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Enhancing Leaf Potassium and Corn Yield in Degraded Ultisols with Vermicompost Fertilizer

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ABSTRACT

The study addresses the constraints of Ultisols and underscores the need for vermicompost fertilizer application. The primary objective is to assess whether augmenting the quantity of vermicompost fertilizer enhances potassium (K) levels in leaves and subsequently boosts corn yields. The research spanned from June to December 2022 in Sri Kuncoro Village, Pondok Kelapa District, Central Bengkulu Regency. Employing a Randomized Complete Block Design (RCBD) with 5 treatment levels and 5 replications resulted in 25 plots, encompassing doses of 0, 7.5, 13, 22.5, and 30 tons per hectare. Upon analyzing the data, it is evident that applying vermicompost fertilizer at a rate of 30 tons per hectare leads to a 1.4093% increase in leaf K levels, a K uptake of 3.2035 g tons-1, and a dry stover weight of 232.351 g tons-1. However, there is no significant evidence indicating an increase in root dry weight, shoot dry weight, cob weight without husk, and dry shell weight

Keywords : corn, Ultisols, vermicompost

INTRODUCTION

Organic material incorporated into the soil can enhance soil nutrients, fertility, and structure (Halasan *et al*., 2018). Vermicompost, a specific organic material, is recognized for its beneficial effects on soil and plants. According to Rekhina (2012), vermicompost facilitates the decomposition of soil organic matter, improves water infiltration, increases water content in soil aggregates, enhances microbial activity, and promotes soil aeration and root penetration. Vermicompost, resulting from the breakdown of organic material by earthworms, contains chemical components, including N (3.32%), P_2O_5 (0.32%), K_2O (0.39%), Cl (0.04%), C-Organic (5.6%), S (0.04%), C/N ratio (< 18%), Fe (0.31%), Zn (0.01%), Mg (0.14%), Al (0.19%), and Ca (0.03%).

Additionally, vermicompost contains humus material with humic substances, influencing inorganic and complex reactions in the soil that directly or indirectly impact plant growth (Fatahillah, 2017). With its high organic content, vermicompost serves a dual purpose as a natural fertilizer or soil conditioner (Latupeirissa, 2011). Vermicompost also plays a role in nutrient release by breaking down soil organic matter through enzymes like amylase, cellulase, lipase, and kinitase (Sinha *et al*., 2010). Studies by Pandega & Napoleon (2022), Muhazir & Napoleon (2022), and Riwandi *et al*. (2022) have highlighted the potential of vermicompost in increasing K levels, enhancing soil properties, and being environmentally friendly.

In Indonesia, ultisols, covering up to 25% or 45,794,000 hectares of total land area, are widespread (Prasetyo & Suriadikarta, 2006). Ultisols in Bengkulu Province, spanning 706,000 hectares, have agricultural potential but face biological, physical, and chemical limitations. These soils lack microorganisms, have low organic matter decomposition, are prone to erosion, possess a clayey texture, low water holding capacity, lower permeability, and chemical imbalances, including high concentrations of Al, Fe, and Mn that are toxic to plants (Fitriani *et al*., 2014). Ultisols are also characterized by a dense argillic horizon, posing challenges for plant growth, and are often degraded due to factors like erosion, poor agricultural practices, pollution, and physical stress (Subowo, 2012). Potassium, crucial for plant growth, especially in corn, plays key roles in sugar and starch formation, sugar translocation, enzyme activity, and stomata movement (Pradipta *et al*., 2014). Corn, the second most important cereal crop in Indonesia after rice (Kementerian Pertanian, 2015), faces challenges like limited productive land due to conversion, leading to low soil fertility, particularly in ultisols. Corn

plants demand fertile soil as they need substantial nutrients for optimal growth and productivity (BPTP, 2009). Specifically, corn plants require significant amounts of essential nutrients like nitrogen (N), phosphorus (P), and potassium (K), with a particular emphasis on potassium. However, ultisols soil contains minimal quantities of these crucial nutrients (Sirappa, 2010). The aim of this research was to determine the ability of vermicompost fertilizer doses to increase leaf K levels and corn crop yields.

MATERIALS AND METHODS

This research was conducted in Sri Kuncoro Village, Pondok Kelapa District, Central Bengkulu Regency, from June to December 2022. Soil and leaf analyses were performed at the Soil Science Laboratory, Faculty of Agriculture, Bengkulu University. The research site is located at an altitude of 28.4 meters above sea level, with coordinates 3°43‟54.5” S 102°17‟06.9” E.

The materials and tools utilized in this study included soil drills, machetes, raffia rope, filter paper, furadan, universal pH 0-14, H_2O_2 30% p.a, distilled water, corn seeds, dolomite, vermicompost, urea (175 kg ha^{-1}), SP36 (100 kg ha^{-1}), KCl (50 kg ha^{-1}), pesticide, clean water, bucket, bottle, brown paper bag, asoi, bamboo, fertilizer, software, emamectin benzoate 30g L^{-1}, knapsack sprayer, statistical applications for processing research data, and chemicals for soil and plant analysis.

The experimental design employed was a Randomized Complete Block Design (RCBD) with treatment levels: V_0 = 0 tons ha^{-1}, V_1 = 7.5 tons ha^{-1}, V_2 = 15 tons ha^{-1}, V_3 = 22.5 tons ha^{-1}, and V_4 = 30 tons ha^{-1}, each with 5 repetitions. The experimental plot dimensions were 3 m x 2 m, with a planting distance of 75 cm x 20 cm, resulting in 40 plants per plot. The distance between plots was 1 m, and the distance between plots and the edge of the land was 2 m, making the total land area 414 m^2 .

RESULTS AND DISCUSSION

The analysis of variance results indicates that there are three observed variables that have a significant impact, namely K content, K absorption, and dry stover weight . On the other hand, the dry weight of roots, dry weight of shoots, weight of cobs without husks, and dry weight of grains have no significant effect (Table 1).

The dosage of vermicompost shows a linear relationship pattern with the equation Y = 1.0253 + 0.0128 X, meaning that each unit increase in vermicompost dosage will increase the average leaf K by 0.0128 units (Figure 1). The highest value is achieved at a vermicompost dosage of 30 tons ha-1, amounting to 1.4093%. The coefficient of determination, R^2 = 0.3174, indicates that the regression equation Y = 1.0253 + 0.0128 X can represent 31.74% of the variation in leaf K data. This suggests that the appropriate application of vermicompost can enhance soil microorganism activity and improve soil fertility. Microorganisms present in vermicompost can aid in the plant nutrient cycle, including increasing leaf K content. In line with Astari *et al*., (2016), who stated that vermicompost can enhance K nutrient, although not significantly. The application of a vermicompost fertilizer dosage of 20 tons ha^{-1} resulted in a K content of 0.10%. If the vermicompost fertilizer dosage used is the same as in this study, 30 tons ha^{-1}, which yields an average leaf K content of 0.15%, then the results of this study are superior to those of Astari *et al*. (2016).

Table 1. Effect of vermicompost on the observed variables

Variable	F value
K content	4.01 *
K absorption	3.92 *
Dry weight of roots	2.37 ns
Dry weight of shoots	1.31 ns
Dry stover weight	3.59 *
Weight of cobs without husks	1.17 ns
Dry weight of grains	1.88 ns

Note : * = significant (p<0.05); ns = non-significant (p≥0.05)

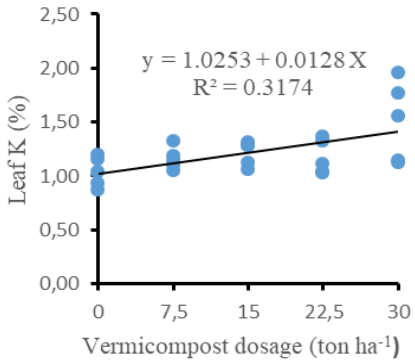

Figure 1. Effect of vermicompost dosage on K in corn plant leaves

The linear relationship pattern with the equation Y = 1.7125 + 0.0497 X is depicted in Figure 2. This means that each unit increase in the dosage of vermicompost will result in an increase in K uptake by 0.0497 g $plant^{-1}$. The highest K uptake value is achieved with a vermicompost dosage of 30tonsha^{-1},

amounting to 3.2035 g per plant. The coefficient of determination, R2 = 0.2808, indicates that the regression equation Y = 1.7125 + 0.0497 X can represent 28.08% of the variation in K uptake data. This suggests that vermicompost, rich in beneficial microorganisms capable of effective decomposition and providing organic nutrients, has the potential to enhance K nutrient uptake by plants. Research by Pandega & Napoleon (2022), indicates that vermicompost can influence soil nutrient levels, thereby improving nutrient uptake for plants.

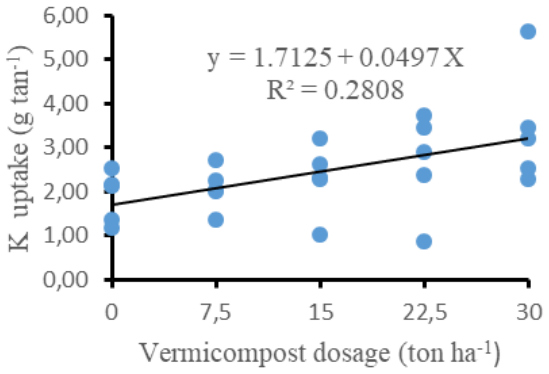

Figure 2. Effect of vermicompost dosage on K uptake in corn plants

The application of vermicompost dosage demonstrates a linear relationship pattern with the equation Y = 172.51 + 1.9947 X (Figure 3). This means that each unit increase in the vermicompost dosage will result in an increase in the dry stover weight by 1.9947 g per plant. The highest value is achieved at a vermicompost dosage of 30 tons ha-1, yielding an average dry stover weight of 232.351 g. The coefficient of determination, R^2 = 0.1011, indicates that the regression equation Y = 172.51 + 1.9947 X can represent 10.11% of the variation in the data of dry weight of panicles. This is because the application of vermicompost fertilizer can enhance plant and stem growth by providing essential nutrients such as N, P, and K for the growth of corn plants. It also assists in increasing chlorophyll levels to improve photosynthetic efficiency and accelerate leaf growth. The results of Libra's study (2018) support the idea that vermicompost can increase the dry weight of panicles .

The application of vermicompost doses had a statistically insignificant effect on the dry weight of roots, shoot, cob without husk, and dry weight of grains (Table 1). This occurred during a planting season with high rainfall, reaching an average of 250 mm per month. Maize plants only require rainfall in the range of 13.83 mm to 128.55 mm to achieve optimal yields (Sirait *et al*., 2020; Herlina & Prasetyorini, 2020). The high rainfall led to nutrient leaching, resulting in a statistically insignificant impact between the given vermicompost doses. Rainfall plays a significant role in soil fertility degradation (Patel *et al*., 2017).

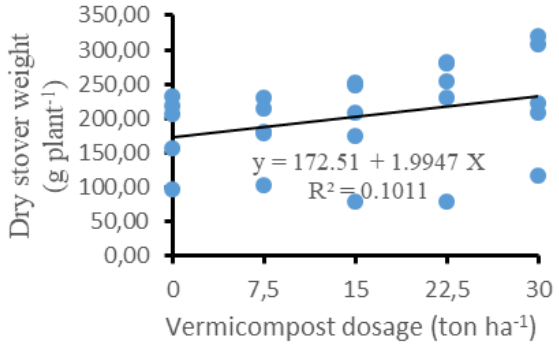

Figure 3. Effect of vermicompost dosage on dry stover weight of corn plants

On average, it is observed that a vermicompost dose of 30 tons/ha produces the highest dry weight of roots and shoots. However, a dose of 22.5 tons/ha is already effective in increasing cob weight and dry grain weight (Table 2). Other research findings indicate that vermicompost enhances soil morphological characteristics, biological activity, and green bean quality but does not have a positive effect on physiological traits (Amiri *et al*., 2017). Adding vermicompost doses balanced with an increase in supplementary fertilizer concentration can improve shallot yields (Aryani *et al*., 2019)

Vermicompost doses have the potential to enhance the growth and yield of maize plants, but several factors can influence these aspects. One of the causes of suboptimal maize yields is environmental factors such as temperature, rainfall, light, and humidity. The study was conducted during the rainy season, with consecutive rainfall in August to December totaling 180 mm, 210 mm, 230 mm, 250 mm, and 202 mm. Additionally, the degradation of ultisols resulting in topsoil depletion can negatively impact soil fertility. Maize plants also faced severe infestation by armyworm pests, ultimately affecting the plant's yield negatively. Fitriani *et al*. (2014) stated that high Al and Fe content in ultisols can be toxic to plants. The high rainfall also contributes to nutrient leaching from vermicompost, causing soluble nutrients to be carried to deeper soil layers, reducing their availability for plant uptake.

Table 2. Effect of vermicompost dosage on corn growth and yield

Vermicompost dosage	Dry weight of roots	Dry weight of shoots	Weight of cobs without husks	Dry weight of grains
ton ha^{-1}	g plant^{-1}			
0	42.00	139.40	13.85	107.13
7.5	42.67	137.80	17.35	136.27
15	59.20	132.40	16.41	134.00
22.5	68.67	155.80	19.47	153.33
30	75.80	158.40	18.47	150.40

CONCLUSION

Based on the observations and discussions, it can be concluded that the application of vermicompost fertilizer at a dose of 30 tons per hectare can increase the leaf potassium (K) content by 1.4093%, potassium uptake by 3.2035 g per plant, and the dry weight of harvested parts by 232.351 g per plant.

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