) has not been done by many farmers. Some research showed a positive effect of biochar on increasing soil pH and cation exchange capacity [9, 20, 21, 22]. Also, biochar has positive impact on crop productivity at acidic upland soil [9, 21, 23, 24]. The study aims to determine biochar-based soil amendment effects on improving acidic upland soil quality and chili productivity.

2. Materials And Methods

2.1. Research Location

The experiment was conducted at Taman Bogo Research Station, Taman Bogo Village, Purbolinggo Sub District, East Lampung District, Lampung Province, with its position is 20-25 m above sea level (asl) and the coordinates of a 105°29'23" BT - 6°0'12" LS. Annual rainfall is 2,200 mm year⁻¹. Soil type of Taman Bogo research station is classified as Typic Kanhapludults [25]. The results of soil analysis before treatment (Table 1) showed soil pH ranged from 4.7 to 4.9 (acidic), high acidity was the main properties of the soil. Potential P₂O₅ (HCl 25% extraction) is very high. The soil is in intensive fertilization at the experimental site. The available P content (Bray 1 extraction) is also very high, a condition not commonly found in acid soils, which generally has a low P availability due to aluminum bonding (in the form of Al-P). Both potential (extracted by HCl 25%) and (morgan extraction) available Potassium content both potential and available is very low, indicating that the potassium input into the soil is relatively low, both from organic and chemical fertilizers. The indication that the land used for the experiment is classified as degraded land is indicated by the content of C-organic soil <1.5% (low), whereas soil organic carbon is one of the important components of soil quality determinant. According to [26] soil quality standards for C-organic content to maintain soil physical and chemical properties, as well as corn production in optimum conditions are in the range of 1.7 - 2.3% or equivalent to the soil organic matter content of 2.9 - 4.0%. Low organic matter content also affects the organic N content which ranges from 0.11 - 0.16% (low). C/N ratio 11-16 (moderate) shows that soil organic matter has been relatively stable or has decomposed quite perfectly. This also shows that the addition of organic matter to the soil is relatively low.

| Table 1. Soil chemical properties (soil pH, organic C, total N, potential P and K, available P and K) |
|---|---|---|---|---|---|
| Block/Value | Extraction 1:5 | Based on dry weight |
| | pH | Organic matter | HCl 25% | Bray 1 | Morgan |
| | | H₂O | KCl | Walkley Black C (%) | Kjeldahl N (%) | C/N | P₂O₅ (ppm) | K₂O (cmolc kg⁻¹) | P₂O₅ | K₂O |
| I Average | 4.74 | 3.95 | 1.90 | 0.16 | 11.90 | 82.68 | 6.80 | 78.73 | 24.38 |
| Std. Dev | 0.19 | 0.14 | 0.55 | 0.04 | 1.95 | 34.95 | 2.20 | 46.52 | 8.56 |
| II Average | 4.92 | 4.01 | 1.54 | 0.11 | 14.92 | 73.15 | 8.06 | 81.10 | 26.81 |
| Std. Dev | 0.23 | 0.14 | 0.16 | 0.03 | 4.90 | 9.07 | 2.73 | 26.75 | 8.15 |
| III Average | 4.95 | 4.16 | 1.59 | 0.11 | 16.56 | 67.38 | 9.63 | 63.77 | 29.73 |
| Std. Dev | 0.28 | 0.23 | 0.15 | 0.03 | 5.23 | 13.69 | 4.21 | 32.47 | 11.24 |

The indicator that the land in the study location is classified as poor is also indicated by the Ca exchange rate Mg, and K which is low, while Na is classified as very low. Cation Exchange Capacity (CEC) is also low, base saturation is still classified as moderate. Al and H cations can be exchanged on average <1% (Table 2).
Table 2. Soil chemical properties (CEC, base saturation, Al$^{3+}$ dan H$^+$) before treatment

| Block/Value | Cation exchange rate (NH$_4$-Acetat 1N, pH7) | KCl 1N |
|-------------|--------------------------------------------|--------|
|             | Ca$^{2+}$ | Mg$^{2+}$ | K$^+$ | Na$^+$ | Sum | CEC | Base saturation | Al$^{3+}$ | H$^+$ |
|-------------|----------|----------|-------|-------|-----|-----|----------------|----------|-------|
| I           | 4.10     | 0.74     | 0.12  | 0.07  | 5.03| 11.29| 45.87          | 0.91     | 0.33  |
| Std. Dev    | 1.07     | 0.37     | 0.05  | 0.02  | 1.12| 2.79 | 13.15          | 0.49     | 0.13  |
| II          | 3.38     | 0.72     | 0.16  | 0.05  | 4.31| 10.12| 42.46          | 0.61     | 0.34  |
| Std. Dev    | 0.34     | 0.32     | 0.06  | 0.02  | 0.65| 0.38 | 5.37           | 0.31     | 0.13  |
| III         | 3.51     | 0.71     | 0.19  | 0.04  | 4.44| 9.60 | 44.80          | 0.57     | 0.30  |
| Std. Dev    | 1.07     | 0.41     | 0.09  | 0.03  | 1.51| 1.72 | 10.87          | 0.38     | 0.15  |

The results of the soil physical analysis before treatment (Table 3) showed that soil bulk density <1 g cc$^{-1}$ mean that the soil was not too dense, with soil porosity> 50%. Pore proportions are calculated based on the results of measurements of water content at various levels of pF shows the proportion of soil pore dominated by fast drainage pore, which ranges from 27-32% by volume. The drainage proportion is slow on average <5% volume, while the available water pores range from 5-7% by volume. This data shows the low ability of the soil to hold water. The addition of organic soil amendment is expected to increase the ability of the soil to hold water. Because even though acidic upland is generally located in wet climate areas [4], but the availability of water is often an obstacle to farming in the dry season.

Table 3. Soil Physical Properties before treatment

| Blok  | Bulk Density | Particle Density | Total pores | Water content | Drainage pores | Water available pores |
|-------|--------------|------------------|-------------|---------------|----------------|-----------------------|
|       | (g cc$^{-1}$) |                  |             |               | Fast | Slow |% volume |% volume |
| I     | 0.98         | 2.30             | 57.53       | 45.94         | 28.89| 24.83| 18.62  | 28.62  | 4.09  | 6.21  |
| Std. Dev | 0.08        | 0.05             | 3.30        | 4.95          | 2.10 | 1.51 | 1.24   | 5.27   | 0.78  | 0.57  |
| II    | 0.98         | 2.33             | 57.96       | 46.86         | 30.75| 26.54| 19.30  | 27.21  | 4.22  | 7.24  |
| Std. Dev | 0.06        | 0.05             | 2.67        | 5.67          | 2.38 | 1.98 | 1.29   | 4.39   | 0.99  | 1.60  |
| III   | 0.94         | 2.33             | 59.46       | 42.49         | 27.37| 23.15| 17.61  | 32.08  | 4.21  | 5.54  |
| Std. Dev | 0.07        | 0.10             | 3.89        | 4.14          | 2.91 | 2.89 | 1.82   | 6.49   | 0.50  | 1.58  |

2.2. Material

Ameliorants used were compost and biochar. Biochar is the result of burning with low level oxygen (pyrolysis) of cocoa shells which are mostly found in the research location and have not been used optimally. The estimation results of [27], the average annual cocoa skin production in Indonesia is around 200,000 ton. Biochar derived from cocoa skin has relatively good properties as an ameliorant material. The results of the cocoa biochar analysis [28] showed a pH value of about 10.8, a total C of 33.04%, N, P, and K content respectively were 0.3, 0.33, and 11.25%, Ability to hold water around 50% dry weight. Indicator plants in this experiment used red chili (Capsicum annum L.). Compost is from the decomposition of manure. Biochar and compost are crushed and sieved through a 1 mm sieve. KK-50 soil amendment is a mixture of biochar and compost with a composition of 50% biochar and 50% compost. while KK-20 is a mixture of 20% biochar and 80% compost. Mulch used is gray plastic mulch.
2.3. Methods
The experiment was carried out using a completely randomized block design with seven treatments and 3 replications. The treatment consists of: P0 = Control (without soil amendment and mulch), P1 = Biochar KK20, P2 = Biochar KK20 + mulch, P3 = Compost, P4 = Compost + mulch, P5 = KK50, and P6 = KK50 + mulch. Soil amendment (compost, biochar KK-20 and biochar KK-50) were applied 1 week before planting, mixed evenly at a depth of 20 cm. Ameliorant dose used is 20 t ha\(^{-1}\).

Chili planted in experimental plots are around 4 weeks old (an average of 4-5 strands of leaves, about 5-10 cm high). Treatment plot sizes of 5 m x 4 m each, soil bed dimension size (5 x1x 0.3) m\(^3\) (lengthxwidthxheight) and the distant between bed is 25 cm. Chili are planted with a spacing of 40 cm x 75 cm. Basic fertilizers are given according to the level of fertilizer recommendations for red chili plants, namely: N fertilizer 117 kg ha\(^{-1}\) (260 kg ha\(^{-1}\) urea), P\(_2\)O\(_5\) is 40 kg ha\(^{-1}\) (112 kg ha\(^{-1}\) SP-36), and K\(_2\)O 131 kg ha\(^{-1}\) (218 kg ha\(^{-1}\) KCl) [29].

The plant parameters observed were the growth and production of chili plants. Plant height is observed every 2 weeks. Soil samples for soil analysis after treatment taken before harvest, at a depth of 0-20 cm. Sampling of whole soil (undisturbed) for analysis of soil physical properties using a ring sample measuring 7.5 cm in diameter and 4 cm high. Sampling of composite soil for chemical analysis using a 1 inch soil auger and for each soil sample plot was taken from six points then mixed. Soil samples were then taken ± 0.5 kg. The properties of the soil analyzed were: (1) Soil physical properties namely bulk density (BD), particle density (PD), and pore distribution, (2) soil chemical properties namely pH, cation exchange capacity (CEC), content of organic C, N, P and K, and Al.

BD and PD analysis was carried out using the gravimetric method, while the pore distribution is calculated based on the pF curve. pH analysis using H\(_2\)O extraction. Potential P\(_2\)O\(_5\) and K\(_2\)O use 25% HCl extract, while available P and K are each using the Bray and Morgan methods. Organic C and N analyzes each used Walkey and Black and Kjedal methods. Bases can be exchanged analyzed by extraction method of NH\(_4\) Acetat 1 N at pH 7. While Al and H used extraction of KCl 1 N.

Data analysis was performed statistically on the soil physical and chemical properties, plant growth, and yield using analysis of variance (ANOVA) or diversity testing with a confidence interval of 95%. To see the effect of the real difference from the variables due to the treatment and their interactions, LSD tests were carried out at a significantly level of 5%.

3. Results and discussion

3.1. Effects of Ameliorant on Soil Chemical Properties
Soil acidity is a major limiting factor for crop productivity in acid upland. Therefore, one of the keys to the success of increasing acid upland productivity is to control soil acidity. The results of this study indicate that ameliorant treatment significantly affected soil acidity (Table 4). The average acidity of the soil in the biochar treatment is lower than the control and compost treatment, indicated an average pH value greater than 5 in the biochar treatment KK-20 or KK-50, while the average soil pH in the control and compost treatment is still less than 5. The effectiveness of biochar in increasing the pH of acid soils is also shown by [9, 20, 21, 23, 24, 30]. [30]states that the association of H\(^+\) ions with biochar and decarboxylation processes was likely to be the main factor of neutralizing soil acidity. Based on several research results, [20]concluded that the degree of influence of biochar on changes in soil pH is determined by the pH of biochar, and according to [31] the pH of biochar is influenced by the type of feedstock, production temperature, and production duration.

Biochar application to agricultural land is significant as a strategy for C sequestration [23, 27]. Though having a relatively high C content, biochar also has a higher potential in carbon sequestration, [32] states that biochar is a source of stable organic matter, carbon in biochar is more resistant to chemical and biological decomposition than the material in natural condition, which results in increased soil carbon stock, and mitigation of CO\(_2\) emissions [23 and 31]. The results of this study showed that biochar treatment (KK-20 and KK-50) produced significantly higher organic C content than control, whereas compost treatment produced C organic content which was not significantly
different from control, even though the value of soil C content achieved by each treatment was still less than 2%.

Ameliorant treatment with the highest proportion of biochar (KK-50), especially those added with mulch treatment, had significantly higher N content than control. Although biochar had a significant effect on the content of C and N in the soil, the CN ratio in all treatments showed no significant difference, averaging around 9-11. Aluminum is a limiting factor for plant growth that is often encountered in acidic upland [3, 6]. Data in Table 1 showed the amelioration treatment using biochar has a significant effect on the reduction of Al, mainly biochar KK-50. The results of the study of [22] also showed that biochar rice husk application at a dose of 24 t ha$^{-1}$ showed a significant effect on the reduction in exchangeable Al.

Table 4. The effect of soil amendment on soil pH, organic C, total N, CEC, exchangeable Al and H

| Treatments          | pH H$_2$O | C (%) | Walkey& Black | N Kjedahl | CN Ratio | CEC | Al$^{3+}$ | H$^+$ |
|---------------------|-----------|-------|---------------|-----------|----------|-----|-----------|-------|
| Control             | 4.95ab$^1$| 1.25  | 0.13b         | 10a       | 4.59a    | 0.58a| 0.27a     |       |
| Biochar KK-20       | 5.07a     | 1.52ab| 0.14ab        | 11a       | 4.91a    | 0.32ab| 0.19b     |       |
| Biochar KK-20 +mulch| 5.21a     | 1.52ab| 0.14ab        | 11a       | 5.05a    | 0.13b| 0.17b     |       |
| Compost             | 4.95ab    | 1.28bc| 0.14ab        | 9a        | 4.42a    | 0.41ab| 0.19b     |       |
| Compost +mulch      | 4.73b     | 1.47abc| 0.14ab       | 10a       | 5.24a    | 0.57a| 0.22ab    |       |
| Biochar KK50        | 5.26a     | 1.49ab| 0.14ab        | 10a       | 5.45a    | 0.12b| 0.17b     |       |
| Biochar KK50 +mulch | 5.11a     | 1.55ab| 0.16a         | 10a       | 4.95a    | 0.23b| 0.19b     |       |

$^1$Number in the same column followed by the same letter are not significantly different at $\alpha$ 5% based on the DMRT test

The data in Table 5 shows the effect of ameliorants on the potential P and K content and available P and K. The highest potential P content was achieved in the KK-50 treatment with mulching. The potential P content achieved by this treatment is significantly higher than other treatments. Likewise with the available P content (P-Bray), the KK-50 biochar treatment plus mulching produced significantly higher available P content compared to other treatments. The results of the study of [22] on acid dry land also showed a positive effect of biochar on increasing available P. The potential and available K content (K Morgan) in the soil in the KK-50 and KK-20 biochar treatments also showed a significant increase compared to control.

Table 5. The effects of soil amendment on potential P and K also available P and K

| Treatments          | HCl (25%) | KCl 1N |
|---------------------|-----------|--------|
|                     | P$_2$O$_5$ (mg 100g$^{-1}$) | K$_2$O (cmolc kg$^{-1}$) |
| Control             | 69.67b$^1$| 2.67c  |
| Biochar KK-20       | 72.67ab   | 16.00ab|
| Biochar KK-20 +mulch| 70.33b    | 20.67a |
| Compost             | 70.33b    | 6.33c  |
| Compost +mulch      | 76.33ab   | 9.67bc |
| Biochar KK-50       | 72.33b    | 20.67a |
| Biochar KK-50 +mulch| 90.33a    | 21.67a |

$^1$Number in the same column followed by the same letter are not significantly different at $\alpha$ 5% based on the DMRT test

The ameliorant treatment in acidic upland also had a significant effect on the exchangeable bases content, especially Mg and K (Table 6). [28 and 34] stated that biochar is rich in macro nutrient. In this study amelioration by using a mixture of biochar and compost did not show any significant effect on CEC. The effect of biochar on CEC does not show a consistent effect, some research results show
a positive effect of the use of biochar on CEC [35-37], while several other research results show no significant effect [21 and 38].

Table 6. The effects of soil amendment on exchangeable Ca, Mg, K, and CEC

| Treatment                      | Exchangeable cations (NH4-Acetat 1N, pH7) | CEC            |
|--------------------------------|------------------------------------------|----------------|
|                                | Ca\textsuperscript{2+}  | Mg\textsuperscript{2+} | K\textsuperscript{+} |----------------|
| Control                        | 3.42a\textsuperscript{1} | 0.33c            | 0.057d           | 4.59a           |
| Biochar KK-20                  | 3.56a            | 0.66ab           | 0.44ab           | 4.91a           |
| Biochar KK-20 +mulch           | 3.81a            | 0.87a            | 0.58a            | 5.05a           |
| Compost                        | 3.37a            | 0.45bc           | 0.15dc           | 4.42a           |
| Compost +mulch                 | 3.49a            | 0.49bc           | 0.27a            | 5.24a           |
| Biochar KK50                   | 3.96a            | 0.76a            | 0.57a            | 5.45a           |
| Biochar KK50 +mulch            | 3.77a            | 0.77a            | 0.60a            | 4.95a           |

\textsuperscript{1}Number in the same column followed by the same letter are not significantly different at \(\alpha\) 5\% based on the DMRT test.

3.2. Soil Amendment Effects on Soil Physical Properties

Biochar and compost-based soil ameliorant had a significant effect on the improvement of selected soil physical properties, especially on BD, total porosity and percent of macro pores (acted as fast drainage pores and aeration pores); while on particle density and proportion of low drainage pores and available water pores, the amelioration did not show any significant effect (Figure 1 and Table 7)

Figure 1. The effects of soil amendment on soil bulk density and total pore space on degraded acidic soil

The average of soil BD (bulk density) of the soil in the ameliorant treatment was significantly higher than in control. The use of biochar KK20 combined with plastic mulch resulted in significantly lower soil BD compared to controls, while compost and biochar KK-50 with or without plastic mulch produce significantly lower BD than control. Biochar KK20 also significantly affected total pore space if it is accompanied by mulch. As for compost and Biochar KK-50 with or without mulch significant effect on the increase in total pore space. The previous studies of [9 and 17] showed that biochar had positive effect on improving soil physical properties in both of acidic upland and upland at semi-arid climatic zone. However, as stated by [28] the effect of biochar is largely determined by dose, quality and type of biochar.

Table 7. The effect of soil amendment on soil particle density and soil pore distribution on acidic upland soil

| Treatment  | Partikel density | Fast drainage | Low drainage | Available |
|------------|------------------|---------------|--------------|-----------|-----------|
| Control    |                  |               |              |           |           |
| Biochar KK20+mulch    |                  |               |              |           |           |
| Compost    |                  |               |              |           |           |
| Biochar KK-20 +mulch |                  |               |              |           |           |
Table 7 shows that the treatment of soil ameliorants also affects the pore distribution, especially for macro pore as drainage pore and aeration pore. Available water pore was significant among treatments, however compared to control, ameliorant did not produce significant available water pores. The effectiveness of soil organic ameliorant both in the form of compost and biochar is also shown by several results in previous studies [9, 17, 35]. On upland soil, water availability is often a limiting factor in crop production (both of upland soil at wet climatic zone and acidic upland in general). Therefore the effect of amelioration treatment using biochar on soil physical properties is expected to have a positive impact on soil water holding capacity, as shown by some previous research results [36-42].

3.3. The Effect of Biochar on Plant Growth and Yield

The result of the study indicated that on acidic upland, amelioration treatment of biochar- compost mixture had significant effect on chili growth, especially at 6 weeks after planting, biochar treatment KK-20 and KK-50 produced significantly higher plant height compared to control. The average plant height at 2, 4, 8, and 10 weeks after planting in the KK-20 and KK-50 also tended to be higher even though the difference was not significant compared to control. The addition of mulch treatment did not produce a positive impact on plant growth (Table 8).

Table 8. Effect of soil ameliorant and mulching on red chilli plant height on acidic upland soil in KP Taman Bogo, Lampung

| Treatments                  | Plant height (cm) at weeks after planting (WAP) |
|-----------------------------|-----------------------------------------------|
|                             | 2   | 4   | 6   | 8   | 10  |
| Control                     | 16.87a* | 31.17a | 49.47a | 59.03a | 60.77a |
| Biochar KK20 20 t/ha        | 17.20a | 34.23a | 54.23b | 65.00a | 68.47a |
| Biochar KK 20 t/ha+mulch    | 16.83a | 29.33a | 47.37a | 60.57a | 65.00a |
| Compost 20 t/ha             | 18.37a | 36.67a | 56.00b | 66.40a | 68.50a |
| Compost 20 t/ha+mulch       | 16.97a | 28.37a | 44.03a | 57.57a | 59.80a |
| Soil ameliorant KK50 20 t/ha| 18.97a | 35.93a | 56.87b | 65.80a | 65.33a |
| Soil ameliorant KK50 20 t/ha+mulch | 15.23a | 28.57a | 46.50a | 59.53a | 63.80a |

WAP=weeks after planting. *Number in the same column followed by the same letter are not significantly different at α 5% based on the DMRT test

Biochar could be used as a soil ameliorant to increase crop yield. Several research results have shown the positive effects of biochar on crop production such as upland rice [38 and 43]. Figure 2 showed the effect of biochar on red chili yields on acidic upland in Taman Bogo, Lampung. Soil ameliorant with or without mulching showed higher yields of chili than controls. The combined of amelioration and plastic mulch showed a positive effect on the chili yield. Some of the results of...
previous studies show a positive effect of the use of plastic mulch on the production of chili plants, this is stated as the impact of the use of mulch in maintaining soil moisture [44 and 45].

**Figure 2.** Effect of ameliorant on red chili production

4. **Conclusion**
Amelioration of degraded acidic upland soil by biochar and compost mixture had a significant effect on soil quality, namely improving soil physical properties, indicated by the average BD values which was significantly lower and the soil porosity was significantly higher. The treatment of biochar with or without mulch also results in significantly higher aeration pores than control treatment. The average soil pH in the control treatment <5, while the average pH in the biochar treatment >5. Ameliorant application also has a positive effect on the other soil chemical quality, namely increasing of potential and available P and K, also exchangeable Mg and K. Amelioration formulation with higher biochar proportions resulted higher C and N contents compared to control significantly. Amelioration treatment has a significant effect on the growth of chili plants. The average chili production in the amelioration treatment was relatively higher than control. Treatment of amelioration and mulching showed a positive effect on increasing chili production. Amelioration of degraded acid upland can be carried out using a mixture of biochar and compost, but still requires a relatively high dose of use. Especially for biochar, the possibility of using dosage can decrease with time, due to the residual effect of biochar.

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