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Accumulation Levels of Available Cu and Cu Absorption in Corn in Ultisolss and Alfisolss After the Addition of Fly Ash and Organic Materials

Akumulasi Kadar Cu Tersedia dan Serapan Cu pada Tanaman Jagung di Tanah Ultisols dan Alfisols Setelah Penambahan Abu Terbang dan Bahan Organik

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ABSTRAK

Abu terbang merupakan hasil sampingan dari pembakaran batubara di pembangkit listrik termal yang dapat dimanfaatkan dalam dalam bidang pertanian sebagai sumber hara mikro. Penelitian ini bertujuan untuk mengetahui pengaruh abu terbang yang dikombinasikan dengan Biochar dan Pupuk Kandang terhadap sifat kimia tanah, pertumbuhan tananam, serta serapan Cu oleh tanaman jagung. Rancangan penelitian menggunakan rancangan acak kelompok faktorial, dengan faktor jenis tanah dan kombinasi perlakuan, dengan tiga kali ulangan. Pengamatan agronomi yang dilakukan meliputi tinggi tanaman, berat kering akar, dan berat kering tajuk. Analisis laboratorium yang dilakukan meliputi analisis tanah awal, Abu Terbang, Pupuk Kandang, Biochar, tanah setelah panen, dan analisis Cu dalam daun. Hasil penelitian menunjukkan ketersedian unsur Cu di Ultisols lebih tinggi sebesar 5,37mg/kg jika dibandingkan dengan Alfisols dengan rerata sebesar 3,90 mg/kg. Serapan Cu pada tanaman jagung yang ditanam di tanah Alfisols lebih besar dengan rerata sebesar 54,7mg/g lebih besar jika dibandingkan dengan yang ditanam di tanah Ultisols rerata sebesar 50,3 mg/g. Perlakuan antara Abu Terbang dan Pupuk Kandang dengan perbandingan 1:1 mempunyai tendensi untuk meningkatkan serapan Cu dengan nilai sebesar 68 mg/g. Tanah Alfisols berkorelasi nyata dengan bahan organik terhadap serapan Cu pada tanaman Jagung dengan nilai R= 0,827. Kesimpulan dari penelitian ini adalah ketersedian unsur Cu ditanah Ultisols lebih tinggi dibandingkan di tanah Alfisols dan Serapan Cu pada tanaman jagung lebih rendah setelah diberikan perlakuan penambahan pupuk kandang dan Biochar dan pertumbuhan tanaman jagung lebih baik.

Kata kunci: limbah batubara, sumber hara mikro, bahan organik, pertumbuhan tanaman

ABSTRACT

Fly ash was a byproduct of burning coal in thermal power plants that can be used in agriculture as a source of micronutrients. This study aimed to determine the effect of fly ash combined with Biochar and Manure on the chemical properties of the soil, plant growth, and the absorption of Cu corn plants. The study design used a randomized design of factorial groups, with soil type factors namely Alfisols and Ultisols with three repeats. Agronomic observations include plant height, dry weight of roots and headers. Laboratory analysis includes preliminary soil, Fly Ash, Manure, Biochar, soil analysis after harvest, and Cu in leaf. The results showed that the availability of Cu elements in Ultisols was higher by 5.37 mg/kg than Alfisols with an average of 3.90 mg/kg. Cu absorption in maize crops grown in Alfisols soil was greater with an average of 54.7 mg/g when compared to those planted in Ultisols soil by an average of 50.3 mg/g. The treatment between Fly Ash and Manure in a ratio of 1:1 has a tendency to increase Cu absorption with a value of 68 mg/g. Alfisols soil was significantly correlated with organic matter to Cu absorption in Corn plants with a value of R= 0.827. The conclusion of this study was that the availability of Cu elements in Ultisols soil was higher than in Alfisols soil and Cu uptake in corn plants was lower after being treated with the addition of manure and Biochar and corn plant growth was better.

Keywords: coal waste, micronutrients, organic matter, plant growth

INTRODUCTION

Fly ash was a by-product of burning coal in thermal power plants. The use of fly ash in agriculture could be a solution to safe disposal without damaging effects (Sahu et al., 2018). Fly ash was a side material produced from the combustion process that has heterogeneous components in the form of amorphous and crystalline (Dwivedi et al., 2014). The average concentration of various elements present in fly ash from the highest to the lowest Mn > Zn > Cu > Pb > As > Mo > Se (Patra et al., 2012). The fly ash contains 3.5% K, P, S, Na as well as the rest were some trace elements such as Mo, Se and B (Jambhulkar et al., 2018). Fly ash has higher levels of elemental turnover of phosphorus (P), magnesium (Mg), copper (Cu), zinc (Zn), molybdenum (Mo) than loessial soils (He et al., 2017). The addition of 50% fly ash in sandy could increase the capacity of sandy groundwater from 0.38 cm/cm to 0.53 cm/cm (Biswal, 2018).

In terms of water storage capacity, fly ash was superior in impact and has a low specific gravity (Tejasvi & Kumar, 2012). The properties of the soil interact with fly ash to modify pH and salinity (Biswal, 2018). The nature of fly ash could also change rough-textured soils to sandy and silted (Skousen et al., 2013). The nature of fly ash contains almost nothing organic carbon and phosphorus (P) elements (Shaheen et al., 2014). Fly ash could be used to improve the chemical properties of the soil as a nutrient enhancer and ameliorant Gupta et al., 2012). Biochar-based bioformulation with Fly Ash mixture act as a substitute for chemical fertilizers in a sustainable manner (Tripti et al., 2017). The addition of Biochar have no stimulating effect on the size of the soil microbial community (Usmani et al., 2019).

The addition of Fly Ash and Biochar could be achieved by adding fertilizers containing N elements or organic waste with a small C/N ratio (Belyaeva & Haynes, 2012). High doses of Fly Ash application will damage soil health and increase the bioavailability of toxic metals in the soil (Singh et al., 2016). Fly Ash applications in agriculture have constraints such as low nutrient availability and heavy metal toxicity (Bhattacharya et al., 2012). This study combined fly ash with organic materials such as biochar and manure fertilizer. The availability of heavy metals on the soil was greatly influenced by soil acidification. Soil pH was an important

factor for determining the availability of essential and non-essential elements for plants (Neina, 2022).

Transfer of Cu with relatively high concentrations from the earth's soil layers was determined by weather, soil formation processes, watering, oxidation-reduction potential, amount of organic matter in the soil and pH. As a metal element, copper can also coordinate with organic materials that form a bond, chelation.

This study aimed to observe the availability of Cu on acidic and rather neutral soils. Fly ash contains heavy metal elements and nutrients needed by plants, so it was necessary to test the effect of coal ash on cu-available in the soil. Then, the study used Biochar and Manure with the aimed of finding out whether manure and biochar could be used to reduce the content of heavy metals in the soil.

MATERIALS AND METHODS

Research Area

This research was carried out through several stages, namely the preparation of tools and materials, preparation of soil samples, soil incubation, observation of plants in greenhouses, laboratory analysis and data analysis. Field observations include soil sampling.

Observation in the Greenhouse for 12 weeks, starting from 1 week after planting. Laboratory analysis activities were carried out at the General Soil Laboratory, Soil Chemistry and Fertility Laboratory and Brass Laboratory, Department of Soil, Faculty of Agriculture, Gadjah Mada University with the type of plant used was Corn. Soil sampling was conducted in February 2018.

The soil samples used have different characteristics in terms of kima properties, namely Alfisols and Ultisols soils**.** The Alfisols soil sampling location was located in Patuk District, Gunung Kidul Regency, Yogyakarta while Ultisols soil collection was carried out in Somagede District, Banyumas Regency, Central Java.

Research Procedures

This research began with the incubation stage of soil in polybags which was 14 days to homogenize the soil with fly ash, cow manure, and biochar from coconut shell. The treatment ratio consists of fly ash dose 12 tons/ha, fly ash dose 20 tons/ha, combination of fly ash and biochar ratio 1: 2, combination of fly ash and biochar ratio 1: 1, combination of fly ash and manure ratio 1: 2, combination of fly ash and manure ratio of 1: 1. Activities were carried out by planting corn seeds until the vegetative period, namely plant growth at the time of flower formation or panicle. While waiting for the planting period, lab tests were carried out on the initial soil samples and after the research treatment, the procedure continued with lab tests on the content of Manure, Biochar, and Fly Ash. Initial and late soil analyses include N-total by Kjedhal method, Cu with DTPA extractor, determination of soil actual pH, determination of organic carbon using Walkley and Black method, Cu read with AAS with DTPA extractor, determination of cation exchange capacity (CEC) using ammonium acetate pH 7. The study continued with the analysis of Fly Ash characteristics including testing pH levels using a pH meter, water levels by gravimetric method, Cu with DTPA extractors. Before being applied to the soil, the content analysis stage of Manure and Biochar will be used in the form of pH H2O, C-organic with the method of determining ash content using furnace muffle, N-total with the Kjedhal method, Cu with DTPA extractor.

Data Analysis

Data analysis in this study used the SPSS application for the test the research design in the form of a Randomized Design of Factorial Groups, the first factor in this study was in the form of soil type and the second factor was a combination of Fly Ash, Manure, and Biochar. Each treatment was repeated 3 times so that the number of treatment combinations was 42. Furthermore, the data generated from field

tests in the form of plant height and weight were analyzed in the form of an anova test and a tukey follow-up test at a level of 5%.

RESULTS

Early Soil Characteristics of Alfisols Patuk and Ultisols

The Alfisols soil used in this study was Alfisols soil taken in the Patuk area, Gunung Kidul. The Ultisols soil used in this study was Ultisols soil taken in the Somagede area, Banyumas. The results of the soil analysis showed that soil fertility was low. This research was in accordance with the statement of Olowoake et al. (2015) in their research which states that Alfisols has a low content of organic matter, N and K elements so that it needs to add nutrients. The results of the early soil characteristics test (Table 1).

Characteristics of Fly Ash, Cow Manure, and Coconut Shell Biochar

The fly ash used in this study came from PT Pupuk Sriwidjaja Palembang. Based on the results of the analysis of the chemical properties of Fly Ash was mostly influenced by the coal combustion process, so at the time of testing the nitrogen element content was not found. Fly ash which was waste from coal undergoes a combustion process with high temperatures so that element N was not found. The biochar used in this study came from coconut shell waste and the manure used in this study came from cow dung. The addition of Manure and Biochar in this study was able to improve chemical properties. The results of the fly ash, Cow Manure, and Biochar characteristic test were presented in Table 2.

Table 1. Early soil characteristics of alfisols patuk and ultisols somagede

Variables	Unit	Alfisols	Ultisols
pH H2O		5.9	4.92
N-Total	%	0.19	0.13
C-Organic	%	1.8	1
Organic Matter	%	2.2	1.7
Available Cu	mg/kg	0.6	1.2
CEC	cmol (+)/kg	18.95	12.74
Texture			
Sand	%	39	45
Dust	%	10	19
Clay	%	51	36
Class		Clay	Loam Clay

Table 2. Early characteristics of fly ash, cow manure, and biochar

Material	Parameters	Unit	Value	Description
Fly Ash	pH H2O		8.71	Alkaline
	C-Organic	%	0.8	Lowest
	Organic Matter	%	1.4	
	Cu	mg/kg	78.6	
	N- Total	%	1.77	
Cow Manure	pH H2O	-	8.8	
	C-Organic	%	32.93	
	Organic Matter	%	56.77	
	N- Total	%	0.15	
Biochar	pH H2O	-	10.3	
	C-Organic	%	18.24	
	Organic Matter	%	31.45	

Results of Treatment Analysis of Soil Chemical Properties

Measured parameters of soil chemical properties after harvest include PH H2O, N-total, Organic Matter, and Cu available.

Effect of Treatment on Two Types of Soil on pH H2O

The treatment used was fly ash with different doses and fly ash enriched with biochar and manure. Based on the research conducted, the addition of materials in the form of fly ash, biochar and manure was able to increase the pH of the soil. Soil pH test results after the addition of Fly Ash, Biochar and Manure were presented in Table 3.

Effect of Treatment on Two Soil Types on N-Total

The addition of organic matter to the soil could affect the total N-content of the soil. Organic matter added to the soil in the form of Manure and Biochar derived from coconut shells. The results of the N-total test after the addition of Fly Ash, Biochar and Manure were presented in Table 4.

Effect of treatment on two soil types on organic matter

Based on this study, it could also be seen the difference in the effect of the addition of biochar and manure on the content of soil materials. The test results of organic matter after the addition of Fly Ash, Biochar and Manure were presented in Table 5.

Effect of Treatment on Two Types Soil on Available Cu

Fly Ash in this study became the main source of Cu to the availability of Cu. Based on this research, Fly Ash affects the availability of Cu. The addition of Manure and Biochar was able to reduce the availability of Cu on the soil to reduce pollution. The results of the Available Cu test of The addition of Fly Ash, Biochar and Manure were presented in Table 6.

Tabel 3. Effect of treatment on two soil types (Alfisols and Ultisols) on H2O pH

Treatment	Soil pH		Average
	Alfisols	Ultisols	
Control	5.65 $_{d}$	5.57 $_{f}$	5.61
Fly Ash (12 ton/ ha)	5.81 $_{d}$	5.76 $_{e}$	5.78
Fly Ash (20 ton/ha)	6.00 $_{c}$	5.91 $_{d}$	5.96
Fly Ash + Biochar (1:2)	6.03 $_{c}$	5.98 $_{c}$	6.01
Fly Ash + Biochar (1:1)	6.62 $_{a}$	6.11 $_{b}$	6.37
Fly Ash + Cow Manure (1:2)	6.25 $_{b}$	6.12 $_{b}$	6.19
Fly Ash + Cow Manure (1:1)	6.40 $_{b}$	6.18 $_{a}$	6.29
Average	6.11	5.95	+

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Tabel 4. Effect of treatment on two types soil (Alfisols and Ultisols) on N-Total

Treatments	N-total (%)		Average
	Alfisols	Ultisols	
Control	0.15 $_{e}$	0.11 $_{c}$	0.13
Fly Ash (12 ton/ ha)	0.36 $_{d}$	0.12 $_{c}$	0.24
Fly Ash (20 ton/ha)	0.37 $_{d}$	0.19 $_{c}$	0.28
Fly Ash + Biochar (1:2)	1.31 $_{c}$	1.08 $_{b}$	1.20
Fly Ash + Biochar (1:1)	1.43 $_{bc}$	1.16 $_{b}$	1.30
Fly Ash + Cow Manure (1:2)	1.60 $_{b}$	1.2 $_{ab}$	1.40
Fly Ash + Cow Manure (1:1)	1.84 $_{a}$	1.36 $_{a}$	1.60
Average	1.01	0.75	+

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 5. The effect of treatment on two types of soil on organic matter

Treatments	Organic Matter (%)		Average
	Alfisols	Ultisols	
Control	2.38	0.81	1.60 $_{c}$
Fly Ash (12 ton/ ha)	2.69	0.94	1.82 $_{bc}$
Fly Ash (20 ton/ha)	2.55	1.12	1.84 $_{abc}$
Fly Ash + Biochar (1:2)	2.87	1.03	1.95 $_{abc}$
Fly Ash + Biochar (1:1)	3.09	1.08	2.09 $_{abc}$
Fly Ash + Cow Manure (1:2)	3.45	1.34	2.40 $_{ab}$
Fly Ash + Cow Manure (1:1)	3.72	1.21	2.47 $_{ab}$
Average	2.96 $_{a}$	1.08 $_{b}$	-

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 6. Tukey effect of treatment on two soil types on Cu availability

Treatments	Cu Available (mg/kg)		Average
	Alfisols	Ultisols	
Control	4.23	4.56	4.39 $_{a}$
Fly Ash (12 ton/ ha)	4.40	5.75	5.07 $_{a}$
Fly Ash (20 ton/ha)	4.99	6.11	5.55 $_{a}$
Fly Ash + Biochar (1:2)	3.64	5.35	4.49 $_{a}$
Fly Ash + Biochar (1:1)	2.87	5.91	4.39 $_{a}$
Fly Ash + Cow Manure (1:2)	3.48	4.77	4.12 $_{a}$
Fly Ash + Cow Manure (1:1)	3.71	5.12	4.42 $_{a}$
Average	3.90 $_{b}$	5.37 $_{a}$	-

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Effect of Treatment and Soil Type on Corn Plant Growth

Effect of Treatment on Two Soil Types on Maize Crop Height

Corn plants that were fed with manure experience better growth due to the availability of nutrients for plants. The dose of fly ash used was 12 tons/ha and 20 tons/ha. The results of the plant height test against the addition of Biochar Fly Ash and Manure were presented in Table 7.

The Effect of Treatment on Two Types Soil in Dry Weight of Corn Roots

The dry weight of the plant reflects the accumulation of organic compounds that plants successfully synthesize from inorganic compounds. The effect of the application of fly ash enriched with biochar and dry heavy manure of the roots of corn crops was presented in Table 8.

Effect of Treatment on Two Types Soil in Dry Weight of Corn Shoots

Based on the research conducted, the combination of treatment between fly ash and manure and biochar affects the dry weight of the heading. The results of measuring the dry weight of the shoot of the crop after harvesting were presented in Table 9.

Effect of Treatment on Two Soil Types on Total Dry Weight of Corn

The dry weight of the whole plant was obtained from adding up the canopy and root parts of the crop after harvesting. The results of the measurement of the overall dry weight of the crop after harvesting were presented in Table 10.

Effect of treatment on two soil types on cu tissue levels on leaves

This study measured the absorption of Cu elements on the leaves of the sweet corn plant after adding materials in the form of fly ash, organic fertilizers and biochar. Plants could absorb Cu at a time when the fertility conditions and soil organic matter content were low. The results of measurements of Cu tissue on leaves were presented in Table 11.

Table 7. Effect of treatment on two types of soil on maize crop height

Treatments	Crop Height (cm)		Average
	Alfisols	Ultisols	
Control	147	133	140.2 $_{a}$
Fly Ash (12 ton/ ha)	150	149	149.7 $_{a}$
Fly Ash (20 ton/ha)	159	156	157.7 $_{a}$
Fly Ash + Biochar (1:2)	157	158	158 $_{a}$
Fly Ash + Biochar (1:1)	154	142	148.3 $_{a}$
Fly Ash + Cow Manure (1:2)	165	161	163 $_{a}$
Fly Ash + Cow Manure (1:1)	167	160	163.5 $_{a}$
Average	157.1 $_{a}$	151.6 $_{a}$	-

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 8. The Effect of treatment on two types soil in dry weight of corn roots

Treatments	Dry Weight (g)		Average
	Alfisols	Ultisols	
Control	3.6	2.1	2.9 $_{a}$
Fly Ash (12 ton/ ha)	3.1	2.3	2.7 $_{a}$
Fly Ash (20 ton/ha)	3.7	2.2	3.0 $_{a}$
Fly Ash + Biochar (1:2)	5.5	3.8	4.6 $_{a}$
Fly Ash + Biochar (1:1)	3.4	2.8	3.1 $_{a}$
Fly Ash + Cow Manure (1:2)	4.6	3.8	4.2 $_{a}$
Fly Ash + Cow Manure (1:1)	4.6	4.3	4.5 $_{a}$
Average	4.1 $_{a}$	3.0 $_{b}$	-

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 9. The effect of treatment on two types of soil on the dry weight of the corn shoots

Treatments	Dry Weight of Corp Canopy (g)		Average
	Alfisols	Ultisols	
Control	19.5	12.5	16.0 $_{b}$
Fly Ash (12 ton/ ha)	16.8	17.6	17.2 $_{ab}$
Fly Ash (20 ton/ha)	22.5	18.3	20.4 $_{ab}$
Fly Ash + Biochar (1:2)	22.7	24.4	23.6 $_{ab}$
Fly Ash + Biochar (1:1)	25.6	16.4	21.0 $_{ab}$
Fly Ash + Cow Manure (1:2)	26.3	21.7	24.0 $_{ab}$
Fly Ash + Cow Manure (1:1)	29.2	21.4	25.3 $_{a}$
Average	23.2 $_{a}$	18.9 $_{b}$	-

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 10. Effect of treatment on two types of soil on the total dry weight of corn

Treatments	Total Dry Weight of Corn (g)		Average
	Alfisols	Ultisols	
Control	23.1	14.6	18.8 $_{b}$
Fly Ash (12 ton/ ha)	19.9	19.9	19.9 $_{ab}$
Fly Ash (20 ton/ha)	26.3	20.4	23.4 $_{ab}$
Fly Ash + Biochar (1:2)	28.1	28.2	28.2 $_{ab}$
Fly Ash + Biochar (1:1)	29.0	19.2	24.1 $_{ab}$
Fly Ash + Cow Manure (1:2)	31.0	25.4	28.2 $_{ab}$
Fly Ash + Cow Manure (1:1)	33.8	25.7	29.8 $_{a}$
Average	27.3 $_{a}$	21.9 $_{b}$	-

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 11. Effect of treatment and soil type on tissue Cu levels

Treatments	Cu Plant Tissue (mg/kg)		Average
	Alfisols	Ultisols	
Control	31.12 $_{d}$	30.63 $_{f}$	30.88
Fly Ash (12 ton/ ha)	33.29 $_{cd}$	47.99 $_{c}$	40.64
Fly Ash (20 ton/ha)	38.25 $_{bc}$	54.42 $_{a}$	43.86
Fly Ash + Biochar (1:2)	40.47 $_{ab}$	52.4 $_{ab}$	46.44
Fly Ash + Biochar (1:1)	41.86 $_{ab}$	50.45 $_{bc}$	46.16
Fly Ash + Cow Manure (1:2)	45.31 $_{a}$	40.72 $_{e}$	43.02
Fly Ash + Cow Manure (1:1)	44.67 $_{a}$	44.06 $_{d}$	44.37
Average	39.28	45.81	+

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Effect of Treatment and Soil Type on Cu Uptake on Leaves

This study also carried out calculations related to the absorption of Cu elements. The Cu element has a very low mobility in the soil, so the mechanism of movement of nutrients from the soil to the roots was diffused. In order to be absorbed by plants, the element Cu must be on the surface of the plant roots. The results of the measurement of Cu Absorption on soil were presented in Table 12.

Effect of Observation Parameters on Plant Dry Weight Biomass and Cu Uptake

Soil chemical properties affect cu uptake in corn crops and the total dry weight of the plant. This section describes the correlation or relationship between soil chemical properties in the form of pH, N-total, organic matter, and Available Cu. And from the correlation of some of these parameters, it could be known which were the most influential properties of kima in terms of cu absorption and plant weight.

Effect of Observation Parameters on Total Dry Weight of Plants

This data was the result of regression analysis between the total dry weight of corn plants (Y) with observation parameters in the form of pH (X1), N-total (X2), organic matter (X3), and Available Cu (X4). Based on the existing observation parameters, regression analysis was carried out using the stepwise method to find out the most influential parameters. Regression analysis by the stepwise method was performed by incrementally inserting predictors based on the significant F value (sig F below 0.05).

The initial analysis was performed by entering a combination of all parameters and the subsequent equation was combined by eliminating insignificant parameters (sig F above 0.01). The first equation was the model Y= - 8.8 + 3.51 X1+ 9.09 X2 - 2.62 X3 + 3.39 X4 was a regression model with all free changes in Alfisols, the second equation Y= 9.9 + 1.47 X1 + 4.69 X2+ 1.27 X3 showed that the parameter X4 (Cu Available) was insignificant so that the parameter was eliminated to proceed to the next equation, the third equation Y= 13.3 + 1.38 X1 + 5.56 X2 shows that the parameter X3 (Organic Matter) was insignificant to the total dry weight of the plant and was eliminated to continue to the next equation.

On Ultisols soils The first equation was the model Y= - 8.8 + 3.51 X1+ 9.09 X2 - 2.62 X3 + 3.39 X4 was a regression model with all free changers, the second equation Y= 21.6 – 2.4 X1 + 4.54 X2 + 10.25 X3 that was not significant was parameter X4 (Cu Available), the third equation Y= -26, 13 + 7.7 X1 + 3.26 X2 showed that parameter X3 (Organic Matter) was not significant to the dry weight of the plant. The results of effect of observation parameters on total dry weight of plants were presented in Table 13.

Effect of Observation Parameters on Cu uptake on Corn Crops

This data was the result of regression analysis between Cu uptake and observational parameters in the form of pH (X1), N-total (X2), organic matter (X3), and available Cu (X4). Based on the existing observation parameters, regression analysis was carried out using the stepwise method to find out the most influential parameters. The first equation was the model Y= -46 + 3.6 X1 + 0.8 X2 + 22.1 X3 + 3.2 X4 was a regression model with all free changes in Alfisols, the second equation Y= -28.5 + 1.7 X1 – 3.3 X2+ 25.7 X3 showed that the parameter X4 (Cu Available) was insignificant so that the parameter was eliminated to proceed to the next equation, the third equation Y= 41 – 0.12 X1 + 14.3 X2 shows that the parameter X3 (Organic Matter) was insignificant to the total dry weight of the plant and was eliminated to continue to the next equation. On Ultisols soils The first equation was the model Y= 326 - 79 X1 + 29.8 X2 + 46 X3+ 22,9 X4 was a regression model with all free changers, the second equation Y= 21.6 – 2.4 X1 + 4.54 X2 + 10,25 X3 that was not significant was parameter X4 (Cu Available), The third equation Y= -328.9 + 65.5 X1 – 14.14 X2 shows that parameter X3 (Organic Matter) was not significant to the Cu uptake. The results of effect of observation parameters on Cu uptake on Corn Crops were presented in Table 14.

Table 12. Effect of treatment and soil type on Cu uptake on leaves

Treatments	Cu Uptake (mg)		Average
	Alfisols	Ultisols	
Control	39.7 $_{b}$	25.0 $_{b}$	32.4
Fly Ash (12 ton/ ha)	54.2 $_{b}$	57.1 $_{a}$	55.7
Fly Ash (20 ton/ha)	44.0 $_{b}$	53.6 $_{ab}$	48.8
Fly Ash + Biochar (1:2)	55.2 $_{b}$	61.8 $_{a}$	58.5
Fly Ash + Biochar (1:1)	57.6 $_{ab}$	52.4 $_{ab}$	55.0
Fly Ash + Cow Manure (1:2)	51.4 $_{b}$	46.6 $_{ab}$	49.0
Fly Ash + Cow Manure (1:1)	80.5 $_{a}$	55.4 $_{a}$	68.0
Average	54.7	50.3	+

Note: Numbers followed by unequal letters show a noticeable difference on the Tukey test of 5%. The sign (+) indicates the presence of interaction

Table 13. Regression analysis of observational parameters to total dry weight

Soil Type	Equation	R	R-Sq
Alfisols	Y= -8.8 + 3.51 X1 + 9.09 X2 – 2.62 X3 + 3.39X4	0.94	0.884
	Y= 9.9 + 1.47 X1 + 4.69 X2+ 1.27 X3	0.903	0.815
	Y= 13.3 + 1.38 X1 + 5.56 X2	0.902	0.813
	Y= -39.4 + 10.9 X1	0.783*	0.614
	Y= 21.42 + 6.120 X2	0.900**	0.81
	Y= 2.795 + 8.272 X3	0.855*	0.731
	Y= 42.257 – 3.819 X4	0.568	0.322
Ultisols	Y= 291- 61 X1 + 19.5 X2 + 40.2 X3 + 6.74 X4	0.794	0.631
	Y= 21.6 – 2.4 X1 + 4.54 X2 + 10.25 X3	0.755	0.57
	Y= -26.13 + 7.7 X1 + 3.26 X2	0.736	0.541
	Y= -69 + 15.29 X1	0.714	0.51
	Y= 17.513 + 5.9 X2	0.718	0.516
	Y= 2.4 + 18.12 X3	0.668	0.446
	Y= 23.45 – 0.286 X4	0.036	0.001

Note: $^{**)}$ Significant correlation at 1% level, $^{*)}$ Significant correlation at 5% level

Table 14. Regression analysis of observational parameters of Cu uptake

Soil Type	Equation	R	R-Sq
Alfisols	Y= -46 + 3.6 X1 + 0.8 X2 + 22.1 X3 + 3.2 X4	0.833	0.649
	Y= -28.5 + 1.7 X1 – 3.3 X2+ 25.7 X3	0.829	0.687
	Y= 41 – 0.12 X1 + 14. 3 X2	0.754	0.568
	Y= -94. 4 + 24.4 X1	0.630	0.397
	Y= 40.3 + 14.2 X2	0.754	0.568
	Y= -11.2 + 22.2 X3	0.827*	0.684
	Y= 87.3 – 8.4 X4	0.447	0.200
Ultisols	Y= 326 - 79 X1 + 29.8 X2 + 46 X3+ 22.9 X4	0.828	0.686
	Y= -591.5 + 120.7 X1- 21.2 X2 – 56.3 X3	0.76	0.577
	Y= -328.9 + 65.5 X1 – 14.14 X2	0.665	0.442
	Y= -143.1 + 32.5 X1	0.594	0.353
	Y= 43.9 + 8.366 X2	0.398	0.159
	Y= 19.8 + 28.2 X3	0.407	0.166
	Y= -19.9 + 13.053 X4	0.636	0.404

Note: *) Significant correlation at 5% level

DISCUSSION

Early Soil Characteristics of Alfisols and Ultisols

Overall the results of the soil analysis show that soil fertility is low. Alfisols soil is a soil that experiences a high level of weathering which causes nutrients in the soil to leach. Alfisols soil has a low content of organic matter, N and K elements so it needs to add nutrients (Olowoake et al., 2015). The results of the initial Ultisols soil lab test in this study showed that the soil is less fertile, this type of soil also has problems, namely high acidification, high Al exchange in the soil and low KPK and low N, P, and K soil content. The organic C content in basaltic andesite pedons of Ultisols soils ranges from very low (< 1%) to low (1-2%), while in basaltic andesite tuff/lava it ranges from very low to medium (2-3%) (Purwanto et al., 2021).

Characteristics of Fly Ash

Based on the results of the initial analysis, fly ash has an H2O pH of 8.7 which is classified as alkaline. The characteristics of carbonate and hydroxide in fly ash can neutralize acid soils and the addition of fly ash affects increasing pH (Ilham et al., 2020). Fly ash is used as an ingredient for the liming process in neutralizing soil acidity and providing nutrients for plants. C-Organic content of 0.8% and organic matter of 1.4% which is relatively low. The oxidation content of C and N in fly ash was drastically reduced during combustion. The oxidation content of C and N in fly ash was drastically reduced during combustion. Laboratory measurements showed that the Cu content in fly ash was 78.6 mg/kg. Cu is a micronutrient that plays an important role in plant growth, so its presence in fly ash can increase soil fertility and nutrient availability. No N content was found in fly ash. Fly ash which is a waste from coal, of course, has undergone a high-temperature combustion process so that the element N was not found. These conditions change the physical and chemical properties so that the composition of the ash is different from the mineral composition (Kinasti et al., 2018).

Characteristics of Coconut Shell Biochar and Cow Manure

Based on the results of the initial analysis, it can be explained that biochar has an H2O pH of 10.3 which is classified as alkaline. The total N content of biochar was 0.15%, the C-organic content of biochar was 18.24% and the organic matter content was 31.45%. The C-organic content in biochar was low because, during the research, the sample was mixed with ash because the manufacturing process did not

use a little oxygen. The nutrient content and CEC in biochar are relatively low so that they are unable to supply nutrients while the pH, C-Organic content, and the ability to hold water are high enough that biochar is more suitable to be called a soil enhancer to increase organic matter content, increase groundwater availability and reduce soil acidity. Biochar derived from coconut shells has a pH of 9.9. The nitrogen content was 0.34 and the C-total content was 80.59% (Nurida, 2014). Based on the results of the initial analysis, it can be explained that manure has an H2O pH of 8.8 which, if rated, is classified as alkaline. The total N content of the manure was 1.77%, the C-organic content of the manure was 32.93% and the organic matter content was 56.77%. Based on the results of the analysis, manure can be used as a source of nutrient supply.

Effect of Treatment on Two Types of Soil on PH H2O

The results of the fingerprint analysis showed that the pH of the soil differed markedly between treatments and differed markedly between Alfisols and Ultisols soil types. Based on the analysis of the variety of fingerprints, it also shows the interaction between the treatment and the type of soil. The results of the tukey test with a level of 5% showed that the application of fly ash, manure, and biochar could increase pH. The combination of treatment between fly ash and biochar in a ratio of 1: 1 has a tendency to increase the pH of the soil. This is because in the initial analysis biochar has the highest pH of 10.3 and fly ash which is 8.71. Soil pH can increase due to the application of fly ash because it contains bases such as Ca, K, Mg and Na. Ca and mg can serve as lime, so the pH of the soil is further increased. Manure and biochar can increase soil pH, this is because organic matter in the decomposition process will release organic compounds, be it in the form of organic acids or alkaline cations, which will result in an increase in soil pH (Karbeka et al., 2022.)

Effect of Treatment on Two Types of Soil On N-total

The results of the fingerprint analysis showed that the N-total soil differed markedly between treatments and differed markedly between Alfisols and Ultisols soil types. The results of the tukey test with a level of 5% showed that the treatment given had an interaction with the type of soil. The application of Manure and Biochar can increase the total N-content in the soil. This is due to the improvement of the root environment of the plant. The treatment between Fly Ash and Manure ratio of 1:1 has a tendency to increase the total N-content of the soil. This is because in the initial analysis manure has a total N-content of 1.77%. The mineralization process is an important process for the availability of N in the soil. Mineralization plays a role in the degradation process of organic matter where the process involves enzymes. The enzyme is in charge of hirrolysis of complex proteins (Hutasoit et al., 2015).

The Effect of Treatment on Two Types of Soil on Organic Matter

The results of the analysis of variance showed that the soil organic matter was significantly different between treatments and significantly different between Alfisol and Ultisol soil types but the treatment and soil type did not show any interaction. The results of the Tukey test with a level of 5% showed that the application of manure and biochar could increase the organic matter content in the soil. The initial organic matter content before giving treatment to Alfisol soil was 2.2% and Ultisol soil organic matter was 1.7%. The treatment of fly ash with manure in a ratio of 1:1 tends to increase the soil organic matter content which has a value of 2.47%. This is because the added organic matter decomposes rapidly and will increase the cation exchange capacity of the soil and soil nutrient content (Saptiningsih & Haryanti, 2015). Organic matter contains a humic core that encourages soil microorganisms to

decompose organic matter to bind micronutrients (Mindari et al., 2018).

Effect of Treatment on Two Types of Soil on Available Cu

The results of the analysis of variance showed that the effect of treatment on available Cu was not significantly different but the effect between Alfisol and Ultisol soil types was significantly different. Treatment and soil type showed no interaction. The application of fly ash at a dose of 20 tons/ha has a tendency to increase the available Cu content. The higher the dose of fly ash given, the higher the availability of Cu in the soil, while the manure and biochar tend to reduce the availability of Cu in the soil. Based on the results obtained, the availability of Cu in Ultisols was greater than in Alfisols. The available Cu research results are presented in Table 7 and classified as low. Cu element is formed complex and bound with organic matter so that the fraction of Cu ions in the soil solution is very small (Oloniran et al., 2013). The combination of Fly Ash and Manure and Biochar treatments gave the lowest results because the Cu content was closely related to organic matter, which in the research results, the organic matter content of manure and biochar was high. Generally, Cu levels in the soil solution are reduced only when there is CuS deposition or Cu chelation by organic (Virzelina et al., 2019).

Effect of Treatment on Two Types of Soil on Maize Crop Height

The results of the fingerprint analysis showed that the effect of treatment on plant height differed unreally and the influence between the soil types of Alfisols and Ultisols was also insignificantly different. Treatment and Soil type indicate the absence of interaction. Based on the results of the study, it showed that fly ash treatment with manure at a dose of 1: 1 has a tendency to increase plant height with a yield of 163.5 cm. The treatment of fly ash at doses of 12 tons/ha and 20 tons/ha differed markedly from plant height, because the treatment had a low N-total content because the material added to the soil did not contain N elements and had a low organic matter content. Nitrogenous elements are able to increase the vegetative growth of plants due to the presence of a sufficient supply of macro- and micronutrients (Nariratih et al., 2013).

The Effect of Treatment on Two Types of Soil in Dry Weight of Corn Roots

The combination of Fly Ash and Manure and Biochar treatments gave the lowest results because the Cu content was closely related to organic matter, which in the research results, the organic matter content of manure and biochar was high. Generally, Cu levels in the soil solution are reduced only when there is CuS deposition or Cu chelation by organic increase roots growth. The insignificant effect between treatments means that fly ash can replace the role of manure and biochar in corn cultivation. Treatment of fly ash with biochar 1:1 tends to increase the dry weight of plant roots.

Alfisols soil has better chemical properties when compared to Ultisols soil so that it is able to provide sufficient nutrients for plant root growth. The dry weight of the plant reflects the accumulation of organic compounds that plants successfully synthesize mainly water and carbon dioxide. Nutrients that have been absorbed by the roots contribute to the addition of dry weight of all parts of the plant. plants will grow well when enough nutrients are sufficiently available in a form that is easily absorbed by the root of the plant. The better the plant growth, the more it will be able to increase the weight of the plant.

The Effect of Treatment on Two Types of Soil in Dry Weight of the Corn Shoots

The results of the analysis of variance showed that the effect of treatment on dry weight of root shoots was significantly different and the effect of Alfisol and Ultisol soil types was also significantly

different. Treatment and soil type did not show any interaction. The results of the analysis of variance showed that the treatment of fly ash and manure with a ratio of 1:1 tended to increase the dry weight of plant shoots. Alfisol soils show higher canopy dry weight than Ultisols, because Alfisol soils provide sufficient nutrients to meet plant needs in the process of plant growth. The dry weight of the plant is affected by the process of photosynthesis occurring in plants. Plant dry weight is influenced by the process of photosynthesis occured in plants. If photosynthesis goes well, more and more photosynthates are produced, so that later it will be used for the formation of organs and tissues in plants such as leaves and stems. Fly ash and biochar do not provide sufficient nutrients in the process of plant photosynthesis because photosynthesis requires sufficient nitrogen nutrients while manure provides sufficient nutrients for plant growth.

Effect of Treatment on Two Types of Soil on the Total Dry Weight of Corn

The results of the fingerprint analysis showed that the effect of the treatment on the total dry weight of the planting was significantly different and the influence between the soil types of Alfisols and Ultisols was also significantly different. The treatment and type of soil showed no interaction. The results of the fingerprint analysis showed that fly ash and manure treatment in a ratio of 1: 1 had a tendency to increase the total dry weight of corn plants. The application of fly ash without being enriched with manure and biochar cannot be used to improve or improve the growth of corn crops properly. Therefore, the use of fly ash as a source of nutrients must be supplemented by the addition of fertilizers such as manure. Alfisols soils give a higher total dry weight of plants than Ultisols soils, because in Alfisols soils there are sufficient nutrients available to meet plant needs in the process of plant growth. Dry weight is directly proportional to the wet weight of the plant canopy, when the leaf area rises, the rate of assimilation also increases and results in a high dry weight of the plant (Buntoro et al., 2014).

The Effect of Treatment on Two Types of Soil in Tissue Cu Levels on Leaves

The results of the analysis of variance showed that the effect of treatment on tissue Cu was significantly different and the effect of Alfisol and Ultisol soil types was significantly different. Treatment and soil type showed an interaction. Tukey test results with a level of 5% showed a very significant difference in the treatment compared to the control. Application of fly ash, manure, and biochar can increase the Cu content of tissue in leaves. This is due to the improvement in the plant root environment which affects Cu uptake. A very significant effect on tissue Cu was found in the treatment combination between fly ash and biochar. Based on the observations also showed that the higher the dose of fly ash, the higher the Cu content in the leaf tissue. Based on Tukey's further tests with a level of 5%, the combination of fly ash and and biochar treatment when added to Ultisol soil will have a very significant effect and the highest yield. Metals experience movement towards the root cells and are transported through the transport network in the form of the xylem and phloem to other tissues (Irhamni et al., 2019).

The Effect of Treatment and Soil Type on Cu Uptake in Leaves

The results of the analysis of variance showed that the effect of treatment on Cu uptake was significantly different and the effect of Alfisol and Ultisol soil types was also significantly different. Treatment and soil type showed an interaction. The results of the Tukey test with a level of 5% showed a significant difference compared to the controls. Giving fly ash can increase Cu uptake in plants. Treatment of fly ash and manure with a ratio of 1:1 tends to increase Cu uptake with a value of 68 mg. Based on Tukey's advanced test with a level of 5%,

the combination of treatments did not show any interaction between the treatments and the type of soil.

The results showed that high levels of Cu in the soil will reduce the uptake of Cu in plant tissues. The highest yield in fly ash treatment with a 1:1 cage pupk was 80.5 mg because it had a high total dry weight. The addition of Fly Ash, Biochar and Manure supports a better root state and affects the dry weight of the plant. Good plant growth makes plants absorb more nutrients in greater quantities. Nutrient availability is related to H+ ions (Siswanto, 2018). Each of the essential nutrients can be absorbed in amounts equal to or greater than what plants need to produce biomass.

Effect of Observation Parameters on the Total Dry Weight of Plants

Regression analysis by the stepwise method was performed by incrementally inserting predictors based on the significant F value (sig F below 0.05). The initial analysis was performed by entering a combination of all parameters and the subsequent equation was combined by eliminating insignificant parameters (sig F above 0.01). The first equation is the model Y= - 8.8 + 3.51 X1+ 9.09 X2 - 2.62 X3 + 3.39 X4 is a regression model with all free changes in Alfisols, the second equation shows that the parameter X4 (Cu Available) is insignificant so that the parameter is eliminated to proceed to the next equation, the third equation shows that the parameter X3 (Organic Matter) is insignificant to the total dry weight of the plant and is eliminated to continue to the next equation. On Ultisols soils The first equation is the model Y= - 8.8 + 3.51 X1+ 9.09 X2 - 2.62 X3 + 3.39 X4 is a regression model with all free changers, the second equation that is not significant is parameter X4 (Cu Available), The third equation shows that parameter X3 (Organic Matter) is not significant to the dry weight of the plant .

In Alfisols soils, the Y-bound changer data (total dry weight) correlates markedly with the N-total free changer of 0.900, the organic matter-free changer of 0.855 and the pH-free changer of 0.783. Regression models with all free changers on Alfisols soils resulted in the model Y= - 8.8 + 3.51 X1+ 9.09 X2 - 2.62 X3 + 3.39 X4. In Ultisols soils, the Y-bound changer data (total dry weight) correlated markedly with the pH-free changer of 0.775 which was significant at a level of 5%. Regression models with all free changers on Ultisols soils yielded models Y= 291 – 61 X1 + 19.5 X2 + 40.2 X3 + 6.7 X4.

The parameters that most affect the total dry weight of the plant are known using the Stepwise method. On soil Alfisols produced the best model of the Stepwise method containing a free changer X2 or N-total with the equation Y = 21.14 + 6.1 X2 Judging from the value of R = 0.900 this model shows that the N-total parameter is very strongly related to the total dry weight of the plant. On the soil Ultisols produced the best model of the Stepwise method containing a free changer X2 or N-total with the equation Y = 17.51 + 5.9 X2 with a value of R = 0.718. Based on the resulting R value, it shows a fairly strong relationship between N-total and the total dry weight of corn plants. The observational parameters of N-total were markedly correlated to the total dry weight of plants at the level of 1% in Alfisols soils with an R value of 0.918 and were markedly correlated to the level of 5% in Ultisols soils with an R value of 0.827.

Effect of Observation Parameters on Cu uptake on Corn Crops

In Alfisols soils, the Y-bound changer data (Cu Absorption) was significantly correlated with the free changer, namely organic matter of 0.827. Regression models with all free changers on Alfisols soils resulted in models Y= -46 + 3.6 X1 + 0.8 X2 + 22.1 X3 + 3.2 X4. On the soil Ultisols produced a regression model with all model changers Y= 326 - 79 X1 + 29.8 X2 + 46 X3+ 22.9 X4. The next step is to determine the parameters that most affect the absorption of Cu with the Stepwise method.

On the soil Alfisols produced the best model of the Stepwise method. This model contains a free changer X3 or organic matter with the equation Y= -11.2 + 22.2 X3 with a value of R = 0.827 which indicates a strong relationship between organic matter and Cu uptake. On the soil Ultisols produced the best model of the Stepwise method containing a free changer X4 (Cu available) with the equation Y= -19.9 + 13.053 X4 with a value of R= 0.636.

CONCLUSION

The conclusion of this study is that the availability of Cu elements in the Ultisols soil is higher than in Alfisols soils and the application of Biochar and manure does not significantly reduce the availability of Cu in the soil. Cu uptake in corn crops was lower after being given the treatment of adding manure and Biochar and corn plant growth was better. The results showed that the availability of Cu elements in Ultisols was higher by 5.37 mg/kg when compared to Alfisols with an average of 3.90 mg/kg. Cu uptake in corn plants planted in Alfisols soil is greater with an average of 54.7 mg/g greater when compared to those planted in Ultisols soils an average of 50.3 mg/g. The treatment between Fly Ash and Manure in a ratio of 1:1 has a tendency to increase Cu uptake with a value of 68 mg/g. Alfisols soils are significantly correlated with organic matter to Cu uptake in Corn plants with a value of R = 0.827. From this research, further research can be taken regarding the influence of consumption of cultivated plant products by adding fly ash as a source of micronutrients to the human body.

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