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VEGETATIVE COVER OF A MINE TAILINGS WITH BERMUDA GRASS (*Cynodon dactylon* L.) TO MITIGATE POLLUTION

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ABSTRACT

The vegetative cover of mine tailings with grasses has environmental benefits and positive impacts on public health by improving air and water quality, as well as the overall well-being of surrounding communities. This study evaluated the ability of *Cynodon dactylon* L. grass in the cover of a mine tailing using three doses of vermicompost (V_{low} [60 Mg ha^{-1}], V_{medium} [80 Mg ha^{-1}], and V_{high} [100 Mg ha^{-1}]) to improve the conditions of the site, which was physically and chemically characterized. The concentrations of lead (Pb), cadmium (Cd), nickel (Ni), and zinc (Zn) were determined before and during the experiment. Ninety-six and 202 days after planting (dap), grass was harvested to determine the concentrations of the potentially toxic elements (PTE) in the root and aerial sections. The production of dry matter and the growth of the grass were evaluated. Results showed that, before the experiment was established, the tailing had a low concentration of organic matter. After incorporating the vermicompost, an increase was observed in the concentrations of phosphorous (P), potassium (K), calcium (Ca), and magnesium (Mg). Ninety-six days after planting, in the treatment with the low dose of vermicompost, *C. dactylon* absorbed 202.13 mg Pb kg^{-1}, 37.26 mg Ni kg^{-1}, and 164.82 mg Zn kg^{-1} in its roots. Also at 96 dap, the highest PTE concentrations were found in the treatments with the highest dose of vermicompost. The greatest production of dry matter (231.55 kg ha^{-1} at 96 dap) and growth of the grass (9.7 cm, 73 dap) occurred in the treatment with the high dose of vermicompost, which highlights its efficiency in favoring its development and improving the conditions of the tailing. The absorption of the PTE by the grass highlights its contribution towards the reduction of dispersion and runoff of particles from tailings.

Keywords: mine residues, potentially toxic elements, organic amendments, vegetative cover.

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INTRODUCTION

Globally, mining is an activity that plays an important role in the economies of many countries. It not only produces jobs and profits, but it also contributes significantly to the gross domestic product, boosts innovation, and promotes investment in infrastructure and technological development. However, it faces substantial challenges regarding environmental impacts, such as soil, water, and air pollution, the management of mine tailings, erosion, and the loss of biodiversity (Singh *et al.*, 2020b). Likewise, it creates problems such as the displacement of communities, social conflicts, and repercussions in public health and activities such as agriculture (Islam *et al*., 2020).

Mine tailings are residues composed of ground rocks and effluents resulting from mineral processing that accumulate in ecosystems after the extraction of economically valuable minerals, generating environmental problems in open areas (Xiaolong *et al*., 2021). The presence of these residues in communities leads to a public health issue when strong winds or water spread surface particles from the tailings, which contain As, Hg, Pb, and Cd, among others. Inhaling these particles affects the health of people living in nearby areas, including gastrointestinal and respiratory disorders, irritation of the nose and eyes, and other issues that pose a concern to the general population (Mpanza *et al*., 2020).

Vegetative cover is a technique used in the restoration and rehabilitation of areas affected by human activities, such as mining (Márquez-Huitzil *et al*., 2022). It involves the establishment of plants on degraded or altered surfaces in order to restore elements of the ecosystem, such as soil, water, and biodiversity, as well as preventing erosion and pollution (Marcelo-Silva *et al*., 2023). Bermuda grass (*Cynodon dactylon* L.) is used to restore mine tailings and eliminate or stabilize potentially toxic elements. Its resistance to adverse conditions such as drought or salinity (Zhang *et al*., 2023), along with its rapid growth and ability to spread via stolons and rhizomes, make it a valuable plant. This species plays an important role in covering disrupted areas, thus promoting their recovery (Yang *et al*., 2016). Under these conditions, it facilitates ecological succession and provides habitats for other plants and local fauna.

In mine tailings, colonization and succession with native plants is recommended, including those that facilitate the growth and development of young species and those with lower strata. These sites, known as vegetation islands, play an important part in mitigating the dispersion and runoff of particles (Duarte-Zaragoza *et al*., 2020). Establishing plants in the tailings helps the ecosystem to continue accepting the mining activity. Even after the mine ceases to operate, the site will receive many benefits from the presence of the plants. In this task, the incorporation of organic materials such as vermicompost is beneficial since it improves the quality of the tailings by providing nutrients for the plants, improving water retention, and stimulating microbial activity, among other crucial factors for their growth and development. In this way, the success of the vegetative cover is strengthened (Ma *et al*., 2022).

This study analyzed the growth, development, and ability of *C. dactylon* to absorb potentially toxic elements (PTE) in mine tailings conditioned with vermicompost. The goal is to propose this species as a viable alternative in the vegetative cover to mitigate pollution and health problems derived from the dispersion and runoff of particles in surrounding areas.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Dos Carlos mine tailings in Pachuca, Hidalgo, Mexico (20° 06′ N, 98° 43′ W, and 20° 06′ N, 98° 42′ W), within the Pachuca-Real del Monte mining district, in the Pachuca Mountain Range, a metallogenic region in the Mexican Neovolcanic Axis, where primary extraction in colonial times focused on silver. The area of the tailings has an extension of 51.4 ha, a mean height of 20 m, and an estimated amount of 107 659 225 Mg. The area presents temperatures ranging between 10 and 16 °C, an average rainfall between 400 and 900 mm, and a temperate semidry climate (INEGI, 2022). Plantations were performed in July, and harvests took place on the first week of February; during this time, the plants in the mine tailing were exposed to both rain and drought.

Location of the experimental plot

A site representative of the conditions of the tailings (slope, drainage, exposure to the elements, accessibility, stability, and presence of vegetation) was selected (20° 06′ 21.62′′ N and 98° 42′ 46.72′′ W, at an altitude of 2435 m). *Cynodon dactylon* L. was chosen as the proposed vegetative cover for the tailings for its potential in the recovery of polluted areas (Rabêlo *et al*., 2021), speedy growth, high biomass, well-developed root system, and tolerance to conditions of biotic and abiotic stress (Zhang *et al*., 2023). Vermicompost was added to the tailings during plant establishment, which displayed an apparent density of 0.66 g cm^{-3}, moderately alkaline pH (8.20), a concentration of organic matter of 28.02 %, inorganic N (51.33 mg kg^{-1}), P (326.9 mg kg^{-1}), K (914.16 mg kg^{-1}), Ca (33.8 mg kg^{-1}), Mg (63.96 mg kg^{-1}), Pb (0.54 mg kg^{-1}), Cd (0.09 mg kg^{-1}), Ni (0.5 mg kg^{-1}), and Zn (48.96 mg kg^{-1}), in accordance with NOM-021-SEMARNAT-2000 (DOF, 2002). In general, the vermicompost had a high concentration of organic matter and phosphorous and a low concentration of PTE.

Experimental design and statistical analysis

The experimental plot was established in the tailing using the completely randomized block experimental design, leading to a more homogenous plot and improving the accuracy of the comparison between treatments. The study incorporates three levels of vermicompost: a low dose, equivalent to 60 Mg ha^{-1} (Vb); a medium dose, equivalent to 80 Mg ha^{-1} (Vm); and a high dose, equivalent to 100 Mg ha^{-1} (Va). Every dose was considered a treatment, with three repetitions. The plot measured 9 x 9 m and was divided into three blocks; three treatments were established in each block. Thus, a total of nine experimental units were obtained, each measuring 3 x 3 m. A distance of 50 cm was placed between blocks, and each block presented 11 rows in straight lines at a distance of approximately 27 cm.

The data from the variables evaluated on mine tailings and plant material samples were analyzed using a linear model, $Y_{ijk} = \mu + Ti + B_j + \varepsilon_{ijk}$, where Y_{ijk} = observations, μ = general mean, Ti = effect of the i-th treatment, B_j = effect of the j-th block, and ε_{ijk} = experimental error. The statistical program SAS version 9 was used to perform the analysis of variance (ANOVA) and Tukey's test ($p \leq 0.05$).

Establishment and follow-up of the experiment

The surface of the experimental plot was hardened by compacting, making it necessary to break the surface of the tailings. The three doses of vermicompost were then added to each corresponding treatment and mixed homogenously to a depth of 10 cm. Next, in the autumn-winter cycle, 15 kg ha^{-1} of *C. dactylon* were planted (0.0135 kg of seed per experimental unit); the seeds were planted at a depth of 1 to 2 cm on the rows, at a distance of 27 cm between rows. The seeds were then irrigated with a watering can twice a week for one month and a half; after this time, plants were irrigated depending on their requirements. Starting at germination, the average growth of the grass was recorded weekly in each experimental unit.

Physical and chemical analysis of the tailing in the experimental plot

The mine tailings were sampled at 0, 96, and 202 days after planting (dap), and a compound mixture was obtained from subsamples taken from each of the experimental units using the zigzag method, covering the entire experimental plot. The subsamples were taken at a depth of 5 to 10 cm according to NOM-021-SEMARNAT-2000 (DOF, 2002). Compound samples were analyzed in the laboratories of the Chapingo Autonomous University [Environmental Biotechnology Laboratory of the Department of Soils (LBA-Suelos-UACh) and the National Agrifood and Forestry Research and Services Laboratory (LANISAF)], following the procedures described in NOM-021-SEMARNAT-2000 (DOF, 2002), to determine apparent density, pH, percentage of organic matter, and concentration of inorganic N, P, K, Ca, Mg, Pb, Cd, Ni, and Zn.

Sampling, harvest, and plant analysis

After 96 and 202 dap, the grass was cut from the base of the stem (soil level) using pruning shears. At least 500 g of fresh grass and roots (9 root samples and 9 leaf samples per experimental unit) were taken for labeling. The plant material was washed, dried (in a stove at 75 °C until constant weight), and ground in an agate mortar. The concentration of Pb, Cd, Ni, and Zn present in each sample was determined following the AS-14 method described in NOM-021-SEMARNAT-2000 (DOF, 2002). The production of grass was evaluated, and the percentage of dry matter was obtained. For this purpose, the samples were placed in a forced-air oven at 50 °C for 48 h. At the end of this period, they were weighed at 18, 23, 27, 32, 49, and 73 dap using measuring tape. The measurements were taken on these dates because the plants began to display growth.

RESULTS AND DISCUSSION

Physical and chemical characteristics of the tailing

The mine tailings displayed an apparent density of 1.21 g cm^{-3}, a neutral pH of 7.11, a very low concentration of organic matter (0.48 %), a medium content of inorganic N (24.38 mg kg^{-1}), a high concentration of P (15.06 mg kg^{-1}) and K (35.49 mg kg^{-1}), a very low availability of Ca (31.8 mg kg^{-1}), and a medium availability of Mg (27.58 mg kg^{-1}). According to national and international standards for soils, the permissible limits of Pb (10.63 mg kg^{-1}), Cd (0.58 mg kg^{-1}), Ni (0.2 mg kg^{-1}), and Zn (36.21 mg kg^{-1}) were not exceeded (Council of the European Union, 1986; USEPA, 1996; Kabata-Pendias and Pendias, 2010).

According to the statistical analysis, with the establishment of *C. dactylon* at 0, 96, and 202 dap, the treatment that displayed the best results was the one with a concentration of 80 Mg of vermicompost per hectare. The variables that displayed differences between treatments were the concentrations of P, K, Ca, and Mg. An increase was observed in the concentrations of P and K with time, with the treatment performed at 96 dap displaying the highest values. For Mg, the concentrations decreased (Figure 1). Tukey's test displayed differences between treatments for the concentrations of P and K. In both cases, the highest means were presented with medium and high doses of vermicompost at 96 and 202 dap. Both contents were considered high, according to determinations by NOM-021-SEMARNAT-2000 (DOF, 2002). The concentrations of P and K increased over time; the addition of vermicompost resulted in high concentrations at the end of the experiment in the plot. The mine tailings without the incorporation of vermicompost presented values of 15.06 mg kg^{-1} (P) and 35.49 mg kg^{-1} (K); at 96 dap, the values were 55 mg kg^{-1} (P) and 914.16 mg kg^{-1} (K) (Figure 1). A study by Paradelo (2013) concluded that the incorporation of organic materials such as compost and vermicompost into mine tailings increase the accumulation of P and K in plants, since they provide nutrients (Lukashe *et al*., 2019; Singh *et al*., 2020a).

Despite the lack of differences between treatments for apparent density, pH, organic matter, and concentration of N, these variables increased in value with time (Figure 1). At 202 dap, the percentage of organic matter in the experimental plot increased from 0.48 to 1.32 % as a result of the incorporation of vermicompost. Bautista-Gabriel *et al*. (2016) obtained similar data as a result of a greenhouse experiment in which they planted *Lolium perenne* grass in mine tailings and added compost; these researchers increased the percentage of organic matter from 0 to 1.5 %.

Lead, cadmium, nickel, and zinc concentration in the tailing

The statistical analyses displayed differences between treatments for the concentrations of Pb, Cd, and Zn. In general, the highest concentration of PTE was found in the treatments with the highest doses of vermicompost, at 96 and 202 dap. Zn was found in the highest concentration, followed by Pb and Cd; however, none of the three surpassed the permissible limits according to international standards for soils (Figure 2).

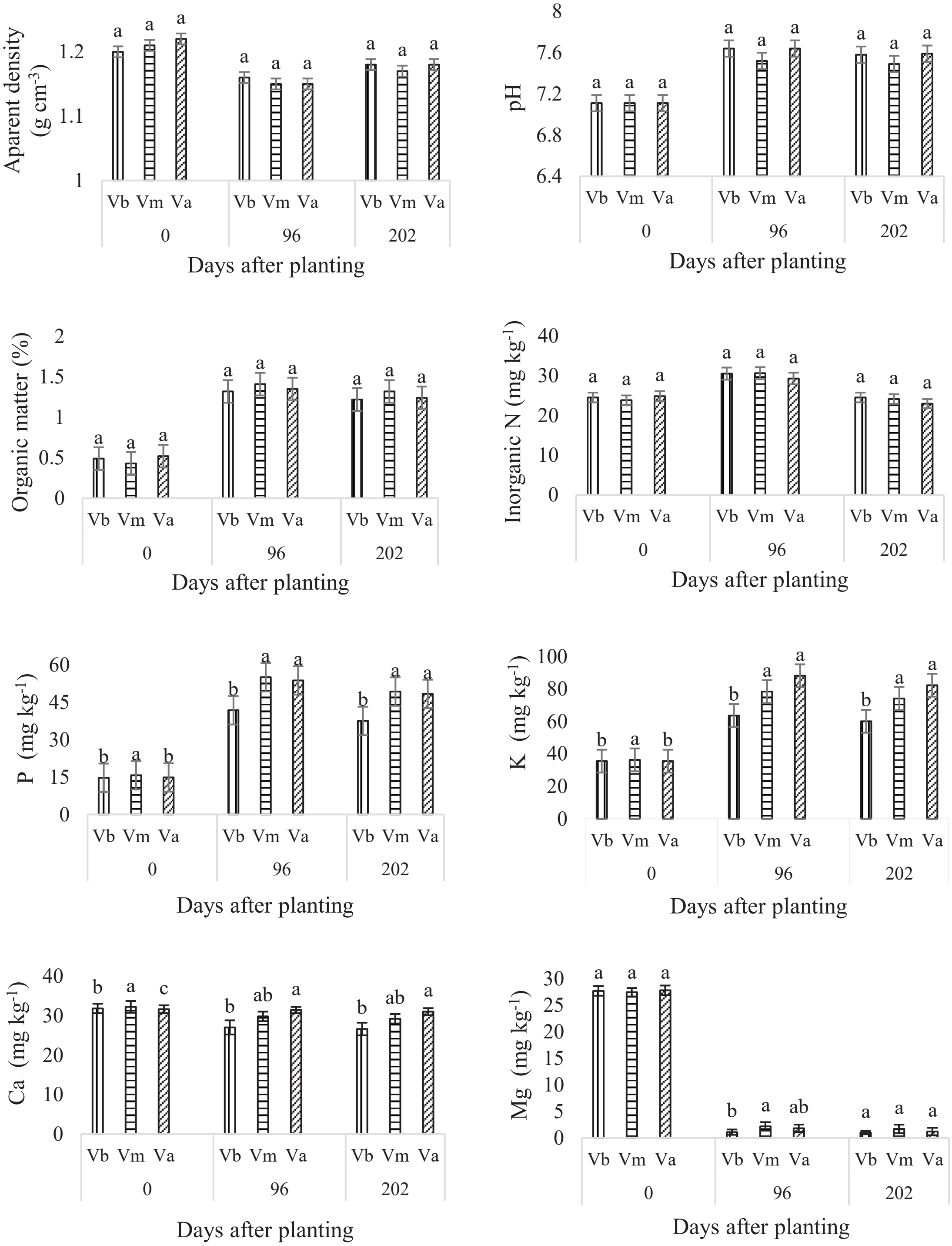

Figure 1. Physical and chemical characteristics of the mine tailing with the establishment of the *Cynodon dactylon* grass at 0, 96, and 202 days after planting. Means ± EE in subfigures with different letters show statistically significant differences (Tukey, $p \leq 0.05$). V_b: 60 Mg vermicompost ha^{-1}; V_m: 80 Mg vermicompost ha^{-1}; V_a: 100 Mg vermicompost ha^{-1}.

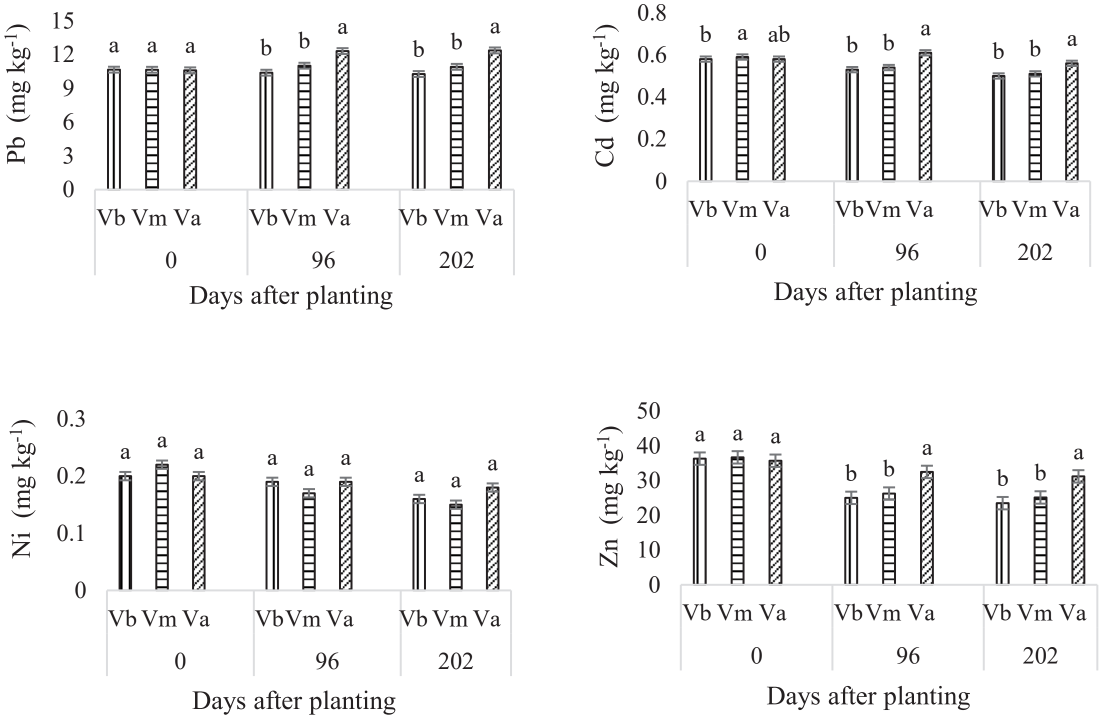

Figure 2. Concentrations of lead, cadmium, nickel, and zinc at the mine tailing, with the establishment of *Cynodon dactylon* grass and vermicompost at 0, 96, and 202 days after planting. Means ± EE in subfigures with different letters show statistically significant differences (Tukey, $p \leq 0.05$). V_b: 60 Mg vermicompost ha^{-1}; V_m: 80 Mg vermicompost ha^{-1}; V_a: 100 Mg vermicompost ha^{-1}.

The highest concentration of Pb was recorded at 202 dap (12.37 mg kg^{-1}) in the treatment with the highest dose of vermicompost. This element was observed to increase in the tailings with time, although the permissible limits were not surpassed (Figure 2). Higher Pb concentrations (34 mg kg^{-1}) were reported by Hernández-Acosta *et al*. (2009) when evaluating concentrations of PTE in the same mine tailings. Regrading increases in Pb, the use of vermicompost is reported to cause its adsorption, particularly on the surface of the soil. Its least acidic pH values increase its adsorption (Barriga-Vélez *et al*., 2023) due to the formation of less soluble chemical species and the precipitation of Pb in the form of Pb-phosphate (McBride *et al*., 2019).

With a high dose of vermicompost, the concentration of Cd increased at 96 dap (0.61 mg kg^{-1}) and decreased at 202 dap (0.56 mg kg^{-1}); these concentrations surpass the normal limit of 0.35 mg kg^{-1} in the soil, which is tolerable for plants according to NOM-021-SEMARNAT-2000 (DOF, 2002). However, these concentrations are not considered dangerous since they are below 1 mg kg^{-1} (Figure 2). Regarding the limit established for the European Union, this element remained below the limit (Kabata-Pendias and

Pendias, 2010). The increase displayed with Cd could have occurred with the addition of vermicompost, but also due to this element having a higher mobility than most PTEs due to the relative solubility of its salts and hydroxides (Kabata-Pendias and Pendias, 2010). On the other hand, its decrease at 202 dap is attributed to its adsorption by the grass, since it is a metal with a greater tendency to accumulate in plants (Reyes *et al*., 2016), such as *Lolium multiflorum* grass, which is tolerant to Cd and has the potential for hyperaccumulation due to its wide distribution, capability of absorption, tolerance, and accumulation of PTE in its plant tissues (Wang *et al*., 2020).

The behavior of the Zn concentration was different. It decreased from 36.66 (at 0 dap in treatment V_m) to 31.19 mg kg^{-1} (at 202 dap in treatment V_a) and did not surpass the permitted limit according to the standards of the United States Environmental Protection Agency and the European Community (Council of the European Union, 1986; USEPA, 1996). The reduction of Zn concentration is related to its ability to form complexes with the vermicompost added to the tailings, which originate from the transformation of the nutrient from the solid phase to forms available to plants; in this condition, the absorption of the metal is favored. Similar findings were reported by Bautista-Gabriel *et al*. (2016), who assessed the effect of compost on mine tailings in a greenhouse by planting *Lolium perenne* and discovered a decrease in the Zn concentration in the tailings at 30 and 60 dap. Zhang *et al*. (2023) showed that *Cynodon dactylon* is a genetically adequate grass to reproduce in mine tailings with high concentrations of Zn. They suggest that it can be used as a cover plant in areas contaminated with this element. Its shoots, stolons, and rhizomes allow it to fulfill various applications and physiological functions (Chen *et al*., 2021).

Lead, cadmium, nickel, and zinc concentration in *Cynodon dactylon*

In general terms, the roots concentrated a higher amount of EPT than in the aerial section (Figure 3). In the roots, differences were identified between treatments regarding the concentrations of Cd and Zn. The highest concentrations of the four EPTs were registered at 96 dap, with a pronounced reduction at 202 dap. This can be attributed to factors such as the differential absorption of the metals by the roots and the processes of metabolization and translocation inside the plant (Xu *et al*., 2021).

In the roots, out of the four metals, Pb presented a notable decrease, dropping from 202.13 mg kg^{-1} at 96 dap with the lowest dose of vermicompost (V_b) to 16.65 mg kg^{-1} at 202 dap with the highest dose of vermicompost (V_a). Similarly, Zn concentrations decreased from 172.79 (at 96 dap in the V_a treatment) to 42.64 mg kg^{-1} (at 202 dap in the V_a treatment) (Figure 3). According to Kabata-Pendias and Pendias (2010), these values fall within the phytotoxicity range. Particularly, Pb can induce toxicity problems in plants, manifesting through changes in coloration. Nevertheless, no signs of this occurrence were observed in *C. dactylon* in this experiment. Mahohi and Raiesi (2021) report that this grass is suitable for phyto-remediating sites contaminated with potentially toxic trace oligo-elements. It is important to highlight that grasses in general have shown remarkable tolerance to the presence of PTE in mine tailings (Amezcua-Ávila *et al*., 2020).

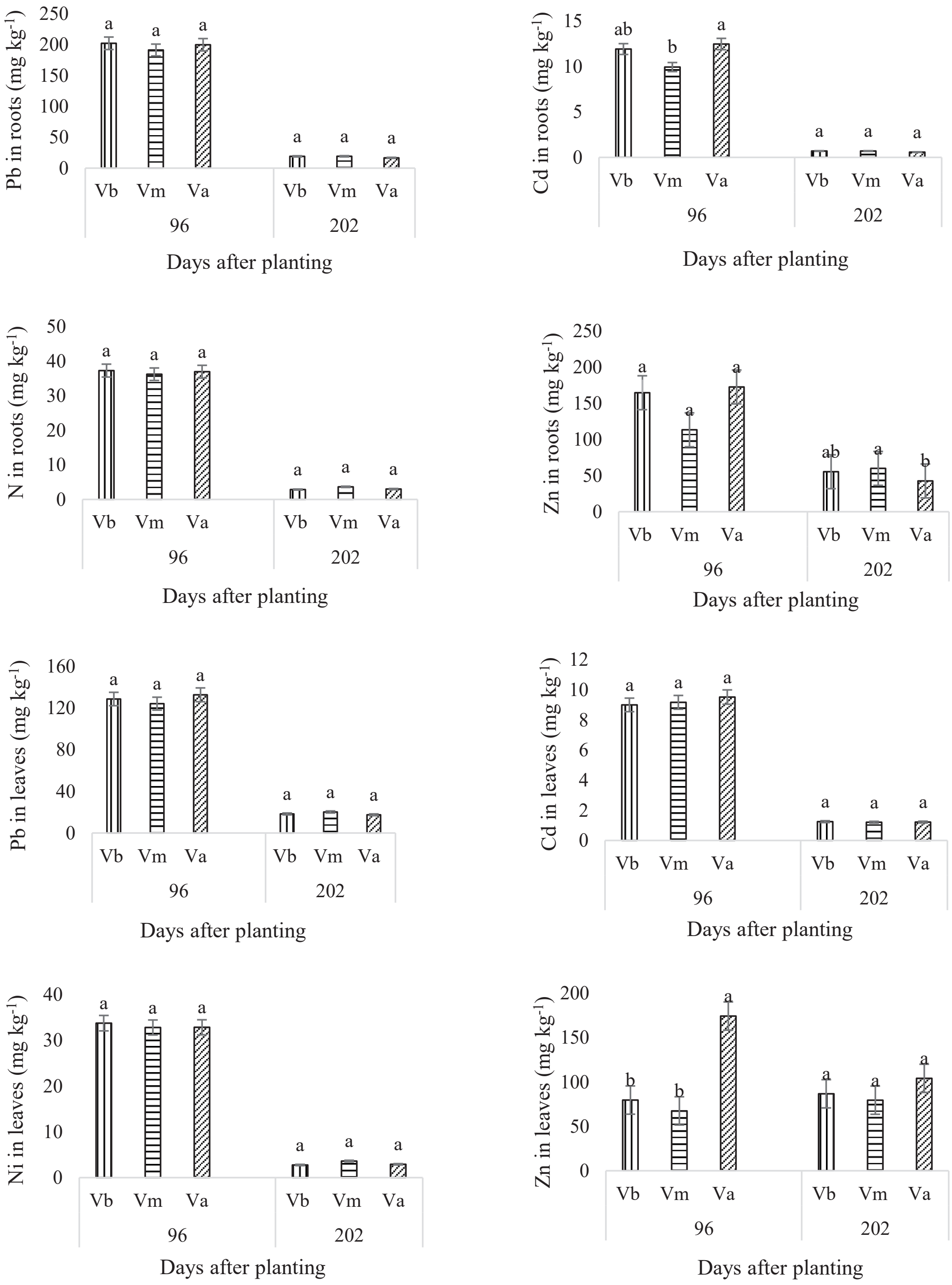

Figure 3. Concentrations of lead, cadmium, nickel, and zinc in roots and aerial section of *Cynodon dactylon* grass planted in the mine tailing conditioned with vermicompost. Means ± EE in subfigures with different letters show statistically significant differences (Tukey, $p \leq 0.05$). V_b: 60 Mg vermicompost ha^{-1}; V_m: 80 Mg vermicompost ha^{-1}; V_a: 100 Mg vermicompost ha^{-1}.

In the aerial section of *C. dactylon*, there were differences at 96 and 202 dap for the concentration of Zn (Figure 3). The highest concentrations in the aerial section at 96 (174.18 mg kg^{-1}) and 202 dap (104.07 mg kg^{-1}) were shown in the treatments with the highest dose of vermicompost (V_a), resulting in a notable reduction of the Zn contents in the tailings. This confirms the ability of *Cynodon dactylon* to accumulate Zn in its roots and to translocate this element, storing phytotoxic amounts of it (Kabata-Pendias and Pendias, 2010). In a similar study, Bautista-Gabriel *et al.* (2016) found a significant reduction in the contents of PTE, including Zn, when applying vermicompost in mine tailings where *Lolium perenne* grass grew. The use of vermicompost is common in agricultural soils for the growth of *Cynodon dactylon* (Erdawati *et al*., 2023); furthermore, the application of organic amendments in contaminated sites is attributed with the ability to reduce the bioavailability of PTE (Perea-Vélez *et al*., 2015).

Production and growth of *C. dactylon* at 96 and 202 dap

At 96 dap, no differences were observed in the variable of dry matter between treatments. The treatment with the highest dose of vermicompost (V_a) displayed the greatest production of dry matter (Table 1). At 202 dap, differences were found between treatments. The greatest yield was observed in treatment V_m; the production of dry matter at 96 dap was greater than that obtained at 202 dap. This reduction in the production of grasses is directly related to the period of lethargy; in the winter, temperatures in the mine tailing reached 0 °C, along with some frosts, causing the mature plants to become dormant (Feuchter, 2018). This phenomenon can be seen on the field, when the aerial section of the grasses turns brown.

Table 1. Production of dry matter (kg ha^{-1}) of Cynodon dactylon grass at 96 and 202 days after planting at the Dos Carlos mine tailing in Pachuca, Hidalgo, Mexico.

Days after planting	Treatments		
	V_b	V_m	V_a
96	79.37 a	152.45 a	231.55 a
202	50.08 b	127.54 a	107.95 ab

Means in the same row with different letters are statistically different (Tukey, $p \leq 0.05$). V_b: 60 Mg vermicompost ha^{-1}; V_m: 80 Mg vermicompost ha^{-1}; V_a: 100 Mg vermicompost ha^{-1}.

It is normal for the production of dry matter in *C. dactylon* to vary with time, particularly in temperate climates with well-defined seasons (Ibrahim *et al.*, 2023). Another factor of influence is irrigation, since water deficit may have a negative impact on the production of dry matter, according to Calderón-Vera and Rivera-Fernandez (2018).

In semi-arid regions without irrigation, *C. dactylon* produces between 8 and 12 Mg ha^{-1} of dry matter per year (Cavalcante, 2013). With an irrigation system, Calderón-Vera and Rivera-Fernandez (2018), in a farm in the province of Manabí, Ecuador, found that the production of biomass in this species ranged between 0.22 and 0.94 kg m^{-2} under different irrigation levels. In turn, Feuchter (2018) mentions that in a prairie with an irrigation system, the optimum establishment of *C. dactylon* is reached 6 months after planting, achieving yields of up to 40 Mg ha^{-1} of dry matter per year. Although this investigation did not evaluate the annual production of dry matter due to the two samplings performed (one in autumn and another in winter), it was observed that the productivity was limited by the adverse conditions of the mine tailing and the lack of irrigation since the crop was rainfed. As a consequence, the highest production reached was 231 kg ha^{-1} of dry matter at 96 dap (in autumn), when the vermicompost had time to mineralize, there was a certain moisture in the mine tailing, and the temperature was not very unfavorable.

The results of the analysis of variance for the average data in the variable of height in time (days) suggest that there are significant differences between treatments. The germination of *C. dactylon* in the mine tailing was produced at 18 dap, a period within the range of 3 to 21 d, according to Delgado-Caballero *et al*. (2017), who studied the germination of *C. dactylon* in mine residues. They highlight that the germination of this species is affected by the presence of PTE and pH. These authors obtained a percentage of germination that ranged between 28 and 35 %, which dropped to 18 % at pH values lower than 7.

The growth of *C. dactylon* started becoming noticeable at 32 dap. In general, the incorporation of vermicompost had a positive effect on the growth of the grass (Figure 4). At 73 dap, with the high dose of vermicompost (V_a), the grass presented a difference in height of 4 cm in comparison to the treatment with a lowest dose (V_b), and a difference of 1 cm in height against V_m. The greatest development in *C. dactylon* was shown when using the highest dose (100 Mg ha^{-1}). This confirms, along with the dry matter production results (Table 1), that grasses were more productive in treatment V_a. The success of the growth of *C. dactylon* in the mine tailing was due to the vermicompost. This fertilizer acted as a source of nutrients, including organic nitrogen, which is gradually released and made available to plants once mineralized. This is supported by Ilahi *et al*. (2020), who explain how organic fertilizers, such as vermicompost, release this element and make it available to plants. The highest grass growth in this study was obtained with a high dose of vermicompost, which increased the availability of nutrients such as nitrogen (Santos *et al*., 2022).

In a study by García-Amador and Castillo-Delgado (2015), *C. dactylon* was planted in contaminated soil from islets in Cuemanco-Xochimilco, Mexico, which had 7.7 % organic matter at the beginning. The grass crop was irrigated by hand with distilled water, and 10 cm of growth was observed 10 weeks after planting (70 d), which is consistent with the results of this study at 73 dap. It is important to note that in this study, irrigation was carried out once a week until 30 dap, and the fertility of the mine tailing was significantly lower than that of the soil.

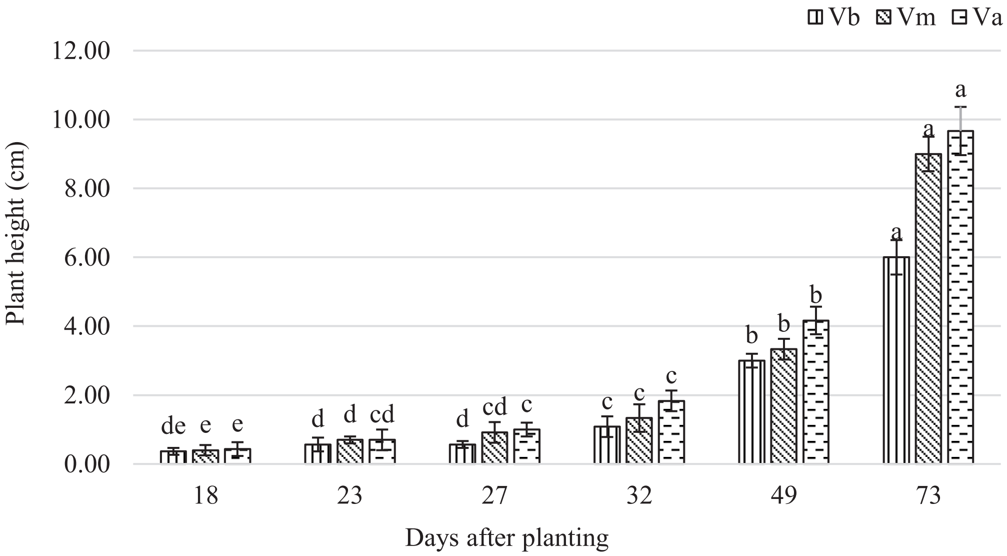

Figure 4. Average growth of *Cynodon dactylon* grass planted at the Dos Carlos mine tailing in Pachuca, Hidalgo, Mexico, under the effect of three vermicompost treatments. Means ± EE in subfigures with different letters show statistically significant differences (Tukey, $p \leq 0.05$). V_b: 60 Mg vermicompost ha^{-1}; V_m: 80 Mg vermicompost ha^{-1}; V_a: 100 Mg vermicompost ha^{-1}.

CONCLUSIONS

Cynodon dactylon grass in mine tailing demonstrated its ability to grow and develop when 100 Mg ha^{-1} of vermicompost was applied. The highest production of dry matter facilitated the concentration of PTE in plant tissues, both in the root and aerial. This ability confirms the use of grass in vegetative cover projects in mine tailings, with the goal of reducing particle dispersion and runoff, as well as mitigating contamination and respiratory diseases in populations near the mine tailings. This study helps to establish an effective and sustainable strategy to mitigate some of the environmental impacts caused by mine tailings.

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