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EFFECT OF BIOCHAR ON *MIANA RED* GROWTH IN ARTIFICIAL CONTAMINATED SOIL WITH CADMIUM

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Abstract: Soil contamination with cadmium is a global issue, in particular in soils with a history of fertilizers, fungicides or municipal waste amendment. Several remediation techniques have been investigated to reduce the environmental impact of Cd-contaminated soil, including the use of organic amendments such as vercomposts and biochars, which can bound part of the soluble fraction of the metal. The objectiv of this work is to study the effect of biovermi compost for remediation of a soil spiked with cadmium (10 mg Cd kg^{-1}) on growth of *miana red*. This research used Completely Randomized Design with four treatments and three replicates. Treatment for compostions such as T5(soil 95% + biochar 5%), T10(soil 90% + biochar 10%), T15(soil 85% + biochar 15%) and T20 (soil 80% + biochar 20%). The research was done for approximately two months from mid Juni to September 2021 in experimental garden Faculty of Mathematical and Natural Science Universitas Negeri Jakarta .The Research shows that the composition of planting media have significant effect on observation variables, such as number of leaves, nuber of brnch and plant height. The result of this research shows, the treatmen of T20(soil 80% + biochar 20%) has higher value among of other treatment
Keywords: Polluted soil, ion Cd^{+2}, biovermicompost, miana red.

1. Introduction

The presence of heavy metals in soils, water and air are global problems that are a growing threat to the environment. There are several sources of heavy metal contamination in the environment including soils, water and air. Soil contamination, with heavy metals, is a serious threat that has arisen from various human activities such as, fertilizers [1], mining exploration [2], pesticide [3], traffic emissions, sewage runoff, and agriculture activity[4].

Heavy metals are one of the most prevalent contaminants causing public health problems, entering the body in food, ingestion of soil and inhalation of dust[5]. The build-up of heavy metal levels in agricultural soils leads to soil contamination and increases heavy metals uptake by growing plants, which affects food quality and safety [6]. Heavy metal in agricultural soils results in increased heavy metal uptake by food crops and vegetables, which in turn may induce serious health risks to human beings [7]. Heavy metal are reported to cause several disorders

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in humans including cardiovascular diseases, cancer, cognitive impairment, chronic anemia, damage of kidneys, nervous system, brain, skin, and bones [8].

There are numerous technologies for the remediation of contaminated soils such as separation, i.e soil replacement[9], soil isolation [10], electro kinetic[11], immobilation [12], encapsulation [13], vermin remediation[14], chelation [15], Phyto stabilization [16] and phyto extraction with microbe [17].

Khalid et al[18], compared the effectiveness of different remediation techniques generally used to clean-up contaminated soils. Technical and financial implications have made soil remediation a complex and difficult task. Most traditional soil remediation techniques do not offer acceptable solutions for the clean up of heavy metal polluted sites. Physical remediation methods can completely remove heavy metal(loid)s from contaminated soil but are destructive in nature and highly costly. These methods can only be applied to small area of soils. Chemical remediation methods are fast, simple, easy to apply, high public acceptability and relatively economical. However, these remediation methods are not eco-friendly because they have limitations of releasing additional contaminants to the environment. Phyto extraction is safe, least destructive, eco-friendly and cost-efficient remediation technique which allows soils clean-up over a large scale. However, still fundamental and field-scale research is needed in this field.. Thus, the development of new technology environmentally friendly and low-cost processes for heavy metal contaminated soils and water are of interest.

Biochar is the carbon-rich material produced from organic feedstock under certain thermal combustion with limited oxygen [19]. In general, bio-char produced at high temperature has higher surface area and carbon content, mainly due to the increase of micro-pore volume caused by the removal of volatile organic compounds at high temperature[20]. Biochar has its own advantages, such as rich carbon content, high cation exchange capacity, large surface area and stability structure [21]. Beneficial role to mitigate CO_2 emission and to improve soil characteristics and impact soil redox processes, such as increasing the pH of acid and neutral soils, increasing water retention

Eliana et al [22]. study the effect of bio-char and biochar plus compost addition on copper mobility, soil microbial biomass and growth of different plant species following remediation of a soil spiked with copper. Contaminated soil was treated with 10 wt% of bio-char or bio-char plus compost. Different plant species (mustard, cress and ryegrass) were grown in the soil during 4 weeks. A significant reduction on the mobile form of Cu was observed in soils treated with bio-char and bio-char plus compost. The highest microbial biomass values were obtained in samples treated with biochar plus compost. After cress growth, the microbial biomass of soil treated with bio-char plus compost was similar to that of non-polluted soil. The germination test showed increased root length in the amended soils compared to the contaminated soils.

Liqiang et al [23]. tested the ability of a wheat straw bio-char, pyrolyzed at 450 °C, to sequester Cd from solution and a contaminated soil. Biochar addition of 5 and 15% (by wt.) to the Cd contaminated soil reduced bioavailable Cd concentration by 53.4%–87.9% over the 240 d experiment as compared to the control soil ($p < 0.001$). Supporting this contention, Beesley et al[24.] showed that an 8% bio-char application rate (wt/wt) reduced the water-soluble Cd concentration in a multi-heavy metal contaminated soil in 56 days incubation pot experiment, due to increasing pH and the creation of insoluble Cd precipitates. In a subsequent study.

Huijie et al [25] was studieds that the application of nano zero valent biochar in Cr(VI)-contaminated soil can effectively enhance the immobilisation of Cr and decrease the migration of Cr in soil, effectively reduce the bioavailability and bioaccumulation of Cr in cabbage mustard seedlings and can enhance plant growth cabbage. Chrysochoou et al[26] investigated green tea nZVI in two granular media, silica sand, and sand coated with aluminum hydroxide. They found that the heavy metal Cr(VI) could be reduced by 30~66%. A reported drawback was that the soil pH was lowered, which resulted in metal leaching (Cr, Fe, and Pb).

Biochar-based nanocomposites have properties that could be beneficial for soil restoration applications, such as allowing the dispersion and low aggregation of nanoparticles, adsorbing and/or immobilizing metal ions in the biochar or nanoparticles to form complexes or through electrostatic interaction, removing or degrading contaminants, preventing the bioavailability of by-products, and improving soil fertility

2. Experiment

2.1 Material and apparatus

Miana red was obtained from Sentra tani store, Jakarta. Biochar was obtain from Sentra Buka Tani Corp, Sleman, Yogyakarta, biochar were produced from rice husk. Cadmium chloride, Urea, ($CdCl_2$) was purchased from Merck, Jakarta,Indonesia.

Apparatus

Plastic pot with 10 cm diameter and height 25 cm, mortar, macro balance, spatula, label.

2.2. Soil sampling

Surface soil samples (0-30 cm depth) were collected from a local garden, Universitas Negeri Jakarta, Indonesia. The collected soil samples were air dried, ground and sieved to pass through a 2 mm sieve to remove debris and stones. The prepared soil sample was analysed for its physical and chemical parameters (Table 1).

Table 1: Physical and chemical properties of the studied soil.

No	Parameter	Value
1	pH	5.42
2	C-Org(mg/kg)	1.06
3	N-Org(%)	0.23
4	P total(%)	0.10
5	K total(%)	0.70
6	Al(mg/kg)	2.02

2.3 Preparation artificial soil contaminated with Cd^{+2}

The sampled soil was contaminated with cadmium at a concentration of 200 mg Cd^{+2} kg^{-1} of soil were incubated during 3 weeks at 20^0 C. The period of incubation was chosen as it is common in studies on heavy metal mobility or soil biological properties. After the incubation period, soil was treated with a 0% biochar (T0), 5% of biochar (T5), 10% biochar (T10) and with 15% of biochar(T15) soil were incubated during two weeks at 20^0C. After that put the soil into the pot, and label it according to the soil formulation used, put *miana red* into the pot, and observe the growth of the *miana red* for 4 weeks. Note down the height, number of leaves, and plant weight.

2.4. Soil analysis

The collected soil samples were subjected for several analyses prior and after biochar applications. Soil pH and EC were determined in 1:1 soil towater suspensions and supernatant, respectively. Nitrate-N was measured by the spectro-photometer method; while chloro stannous acid method was used to determine the available phosphorous.Organic matter was determined using loss on ignition method, and Total contents Cd(II) was measured in the soilsamples following the digestion by aqua regia[27] ,then samples were measured by AAS.

2.5 Characterization of biochar

Physical and chemical characteristics of the used biochar was de-termined following the description of Abdelhafez et al.[28] to pro-vide the basic characteristics of the used biochar and to determine thepotential application for metal ion stabilization. Parameter yang dianalisa adalah Organic matter measured by using loss on ignition method, pH and elec-trical conductivity (EC) were measured by soaking the biochar in distilled water and boiling for 5 min. Thereafter, the pH and EC valueswere measured in the suspension and supernatant.

3. Result and Discussion

3.1 Characterization Biochar

a. FTIR Analysis

In addition, FTIR analysis of the samples was carried out, which showed the broad band at approximately 3340 cm-1 to be associated with stretching vibration in the hydroxyl groups (Fig. 1). The peak at 1100 cm-1 was assigned to the C-O groups . A clearly measurable decrease in wave number was recorded from the peak at 679 cm-1 for vermicompost-biochar to 614 cm-1 for BC or 584cm-1 for biochar. The change in wave number may be due to the bonding effects between vermikompos and biochar. And some studies have shown that the type of bond formed between biochar and iron might be C-O-H due to the signal at about 670 cm-[1.]

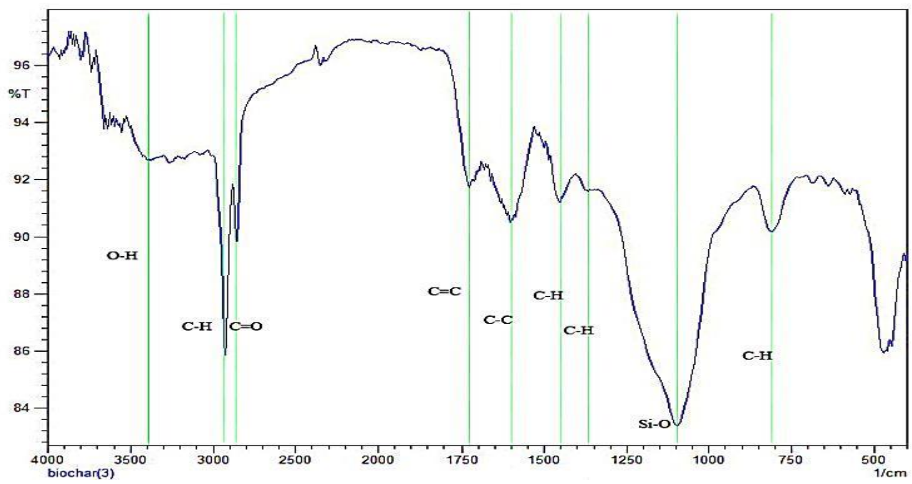

Fig 1: FTIR vermiocmpost- biochar

3.2 Chemical content of biochar

The basic chemical properties of biochar are summarized in Table 2.

Table 2: Chemical properties of the biochar

No	Parameter	value
1	Ash	4.11
2	Corg	84.58
3	CEC	
4	pH	9.45
5	N	1.78
6	P	
7	K	

3.2. Effect of applied biochar on soil chemical properties

Effect of applied biochar on soil chemical properties presented inTable 3

Table 3: Chemicalcomposition of soil afer treatment with biochar

No	Biochar(%)	pH	C org	N(%)	P(%)	K(%)
1	0	5.50	1.06	0.23	0.10	0.70
2	5	6.24	9.82	0..58	0.14	0.11
3	10	6.90	10.56	0.72	0.15	0.13
4	15	7.20	12.00	0.76	0.17	0.15
5	20	7.80	1.248	0.88	0.18	0.16

From Table 3 it can be seen that the addition of biochar to soil polluted with Cd+2 ions can increase pH, C org and macronutrient content such as N, P and K. The same thing was also reported by Abdelhafez et al. [28]. Abdelhafezet al. [28] showed that the addition of biochar to the soil raised the soilpH to 8.81 and 8.47 when the soil was treated with sugar cane and orangepeel biochars, respectively, were the original soil pH was 7.42. The increase of soil pH due to biochar addition might be attributed to the pyrolysis temperature of biochar that increased pH andsurface basicity. Thus, the increases that occurred in the soil pH owing to the application of biochar were mostly related to the alkaline nature of biochar [29].

The total N and P in the soil increased with increasingapplication of biochar. Such increases seemed to be significant onlywith the application of at least 5% biochar (wt/wt). The concentrationof K in the biochar seems to be relatively low; therefore, addition ofbiochar has no significant effect on total K contents in soil. Previousstudies demonstrated that the biochar plays an important role in nutrient transformation [29]; therefore, the results showed that increasing the rate ofapplied biochar, higher than 2.5%, significantly increased the availableforms of N, P and K. The average increments of soil available N, P and Kwere 1.16, 1.13 and 1.17 times the control treatment, respectively.

3.2 Effect of media on plant height *miana red*

Media is organic material that has undergone decomposition by decomposing microorganisms so that it can be used to improve soil properties, increase soil organic matter content, can function as fertilizer, increase soil's ability to maintain soil water content so that the soil becomes crumbs and in turn microbes. Useful soil microbes can live more fertile, besides that in the media there are mineral nutrients which function to provide food for *miana red.* The results showed that the effect of planting media and the amount biochar gave significantly different results on the height growth of miana red as shown in Table 2 and Fig 2

Table 2: Plant height *miana red* at various media

No	Media	Plant height *miana red* (cm) on week to					
		1	2	3	4	5	6
1	T0	10.00	11,40	12.50	13,10	13.70	15.32
2	T5	10.00	12,40	13,20	15.90	17.20	18.56
3	T10	10.00	12.60	13.68	16.40	18.68	19.88
4	T15	10.00	13.00	15.45	17.10	19..65	21.34
5	T20	10.00	14.00	16.45	18.68	20.15	22.44

Based on the Table 2 above, it can be seen that the growth of *miana red* on weeks two until four week has a significant effect, the highest growth rate is 8 cm with T20 treatment. This shows that the media contains more biochar compared the other media. Xu et al [30] reported that plants showed a higher growth rate because the vermicompost contains plant growth hormones and humic acid which increases root hair proliferation and mineral nutrient release and is involved in oxidative phosphorylation, cellular respiration, photosynthesis, protein synthesis and several enzymatic reactions.

(a) (b) (c) (d)

Fig 2: *Miana red* growth six week after seeding: a. To.b.T5. c.T10.d.T15

3.3 Effect of media on branch number

Effect of media on branch number can be seen in Table 3

Table 3. Branch number at various media

No	Media	Number of branch on week					
		1	2	3	4	5	6
1	T0	2	3	4	5	6	8
2	T5	2	4	6	7	8	9
3	T10	2	4	7	8	9	9
4	T15	2	5	7	9	10	11
5	T20	2	5	8	10	11	13

Media with to treatment, produced to eight branch from the second week to the sixth week, or the average number of branch added was 4,2 per week, The number of branch produced by media T20 is more than other media. Media T5 produced an average number of leaves of 6.1, media T10 produced an average number of branch of 6.3, and medium T15 produced an average number of branch of 7.2. The large number of leaves in T20 media is due to the fact that T20 media has sufficient nutrients, so that plant metabolism runs smoothly and the results of this metabolism will increase the number of plant branch

The number of branch is related to the height of the plant, where the taller the plant, the more branch that are formed because the leaves come out of the node, which is where the leaves are on the stem. The more the number of branch in a plant, the more light is absorbed by the plant for the photosynthesis process, so it is very influential in plant growth and development.

3.4 Effect of media on number leave

Fig 2 shows that the administration of biochar at different doses resulted in a different mean value of the number of miana red leaves. At the 6th week of observation, treatment T 20 had the highest number of leaves, which was 35 ± strands, when compared to treatments T10 and T1. The lowest number of leaves was obtained in treatment T0 with the number of leaves 18±0.00

3.5 Soil of analysis

The results of media analysis showed that C/N ratio on T5 media was 7%(moderate), P and K 1.20. Increasing the availability of nutrients not only improve plant height growth, but also tends to increase the number of leaves/ T20 media produced the smallest average height growth of 11 cm, compared to other treatments. This is due to insufficient nutrient availability due to undecomposed soil organic matter, which is indicated by the high C/N ratio value. Based on the results of the media analysis in this study, the T5 media had nutrients N 0.02%, P 0,10% and K 0.18% in sufficient and balanced amount.

Deficiency elemental N in plants cause slow /stunted growth, yellowish green leaves, and yellowing and dying fast old leaves. Deficiency of P can effect obstruction of root and stem systems, as well as K deficiency in addition to affecting the growth of leaves and fruit, it can affect the growth of weak and short stems, so that plants look stunted

4. Conclusion

In combination use of biochar and vermicompos in planting media can increase growth and production cayenne pepper, where compost provides nutrients needed and biochar retain nutrients as well improve soil conditions, however the results showed more biochar effect on crop production

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