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# Recovery of Degraded Soils with Municipal Organic Waste in the Peruvian Amazon

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The objective of the research was to apply compost based on municipal organic waste to recover degraded soils in the Peruvian Amazon. An area of 2500 m2 was considered, where five points were sampled and two calicata were obtained for each one. The depth of the calicata was 20 cm. and, subsequently, 1 kg of degraded soil was taken for physical, chemical and biological analysis. Four treatments were used (T1: Control, T2: MOW, 250 mg., T3: MOW, 500 mg and T4: MOW, 750 mg.) with 5 replications for each treatment with a total of 20 experimental units. The organic matter was composed of egg shell, orange, banana, stems, leaves and roots to be segregated and crushed until 12,000 kg. were obtained. Mountain microorganisms (MM) were added to obtain 3,000 kg., after which the chemical analysis was carried out. Maize (Zea mays. L) was used as an indicator plant, which germinated for 30 days to demonstrate the recovery of degraded soils and variability in agronomic parameters. Significant differences between treatments were measured with Duncan. It is concluded that there is a significant improvement in the recovery of degraded soils using MOW. Treatments 3 and 4 show significant relevance and differences with respect to macronutrients. Finally, in terms of morpho-physiological analysis, treatment 4 shows greater growth in stem, number, length and width of leaves. Therefore, the use of municipal organic waste could be an efficient and effective alternative for the recovery of contaminated soils.

## 1. Introduction

Globally, processes such as erosion and degradation of agricultural soils have affected extensions of crops, changing considerably the physical, chemical and biological composition. The lack of strategies for soil recovery, such as the indiscriminate use of fertilizers (Hengl et al., 2017), anthropogenic activities (Guo et al., 2019), poor management of domestic waste have caused an environmental problem (Nascimento et al., 2021).

Organic fertilizers generally have beneficial effects on fertility, structure, aeration, porosity, stability properties, permeability, hydraulic conductivity and water holding capacity of soils (Murray et al., 2011; Restrepo., 2013). In addition, they have a direct effect on soil sustainability, leading to a greater storage capacity and nutrient supply to the flora, increasing its nutritional status. This allows surface regeneration by providing nitrogen (N) (Lyriano et al., 2015), phosphorus (P), sulfur (S) (Abanto et al., 2019) and others such as copper (Cu) and boron (B) (Montoro et al., 2019; Asadu et al., 2020). Some studies have found among its components amino acids, hormones, acids (humic and fulvic), enzymes and chelators that help to slowly release nutrients, preventing them from being washed away by rain and erosion (FAO, 2015). The frequent use of organic fertilizers improves soil conditions and therefore increases crop productivity (Méndez et al., 2017).

The Peruvian Amazon has abundant water, which has a negative effect on agricultural movement, resulting in only 6% of soils being favorable for productive activity (Ganse et al., 2018), which is why fertilization and soil recovery are necessary (Sun et al., 2020). On the other hand, there is a problem regarding the total generation of municipal solid waste, in 2021 there were 205,598,415 tons. In terms of areas degraded by municipal solid waste, in 2021 it was 50,240 hectares (SINIA, 2021). Some studies support the use of municipal organic waste for soil recovery through dosing (Muñoz et al., 2015).

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It was found as a result that it improves soil chemical characteristics such as P, K and N (Jiang et al., 2016; Monzote et al., 2017). In addition, corn crop was used to measure the soil recovery process (Ogbazghi et al., 2019; Espejo et al., 2021).

## 2. Method

### 2.1. Measurements of the experimental area

The study was carried out in the Yanayacu municipal dump, San José de Sisa district, located in the San Martin region. A total area of 2500 m2 was considered as the study area, with a length of 50 m x 50 m. wide.

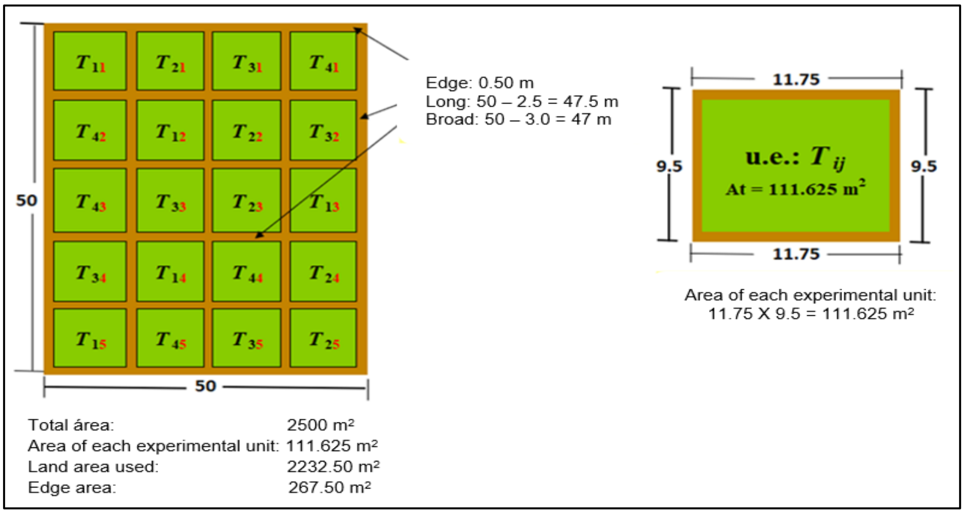


*Figure 1: Measurements of the experimental field and experimental units*

### 2.2. Sampling and collection of a degraded soil sample

For soil sampling, five points of the municipal dump were used. Calicatas (soil pits) of 20 cm depth were dug and 1 kg of soil was extracted from each sampling point. The sample was placed in a labeled container to be transported to the Community Services and Research Laboratory (LASACI, in Spanish) of the Universidad Nacional de Trujillo for physical, chemical and biological analysis.

*Table 1: Coordinates of the sampling points of the experimental site*

| Sampling | Latitude | Longitude | Elevation | Accuracy | Date | Time |
|---|---|---|---|---|---|---|
| 1 | -6.628675 | -76.637447 | 561.9±4 m | 1.4 m | 28.01.2022 | 11:52 am |
| 2 | -6.628749 | -76.637244 | 561.4±4 m | 1.5 m | 28.01.2022 | 12:05 pm |
| 3 | -6.628745 | -76.637152 | 558.5±4 m | 1.5 m | 28.01.2022 | 12:08 pm |
| 4 | -6.628852 | -76.637166 | 558.1±4 m | 1.5 m | 28.01.2022 | 12:19 pm |
| 5 | -6.628752 | -76.637459 | 557.5±4 m | 1.5 m | 28.01.2022 | 12:33 pm |

### 2.3. Preparation of compost from municipal organic waste

We proceeded to collect organic matter, which consisted of: eggshells, oranges, bananas, stems, leaves and roots. All of this was collected from the houses and taken to the collection point at 20 de Mayo in the District of San José de Sisa, to be segregated and crushed, obtaining 12,000 kg., to which mountain microorganisms were added. The mixture was carried out every three days in order to accelerate the decomposition process and obtain a final product of 3,000 kg. of organic fertilizer, of which one kg was taken for its respective physical-chemical analysis.

### 2.4. Experimental treatments of compost and indicator plant Zea mays L.

The treatments were arranged in a completely randomized design with a total of 4 treatments and 5 replications, with a total of 20 experimental units; control treatment (MOW: 000 mg), treatment 2 (MOW: 250 mg), treatment 3 (MOW: 500 mg) treatment 4 (MOW: 750 mg). In order to evaluate the effect of municipal organic waste compost on the recovery of degraded soils, corn (Zea mays) was used as an indicator plant, applying the treatments as organic fertilizer. The plant germinated and was left in the field for 30 days, after which morpho-physiological analyses were performed.

### 2.5. Data analysis method

For the study to assess the effect on the indicator plant, the DUNCAN analysis was applied, which determined the significant differences between the experimental treatments.

## 3. Results

Soil analysis was carried out using a control group to make comparisons with the treatments. P, N, K, Mg, Fe, Ca, Na, C/N, Mo, Zn increased their nutrient capacity for each chemical element according to their unit of measurement in treatments 3 and 4. With respect to the physical and chemical properties, a decrease in pH was observed with respect to treatment 4. Likewise, the cation exchange capacity, organic matter and electrical conductivity increased their values in treatment 4

*Table 2: Soil analysis before and after application of municipal organic wastes.*

| Nutrients | Treatments | | | |
|---|---|---|---|---|
| | T1 Control | T2 MOW: 250 mg | T3 MOW: 500mg | T4 MOW: 750mg |
| P (ppm) | 2.88 | 3.33 | 3.66 | 3.86 |
| N (%) | 0.05 | 0.14 | 0.48 | 0.8 |
| K (ppm) | 55.2 | 57.1 | 61.7 | 64.7 |
| Mg (cmol/kg) | 0.81 | 0.82 | 0.84 | 0.89 |
| Fe (ppm) | 6.1 | 6.4 | 6.9 | 7.5 |
| Ca (cmol/kg) | 17.1 | 17.5 | 17.9 | 18.5 |
| Na (cmol/kg) | 0.10 | 0.12 | 0.15 | 0.19 |
| C/N (%) | 11.74 | 12.02 | 12.85 | 13.54 |
| Mo (%) | 1.23 | 1.53 | 2.92 | 3.42 |
| Zn (ppm) | 2 | 2.02 | 2.08 | 2.24 |
| Physicochemical Properties | | | | |
| pH | 9.19 | 8.9 | 8.5 | 7.9 |
| Effective Cation Exchange Capacity CICEF (cmol/Kg) | 18.18 | 18.22 | 18.30 | 18.54 |
| Organic Matter (%) | 1.34 | 1.55 | 1.67 | 1.99 |
| Electrical conductivity (dS/m) | 0.2 | 0.3 | 0.4 | 0.9 |

*Table 3: Duncan's multiple comparison test to determine significant differences between treatments.*

| Duncans honestly significant difference α = 0.05 | | | |
|---|---|---|---|
| $T_i - T_j$ | $\left\lvert \bar{y}_{i\bullet} - \bar{y}_{j\bullet} \right\rvert$ | *w* | $\left\lvert \bar{y}_{i\bullet} - \bar{y}_{j\bullet} \right\rvert > HSD$ |
| Difference de T1 y T2 | 9.647 | 0.5496 | Significant |
| Difference de T2 y T3 | 11.598 | 0.5796 | Significant |
| Difference de T3 y T4 | 15.430 | 0.5496 | Significant |
| Difference de T1 y T3 | 14.245 | 0.5971 | Significant |
| Difference de T2 y T4 | 12.028 | 0.5671 | Significant |
| Difference de T1 y T4 | 18.675 | 0.7917 | Significant |

The table shows that there is a significant difference between treatments, so that treatments 3 and 4 are the ones that obtained the highest value in terms of nutrient levels. Likewise, a significant difference is observed between treatment 1, which was the control group, compared to treatment 4, which had a higher concentration of MOW 750 mg.

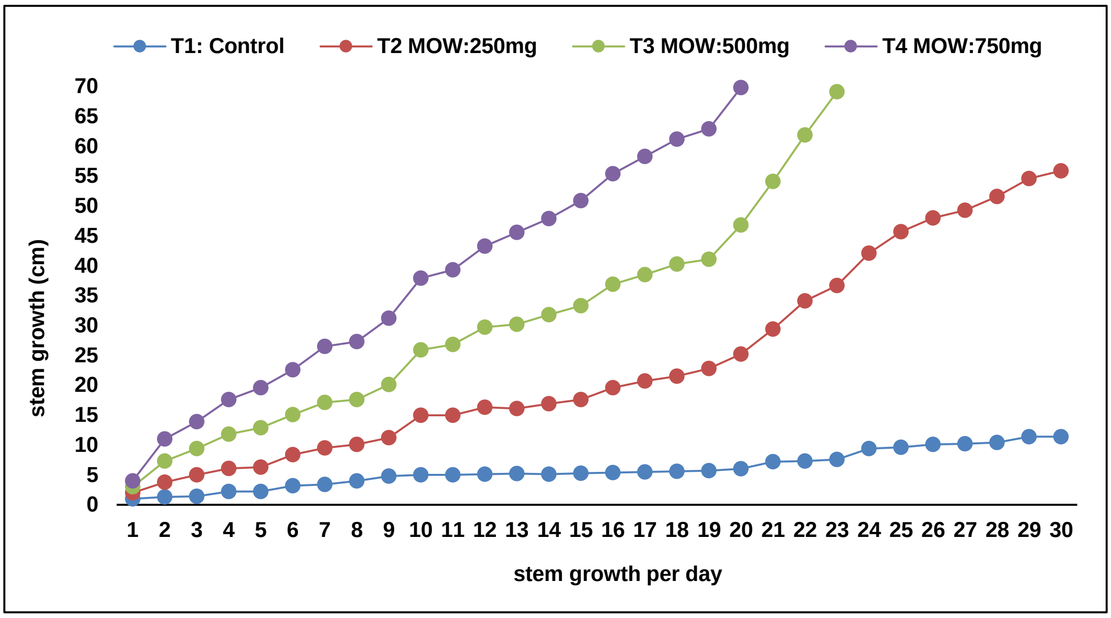


*Figure 2: Stem growth (cm) per day and according to treatment*

In treatment 1 (control), stem growth was relatively constant with a maximum value of 11.4 cm at 30 days of germination. In treatment 2 (MOW: 250 mg), there was greater stem growth from day 21, with a maximum value of 44.5 cm at 30 days of germination. In treatment 3 (MOW: 500 mg), there was greater stem growth from day 10, obtaining a maximum value of 51.4 cm at 30 days of germination. In treatment 4 (MOW: 750 mg), there was greater stem growth from day 8, obtaining a maximum value of 52.9 cm at 30 days of germination.

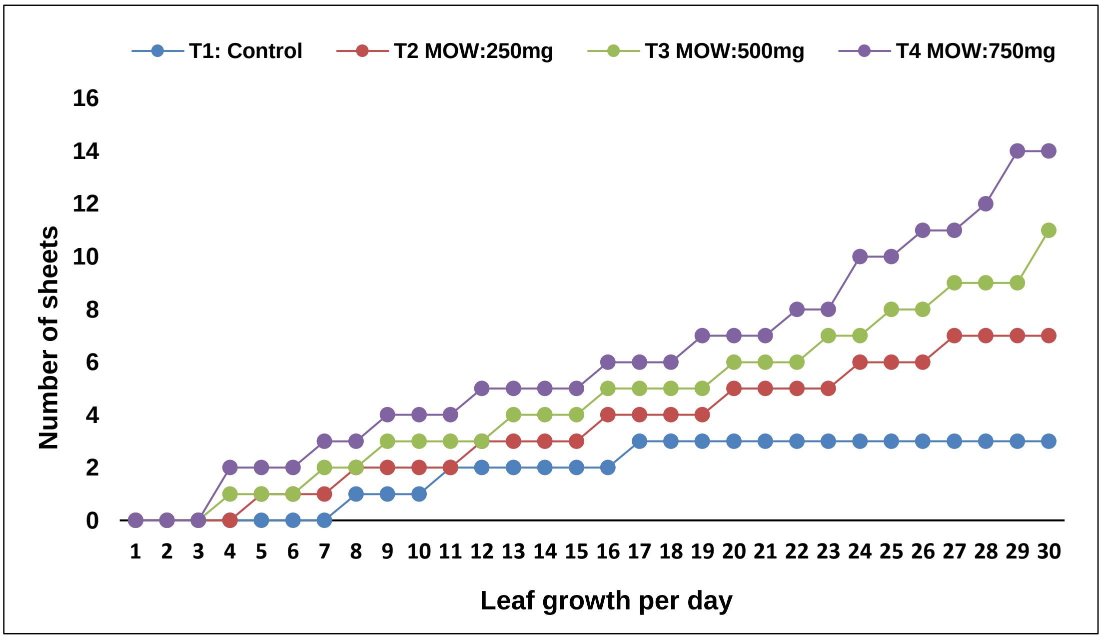


*Figure 3: Number of leaves per day and according to treatments*

In treatment 1 (control), the number of leaves was constant with a maximum value of 3 leaves at 30 days of germination. In treatment 2 (MOW: 250 mg), from day 12 there was a greater number of leaves, with a maximum value of 7 leaves at 30 days of germination. In treatment 3 (MOW: 500 mg), there were more leaves after day 13, obtaining a maximum of 11 leaves at 30 days of germination. In treatment 4 (MOW: 750 mg), there was a greater number of leaves from day 12, obtaining a maximum value of 14 leaves at 30 days of germination.

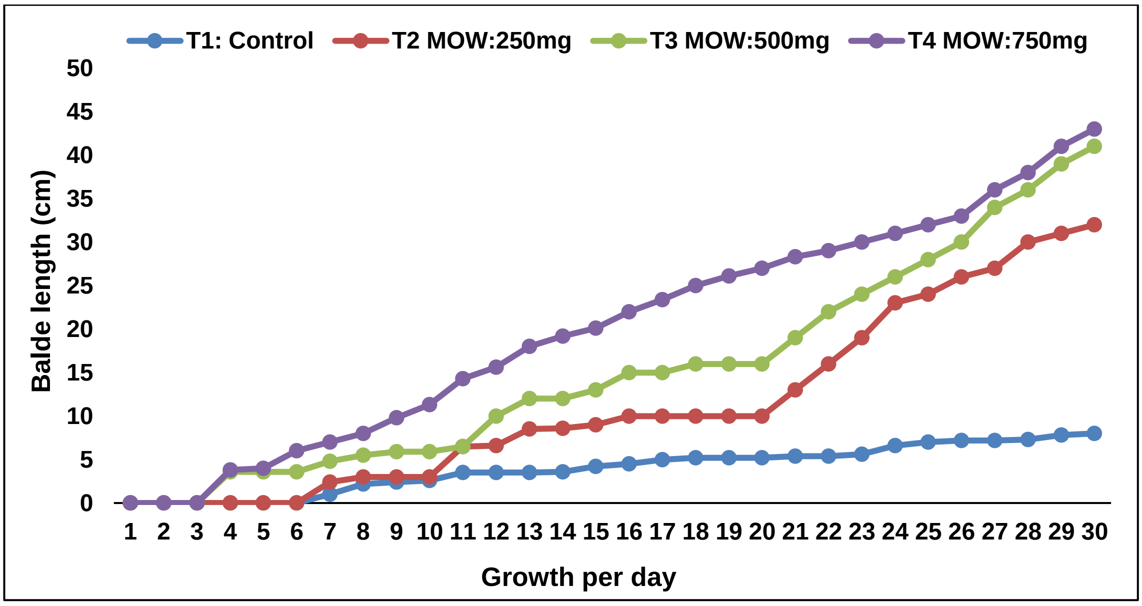


*Figure 4: Leaves length (cm) per day and according to treatments.*

In treatment 1 (control), leaf length was relatively constant with a maximum value of 8 cm at 30 days of germination. In treatment 2 (MOW: 250 mg), there was greater leaf length from day 11 onwards, with a maximum value of 32 cm at 30 days of germination. In treatment 3 (MOW: 500 mg), there was greater leaf length from day 11, obtaining a maximum value of 41 cm at 30 days of germination. In treatment 4 (MOW: 750 mg), there was greater leaf length from day 9, obtaining a maximum value of 43 cm at 30 days of germination.

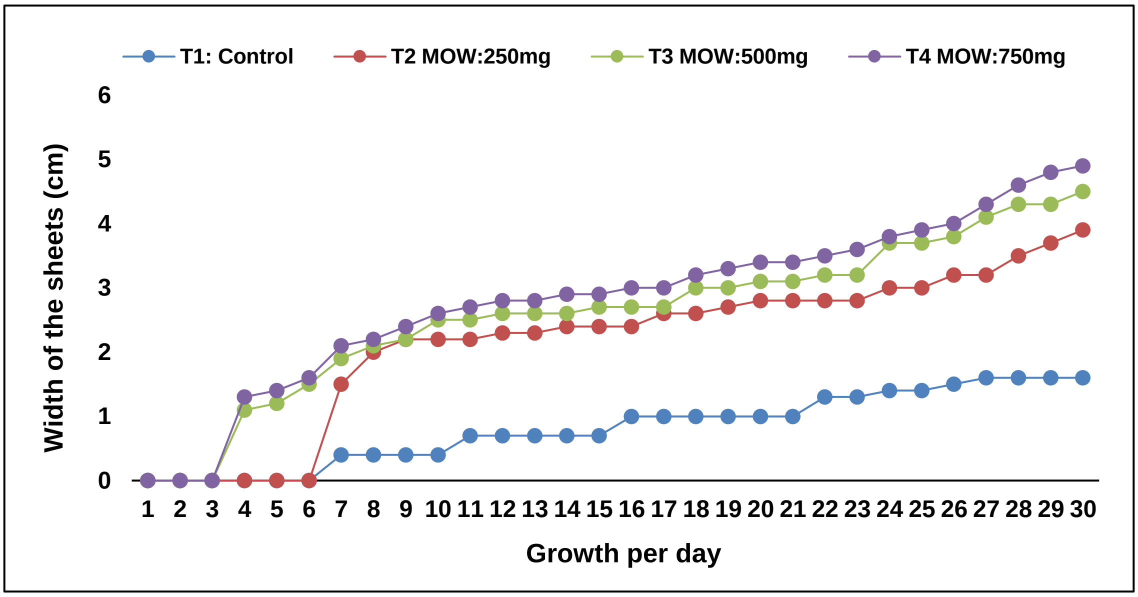


*Figure 5: Leaves width (cm) per day and according to treatments.*

In treatment 1 (control), leaf width is relatively constant with a maximum value of 1.6 cm at 30 days after germination. In treatment 2 (MOW: 250 mg), there was a greater leaf width from day 17, obtaining a maximum value of 3.9 cm at 30 days after germination. In treatment 3 (MOW: 500 mg), there was a greater leaf width from day 8, obtaining a maximum value of 4.5 cm at 30 days after germination. In treatment 4 (MOW: 750 mg), there was a greater leaf width from day 17, obtaining a maximum value of 4.9 cm at 30 days after germination.

## 4. Conclusions

The characterization of the degraded soil was carried out and then the experiment with the different treatments was applied. It was observed that the application of municipal organic waste (MOW) significantly improved the soil. The analysis of multiple comparisons shows significant differences between treatments, being the most efficient treatment 3 (MOW: 500 mg) and treatment 4 (MOW: 750 mg), improving considerably the nutritional values and physico-chemical properties. Morpho-physiological analyses were carried out on the maize plant, showing greater efficiency in treatment 4: (MOW: 750 mg), 52.9 cm stem growth, 14 leaves 30 days after germination, 43 cm leaf length and 4.9 cm leaf width. The use of municipal organic residues could be an environmental alternative to restore degraded soils due to intensive agriculture and the aggressive use of agrochemicals for agricultural crops, promoting a sustainable environment.

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