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EVALUATION OF LEAD (PB) CONTAMINATION IN GT1 CLONE RUBBER SEEDLINGS USING A COMBINATION OF ORGANIC AND INORGANIC FERTILIZERS

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ABSTRACT

Lead (Pb) is a hazardous heavy metal that can contaminate the environment and inhibit the growth of rubber seedlings. This study evaluated the effects of combining organic (tankos) and inorganic (NPK) fertilizers on Pb accumulation and the growth of GT1 and PB260 rubber seedlings. The method used was a factorial Split-Plot Design (SPD) with two factors: Clone as the main plot and fertilizer combination (0%, 25%, 50%, 75% tankos + NPK) as the subplot, repeated three times. The results showed that the application of NPK and tankos affected soil chemical properties, increasing K-dd, but had no significant effect on P-Bray I, organic C, and total N. No Pb contamination was found in the seedlings, indicating that fertilization remained within safe limits. This study serves as a guide for environmentally friendly fertilizer management, supports the growth of healthy rubber seedlings, and enhances future rubber tree productivity.

KEYWORDS: *Lead (Pb), GT1 Clone, Fertilizer Combination.*

INTRODUCTION

The issue of heavy metal contamination, particularly lead (Pb), in rubber trees (Hevea brasiliensis) has become a serious concern in recent years. Lead is one of the heavy metals that has the potential to contaminate agricultural environments, including rubber plantations, through various sources such as vehicle emissions, industrial waste, and the uncontrolled use of inorganic fertilizers. According to research conducted by Sari et al. (2019), lead concentrations in the soil of rubber plantations in several regions of Indonesia have exceeded the threshold set by the Environmental Agency, which is 300 mg/kg. This indicates a serious risk to the growth of rubber seedlings and the quality of future latex production.

The use of a combination of organic and inorganic fertilizers is considered one of the solutions to reduce the impact of lead contamination on rubber seedlings. Organic fertilizers are known to increase the soil's capacity to bind heavy metals, thereby reducing the availability of lead for absorption by plants. However, the effectiveness of this fertilizer combination still needs further evaluation. According to research conducted by Wahyudi et al. (2021), the application of organic fertilizers such as compost and manure can reduce lead concentrations in the soil by up to 25% compared to the use of inorganic fertilizers alone. These findings demonstrate the significant potential of combining organic and inorganic fertilizers in mitigating lead contamination.

In addition, the selection of rubber clones tolerant to contaminated soil conditions is also a key factor in efforts to mitigate the impacts of lead contamination. The GT 1 clone is one of the most widely used rubber clones in Indonesia due to its high latex productivity and resistance to several diseases. However, the response of the GT 1 clone to lead contamination and the application of a combination of organic and inorganic fertilizers has not yet been extensively studied. According to research conducted by Prasetyo et al. (2023), the GT1 clone exhibits varying responses to lead contamination, depending on the type and dose of fertilizer applied. This highlights the need for a more in-depth evaluation of the interactions between lead contamination, fertilizer type, and the rubber clone used.

Therefore, this study aims to evaluate lead contamination in GT1 rubber seedlings treated with a combination of organic and inorganic fertilizers. The results of this study are expected to provide recommendations regarding the effective use of fertilizers to mitigate the effects of lead contamination and to enhance the growth and productivity of rubber seedlings.

MATERIALS AND METHODS

This study was conducted at the experimental plot of the Faculty of Agriculture, University of Islam Sumatra Utara (3.5317° N, 98.6620° E), located on Karya Wisata Street, Johor Building, Medan Johor Subdistrict, Medan Municipality, North Sumatra Province, at an elevation of approximately 25 meters above sea level, on flat terrain.

The materials used included GT1 and PB260 cloned sprouts, organic fertilizer (empty fruit bunch compost), chemical fertilizer (N-P-K), metal sheets, bamboo, measuring cups, and other supporting materials. The tools used include a machete, tin snips, an analytical balance, a measuring tape, an oven, paper, a cell phone, and other supporting tools.

The research method used was a factorial split-plot design (RPT) repeated three times, with clone type (K) as the main plot, consisting of two rubber clone types, one of which was Clone GT1. Meanwhile, fertilizer application (P) served as the subplot, consisting of four levels: P1 = 100% inorganic (0.35 g/polybeg NPK), P2 = 75% + 25% (0.26 g/polybeg NPK + Tankos 11.25 g/polybeg), P3 = 50% + 50% (0.18 g/polybeg NPK + Tankos 22.50 g/polybeg), and P4 = 25% + 75% (0.09 g/polybeg NPK + Tankos 33.75 g/polybeg).

Laboratory soil analysis of several nutrients such as:

a) Organic Carbon (%), this analysis is performed using the Walkley & Black method, specifically using the formula.

$$Corg = 5x(1 - \frac{T}{S}\ x\ 0.003\ x\ \frac{1}{0.77}\ x\ \frac{100}{BCT}$$

Note

T = vol. titration $Fe(NH_4)_2(SO_4)_2$ 0.5 *N* with soil

S = vol. titration $Fe(NH_4)_2(SO_4)_2$ 0.5 *N* on paper (*Without Land*)

0.003 = 1 mL $K_2Cr_2O_7$ 1 *N* + H_2SO_4 capable of oxidizing 0.003 g C-organic

$\frac{1}{0.77}$ = With this method, only 77% of the organic carbon can be oxidized

BCT = Soil Sample Weight

b) N-Total (%), This analysis was performed using the Kjeldahl method, specifically using the formula.

$$N\ \% = \frac{mLHCl\ x\ NHCl\ x\ 14\ x\ 100}{Berat\ Tanah\ x\ 1000}$$

= mL HCl x 0.014

c) P-Bray I (ppm), This analysis was performed using the Bray I extraction method, specifically using the formula.

$$Pavl\ (ppm) = Plrt\ x\ \frac{20}{2}\ x\ \text{dilution factor (if applicable)}$$

d) K-dd (me/100 g), This analysis was performed using the formula.

$$K\text{-}dd = \frac{C\ x\ V\ x\ f}{W}\ x\ 100$$

Note :

K-dd = Potassium is exchangeable (me/100 g)

C = Concentration K based on instrument readings (me/L atau mg/L)

V = Extract volume (L)

f = Dilution factor

W = Soil weight (g)

e) pH. This analysis was performed using the formula.

pH=−log[H+]

f) Pb (*Timbal*), This analysis was conducted using the method *Wet Digestion* + AAS that is, using the formula.

$$Pb = \frac{C\ x\ V\ x\ f}{W}$$

Note

Pb = lead concentration (mg/kg of soil)

C = resulting Pb concentration AAS (mg/L)

V = final volume of the solution (L)

f = dilution factor

W = sample weight (kg)

g) P_2O_5 (%), This analysis was performed using the Olsen method, specifically using the formula.

$$P = \frac{C\ x\ V\ x\ f}{W}$$ Convert to P_2O_5 = P x 2.29 Convert to P_2O_5 (%) = $\frac{P2O5\ (mg/kg)}{10.000}$

Note

P = phosphorus content (mg/kg)

C = concentration from the spectrophotometer (mg/L)

V = extract volume (L)

f = dilution factor

W = sample weight (kg)

h) K_2O (%) and pH. This analysis is performed using the formula.

$$K = \frac{C\ x\ V\ f}{W}$$ Convert to K_2O = K×1.20 Convert to K_2O (%) = $\frac{K2O\ (mg/kg)}{10.000}$

Note :

K = potassium level (mg/kg)

C = concentration of the device (mg/L)

V = extract volume (L)

f = dilution factor
W = sample weight (kg)

RESULTS

Macronutrients (N, P, K) and micronutrients (Fe, Mg, Zn, Cu, Cl, B) can be transported and utilized optimally for photosynthesis in the leaves, enabling plants to grow well (Marchino, 2010). Soil organic matter generally originates from plant tissues. Plant residues contain 60–90% water, and the remaining dry matter contains carbon (C), oxygen, hydrogen (H), and small amounts of sulfur (S), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). Although present in very small amounts, these nutrients are crucial for soil fertility (Bot and Benites, 2005).

Initial Soil Analysis and Organic Fertilizer from Empty Fruit Bunches (EFB)

Based on the results of the initial soil analysis conducted at the Laboratory of the Agricultural Instrument Standardization Agency (BSIP), it was found that the elements present in the initial soil at the rubber nursery (prior to treatment) were determined using the composite sampling method, both for the soil and the Tankos compost fertilizer.

These results are presented in Table 1 below.

Table 1: Results of Laboratory Analysis of Soil and Fertilizer Samples at a Rubber Tree (Hevea brasiliensis) Nursery.

Type of Analysis	Type of Element	Result	Dignity
Soil	C-Organic (%)	1.22	Low (L)
	N-Total (%)	0.15	Low (L)
	P-Bray I (ppm)	15.55	Very High (VH)
	K-dd (me/100 g)	0.43	Currently (S)
	pH	6.17	Neutral (N)
Tankos Compost Fertilizer	C-Organic (%)	16.16	Very High (VH)
	N-Total (%)	0.59	High (H)
	P_2O_5 (%)	0.52	Very Low (VL)
	K_2O (%)	1.41	Very Low (VL)
	pH	7.98	Neutral (N)

Based on the laboratory analysis results in Table 1 above, it is evident that according to the nutrient analysis criteria of the Bogor Soil Research Center (1983) for the soil sample, the nutrient content of the soil—such as organic carbon (1.22%) and N -Total (0.15%) = Low (L), K-dd (0.43 me/100 g) = Moderate (M), pH (6.17) = Neutral (N), and P-Bray I (15.55 ppm) = Very High (VH). Meanwhile, laboratory analysis results for Tankos compost fertilizer showed that $P_2 O_5$ (0.52%) and K_2 O (1.41%) = Very Low (VL), pH (7.98) = Neutral (N), Total N (0.59%) = High (H), and Organic C -Organic (16.16%) = Very High (VH). Based on the laboratory analysis results in Table 1, soil nutrient criteria according to the Bogor Soil Research Center (1983) indicate that the Organic C (1.22%) and Total N (0.15%) contents are classified as low (L). This indicates that the soil has suboptimal organic fertility to support plant growth (Sutanto, 2019). Low levels of organic carbon can reduce the activity of soil microorganisms, while total nitrogen deficiency inhibits protein synthesis in plants (Havlin et al., 2020).

In addition, the analysis results also indicate that K-dd (0.43 mg/100 g) falls into the moderate (S) category, meaning that potassium availability is sufficient but still requires monitoring to prevent a decline (Brady & Weil, 2022). Meanwhile, the soil pH (6.17) is classified as neutral (N), placing it within the optimal range for plant nutrient uptake (Foth & Ellis, 2021). The P-Bray I element (15.55 ppm) is classified as very high (ST), indicating that the soil has an abundant phosphorus content, so it does not require the addition of phosphate fertilizer in the near future (Sanchez, 2019).

On the other hand, the results of the analysis of Tankos compost fertilizer indicate that the $P_2 O_5$ (0.52%) and K_2 O (1.41%) contents are classified as very low (SR), making this fertilizer less effective in supplying phosphorus and potassium (Simanungkalit et al., 2020). However, the fertilizer's pH (7.98) is neutral (N), so it does not cause significant changes in soil acidity. Total N (0.59%) is classified as high (T), making this fertilizer suitable for increasing soil nitrogen, while Organic C (16.16%) is very high (ST), thereby improving soil organic fertility (Prasad et al., 2021).

Based on the results of this analysis, it can be concluded that the application of Tankos compost fertilizer can address the issues of low organic carbon and total nitrogen in the initial soil (Table 1). With its very high organic matter content, this fertilizer can enhance soil biological activity and the availability of nitrogen to plants (Bhardwaj & Sharma, 2023). However, due to its low P and K content, supplementation with other fertilizers is required to meet nutrient requirements in a balanced manner (Marschner, 2022).

Final Soil Analysis at the GT1 Rubber Tree (Hevea brasiliensis) Clone Nursery

Based on the laboratory analysis results, it was found that the nutrient content of the soil in the rubber (Hevea brasiliensis) nursery changed after treatment with inorganic fertilizer (NPK 16:16:16) and organic fertilizer (Tankos compost). The analysis results are shown in Table 2 below.

Table 2: Final Soil Analysis at the Rubber Tree (Hevea brasiliensis) GT1 Clone Nursery.

Type of Analysis	Fertilization			
	P_1	P_2	P_3	P_4
C-Organic (%)	1.54 (L)	1.62 (L)	1.60 (L)	1.65 (L)
N-Total (%)	0.19 (L)	0.18 (L)	0.19 (L)	0.20 (L)
P-Bray I (ppm)	5.88 (L)	3.36 (VL)	5.94 (L)	4.94 (L)
K-dd (me/100 g)	1.26 (VH)	1.02 (VH)	1.10 (VH)	1.33 (VH)
Pb (Timbal)	ND	ND	ND	ND

Keterangan : P_1 = 100% Inorganic (0,35 g/polybeg NPK); P_2 = 75% + 25% (0,26 g/polybeg NPK+ Tankos 11,25 g/polybeg); P_3 = 50% + 50% (0,18 g/polybeg NPK+ Tankos 22,50 g/polybeg); P_4 = 25% + 75% (0,09 g/polybeg NPK+ Tankos 33,75 g/polybeg) SR = Very Low; R = Low; S = Currently; T = High; ST = Very High; ND = Not Detected.

Soil Nutrient Status in the GT1 Clone Nursery

The results of the soil nutrient analysis in Table 2 show that the organic carbon (OC) and total nitrogen (TN) contents were classified as low (R) under all fertilizer treatments in the GT1 clone nursery. This indicates that the soil has limited organic matter, which may affect the growth of rubber tree (Hevea brasiliensis) seedlings. As stated by Riwandi et al. (2017), low soil organic matter is associated with an unbalanced soil C/N ratio, thereby inhibiting decomposition and the availability of nutrients to plants.

In addition, most P-Bray I levels were classified as low (R), except in the 75% NPK + 25% Tankos fertilizer treatment (0.26 g/polybag NPK + 11.25 g/polybag Tankos), which was classified as very low (SR) with a value of 3.36 ppm.

Low phosphorus levels can inhibit root development and plant photosynthesis (Adnan et al., 2020). Meanwhile, K-dd in all treatments was classified as very low (SR), indicating a potassium deficiency that can affect plant resistance to environmental stress (Kusuma et al., 2021).

Analysis of lead (Pb) contamination and factors affecting soil fertility based on laboratory results (Table 2) showed no detectable lead (Pb) contamination in the rubber nursery soil. This indicates that the study site is relatively free from heavy metal pollution. According to Novandi et al. (2014), sources of Pb contamination generally originate from the battery industry, paint, phosphate fertilizers, and other human activities. The absence of Pb in the soil supports the environmental suitability for rubber cultivation. Factors influencing soil nutrient availability include the physical, chemical, and biological properties of the soil. Physical properties such as soil texture, structure, and permeability determine the soil's ability to retain water and nutrients (Riwandi et al., 2017).

Chemical properties such as pH, cCEC, and DHL affect the solubility of nutrients, while biological properties such as microbial activity play a role in the decomposition of organic matter (Sutandi et al., 2019).

The combination of these factors determines soil fertility and crop productivity.

The Effect of Empty Fruit Bunch (EFB) Compost on Initial Soil Analysis in a GT1 Rubber Clone Nursery

The advantages of Tankos compost in improving soil structure: Tankos compost is an organic fertilizer that offers numerous benefits for the soil. According to Hatta et al. (2014), Tankos compost can improve soil structure by making it looser, increase the solubility of nutrients, and reduce the risk of plant pests. This aligns with analysis results showing that Tankos compost contains Organic C (16.16%), classified as Very High (VH), and Total N (0.59%), categorized as High (H). These contents play a crucial role in enhancing soil fertility, particularly in rubber seedling plots of the GT1 clone, which have Organic Carbon (1.22%) and Total Nitrogen (0.15%) levels classified as Low (L) (Sutanto, 2020).

In addition to improving soil structure, Tankos compost plays a role in enhancing soil nutrient content and serves as a source of nutrients for plants. Research results indicate that this compost contains P_2O_5 (0.52%) and K_2O (1.41%), which are classified as Very Low (VL), but has a pH of 7.98 (Neutral), making it suitable for rubber tree growth. In contrast, the initial soil of the GT1 rubber clone nursery has a P-Bray I content (15.55 ppm) classified as Very High (VH) and a K-dd content (0.43 me/100g) in the Moderate (M) category (Adinurani et al., 2021). Thus, the application of Tankos compost can help balance nutrient availability, particularly by increasing the initially low levels of organic carbon and total nitrogen.

The Effect of Soil pH on Rubber Seedling Growth: Soil pH is a key factor influencing nutrient availability for plants. The initial soil for GT1 rubber cloning had a pH of 6.17 (neutral), while Tankos compost had a pH of 7.98 (neutral-alkaline). According to Prasetyo and

Suriadikarta (2020), neutral to alkaline soil pH tends to increase the availability of nutrients such as phosphorus and potassium. Therefore, the application of Tankos compost can help maintain soil pH stability, making nutrients more available to GT1 rubber seedlings.

The Effect of Applying NPK Fertilizer (16:16:16) Combined with Empty Fruit Bunch Compost (EFB) on Final Soil Analysis in GT1 Rubber Clone Nurseries

The Effect of Fertilizer on Organic Carbon and Total Nitrogen: The results of the final soil analysis indicate that the application of empty fruit bunch compost (Tankos) increased the organic carbon (%) and total nitrogen (%) content. Based on laboratory analysis, organic carbon was classified as very high (ST), while total nitrogen was classified as high (T). However, after fertilization with various ratios of NPK and Tankos, the organic carbon and total nitrogen content in the soil of the GT1 rubber clone nursery was actually classified as low (R) (Table 10). This indicates that although Tankos contains high levels of organic matter, its interaction with NPK fertilizer may affect nutrient availability in the soil. According to Sutanto (2019), the simultaneous use of organic and inorganic fertilizers can affect nitrogen mineralization, so proper dosage adjustment is necessary.

The effect of fertilization on Phosphate (P-Bray I) and Potassium (K-dd), where P -Bray I in the soil after fertilizer treatment fell into the low (R) category, except for the 75% NPK + 25% Tankos treatment (0.26 g/polybag NPK + 11.25 g/polybag Tankos), which showed a very low (SR) level of 3.36 ppm. This low P-Bray I level may be due to phosphate fixation in the soil or an imbalance in the C/N ratio of the organic matter. Conversely, the K-dd content was classified as very high (ST), particularly in the 25% NPK + 75% Tankos treatment (0.09 g/polybag NPK + 33.75 g/polybag Tankos) with a value of 1.33 me/100 g. This high K-dd level is likely due to potassium release from decomposing Tankos. Novizan (2020) states that organic materials such as Tankos can be a good source of potassium, especially when applied in high doses.

The Effect of Fertilization on Heavy Metal (Pb) Content: Analysis results show that no lead (Pb) contamination was detected (TTD) in any of the fertilization treatments (Table 2). This indicates that the use of NPK fertilizer (16:16:16) at the recommended dose does not cause heavy metal contamination. The Ministry of Agriculture (2023) explains that heavy metal contamination generally occurs due to the excessive use of chemical fertilizers, pesticides, and herbicides. Therefore, balanced fertilization between organic and inorganic fertilizers can reduce the risk of heavy metal accumulation in the soil.

CONCLUSION

The soil in the GT1 rubber clone nursery has low levels of organic carbon and total nitrogen, at 1.22% and 0.15%, respectively. In contrast, empty fruit bunch (EFB) compost has a very high organic carbon content (Very High) of 16.16% and a high total nitrogen content (High) of 0.59%. Furthermore, applying a 25% + 75% fertilizer mixture (0.09 g/polybeg NPK + 33.75 g/polybeg Tankos) can increase the K-dd content in the soil of the GT1 rubber clone nursery to 1.33 (Very High). The use of chemical fertilizer (NPK) and Tankos compost fertilizer did not cause Pb (Lead) contamination in the soil of the GT1 rubber clone nursery.

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