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Biofertilizer of Guinea Pig Manure for the Recovery of a Degraded Loam Soil

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Biofertilizers are important for the production of crops and conservation of environmental balance, and thus provide sustainable development. The objective of this research was to determine the recovery of the fertility of a degraded loam soil by applying a biofertilizer obtained from guinea pig manure. For this, 3 different doses of biofertilizer were applied: BF 0.1L (100ml of biofertilizer + 500ml H_2O distilled), BF 0.2L (200ml of biofertilizer + 500ml H_2O distilled) and BF 0.3L (300ml of biofertilizer + 500ml H_2O distilled).
The results showed that BF 0.3L dose was more effective and obtained better recovery values of Nitrogen (2%), Phosphorus (26.92 mg/kg) and Potassium (385.90 mg/kg). Its concluded that the biofertilizer is effective for the recovery of the fertility of a degraded loam soil and can be very used by farmers due to its easy elaboration and for being economically accessible.

1. Introduction

Nowadays, soils are fundamental for the generation of crops, but human activities have made the resource reach critical points. There is a considerable loss of productive soils and this leads to the excessive use of fertilizers, causing soil degradation and rising food prices. Soil degradation is due to land use conversion, excessive fertilizer application, overgrazing, climatic and topographic factors (Nascimento et al., 2021). The excessive use of chemical fertilizers is due to the action of boosting the yield of agricultural crops (Sun et al, 2019) because the soil has lost the capacity to retain water and nutrients (Guo et al, 2019) as a result of poor agricultural practices (Encima et al 2003, Ruiz et al 2016).
Most of the work related to the application of biofertilizers is focused mainly on the recovery of soil fertility for food crops (Asadu et al., 2020, Abanto et al., 2019; Montoro et al., 2019, Alfa et al., 2014). Biofertilizers can be made from residues and manure from different animals such as cows (Pazzini et al., 2018), hens (Sarasty et al., 2016), chickens (Holbeck et at., 2003; Adeli et al., 2016), fish guts (Ahuja et al., 2020).
Biofertilizers are inputs produced with one or several microorganisms, which provide or enhance the availability of nutrients when applied to crops (Grageda et al, 2012). Among biofertilizers we have those that are enriched with wood ash or rock dust that are left to ferment for a period of 30 to 60 days, and their soil recovery effects can be greater than 10 to 100,000 times (Restrepo, 2013). The use of these biofertilizers improves soil fertility and consequently sustains plant growth, thus improving crop yields (FAO, 2016).
The use of biofertilizers made from animal manure could be a viable solution for the recovery of the fertility of degraded soil due to the low cost of processing and easy application. It is also beneficial for the conservation of ecosystem services such as groundwater and forests that may exist in the study area. On the other hand, farmers are the main beneficiaries because these biofertilizers are easy to process (Muñoz et al., 2015; Adeli et al., 2016).Therefore, this research is based on the recovery of a degraded loam soil and its main objective was to improve fertility by applying the biofertilizer obtained from guinea pig manure.
This biofertilizer would have great production and application potential in the different rural areas of South America where guinea pigs are raised for human consumption. In these areas, the population lives from animal husbandry and different crop products, where the use of guinea pig manure as a biofertilizer would be of great importance to improve soil fertility, and consequently improve crop productivity.

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2. Materials and methods

2.1 Soil sampling and characterization

The samples were taken from a degraded soil located in the city of Piura, Peru. For this, an area of 12m^2 was considered using the verification sampling technique (MINAM, 2014). At each point a 30 cm deep pit was made and approximately 4kg of loam soil were taken for each sampling point. For the characterization of the soil samples both before and after the treatment, tests were carried out in the laboratory to determine the pH (pH-meter), organic matter (Walkley and Black), electrical conductivity (electrical conductivity meter), Nitrogen (micro-Kjeldhal method), Phosphorus (Olsen method) and Potassium (extraction method with ammonium acetate).

2.2 Elaboration of the biofertilizer

The guinea pig manure was obtained from a guinea pig farm located in Lima, Peru. For the preparation of the biofertilizer, 5 kg of guinea pig manure, 40L of non-chlorinated water, 1L of milk, 1L of molasses, 100g of rock dust, 100g of wood dust, 250g of yeast, 100g of leguminous plants and 200g of coagulated cattle blood were used (see Figure 1). Afterwards, all the components were mixed and homogenized in an airtight 50L container. The container was conditioned for the release of the gases produced by the anaerobic fermentation for 20 days.

Figure 1: Biofertilizer inputs: a) guinea pig manure, b) non-chlorinated water, c) milk, d) molasses, e) rock dust, f) wood dust, g) yeast, h) leguminous plants and i) coagulated cattle blood

2.3 Application of the biofertilizer

For the application of the biofertilizer (BF), 4 pots were placed, one for control and the other 3 for the different doses of biofertilizer; among them: BF 0.1L (100ml of biofertilizer + 500ml $H_2O_{distilled}$) BF 0.2L (200ml of biofertilizer + 500ml $H_2O_{distilled}$) and BF 0.3L (300ml of biofertilizer + 500ml $H_2O_{distilled}$). After installing the pots, the biofertilizer was applied by means of a foliar irrigation. Figure 2 shows the biofertilizer application diagram in the soil samples.

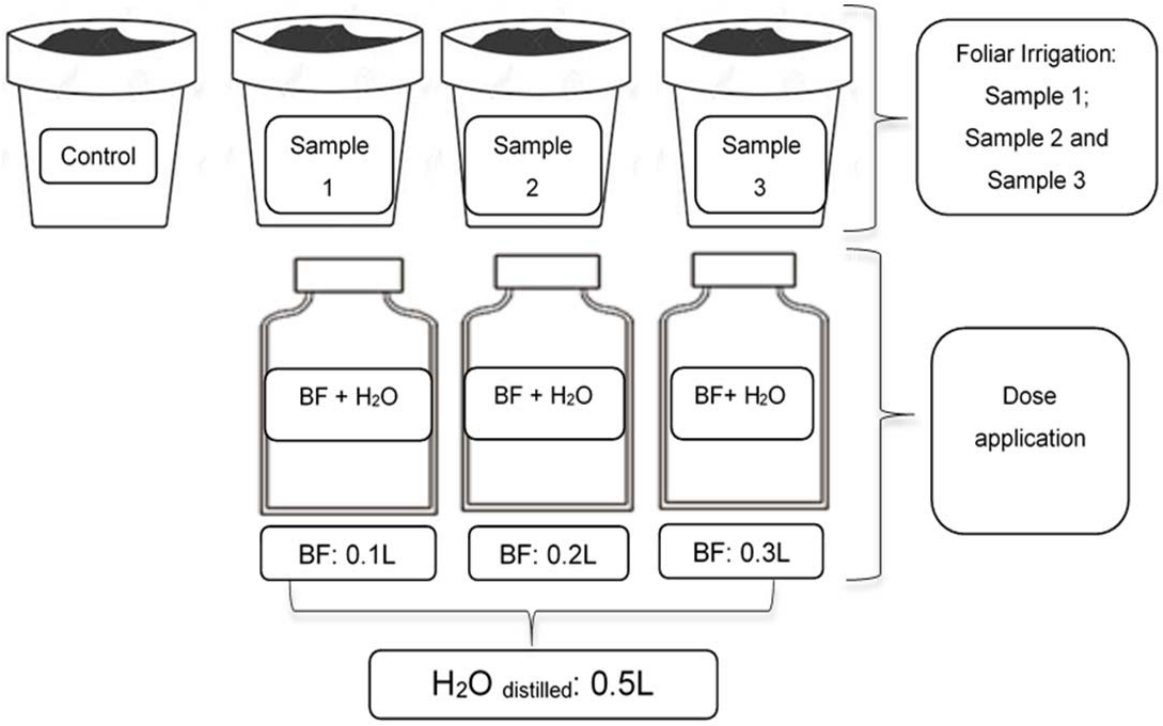

Figure 2: Biofertilizer application diagram

3. Results and discussion

3.1 Physical-chemical parameters of the soil

Table 1 shows the results of the physical-chemical parameters of the loam soils both before and after the application of the biofertilizer. Before the application, the soils were at a high level of degradation due to the indiscriminate use of chemical fertilizers.

Table 1: Physical-chemical parameters of the soil before and after the application of the biofertilizer

Treatment	pH	Electrical conductivity (dS/cm)	Organic matter (%)
Control	6.72	0.47	0.76
BF 0.1L (100ml de biofertilizer + 500 ml $H_2O_{distilled}$)	6.03	3.60	2.18
BF 0.2L (200ml de biofertilizer + 500 ml $H_2O_{distilled}$)	6.14	3.30	2.37
BF 0.3L (300ml de biofertilizer + 500 ml $H_2O_{distilled}$)	6.16	4.90	2.47

From Table 1 it was observed that the pH remains almost constant for the three dosages used because the mixtures were similar (Good, 2013). In addition, it was observed that the electrical conductivity increases slightly due to the presence of mineral salts that are dissolved in the biofertilizer (Molina, 2011). On the other hand, organic matter also had a slight increase due to the various nutrients (N, P, K, Ca, Mg and Fe) contained in the biofertilizer (Gliessman, 2006).
Other authors such as Ramirez et al. (2015) and Vazquez et al. (2020) applied organic fertilizers from cow manure and amendments for the recovery of the physicochemical properties of a degraded soil and consequently its fertility, obtaining pH values of 5.8 and 8.35, and organic matter of 3.21% and 1.30%, respectively. Similarly, Muñoz et al. (2015) developed an organic fertilizer from chicken manure that allowed to recover the quality of the soil, with pH values of 6.15 and organic matter of 11%. Dávila (2018), Saldaña et al. (2018) and Avelino (2018) also obtained favorable results in the recovery of degraded soils using *Pteridium aquilinum* species, fish entrails fertilizer and fertilizer from guinea pig manure, respectively.

3.2 Soil nutrients

The soil was degraded due to the excessive loss of nutrients that hindered the growth of plant species. Given this, the application of the biofertilizer of guinea pig manure improved the nutrient (Nitrogen-N, Phosphorus-P and Potassium-K) content, as shown in Table 2.

Table 2: Soil nutrients before and after biofertilizer application

Treatment	Nitrogen (%)	Phosphorus (mg/kg)	Potassium (mg/kg)
Control	0.5	5.9	45
BF 0.1L (100ml de biofertilizer + 500 ml $H_2O_{distilled}$)	1.40	25.22	339.80
BF 0.2L (200ml de biofertilizer + 500 ml $H_2O_{distilled}$)	1.65	25.78	364.60
BF 0.3L (300ml de biofertilizer + 500 ml $H_2O_{distilled}$)	2.00	26.92	385.90

In Table 2, an increase in the percentage of nitrogen was observed since the biofertilizer has traces of legumes in its composition, which are natural fixers of the nitrogen found in the environment (Restrepo, 2007). In addition, the phosphorus content remains almost constant for the three doses of biofertilizer applied due to the low presence of microorganisms in the soil such as *Bacillus subtilis*, *Micrococcus*, since these are responsible for separating the phosphorus from the organic substrates (Soria, 2009). On the other hand, potassium increased considerably due to cation exchange and meteorization (Cabrera, 2016)
Alfa et al. (2014) developed an organic fertilizer made from cow and chicken manure to improve the fertility of degraded soils, and it contained 2.36% nitrogen. In the research by Saldaña et al. (2018) used a fertilizer made from fish viscera obtaining values of Nitrogen (0.86%), phosphorus (80.51 ppm) and potassium (1639 ppm). Davila (2018) and Avelino (2018) also obtained favorable results in the recovery of soil nutrients using the *Pteridium aquilinum* species and biofertilizer from guinea pig manure, respectively.
With the above mentioned, the results indicated that guinea pig manure as a biofertilizer is beneficial for the recovery of soil fertility and consequently improves food production. In addition, this raw material (guinea pig manure) has similar and even superior properties to the manure of other animals that are used as biofertilizers. Therefore, this product (biofertilizer) is of great importance for farmers due to its easy processing and low production cost.

4. Conclusions

The biofertilizer obtained from the guinea pig manure was efficient for the recovery of a loam soil, positively influencing fertility and is also beneficial to the farmers due to its easy processing and low cost. With the treatment of BF 0.3L (300ml de biofertilizer + 500 ml $H_2O_{distilled}$), the soil nutrients such as nitrogen, phosphorus and potassium improved from 0.5 to 2%, 5.9 to 26.92 mg/kg and 45 to 385.90 mg/kg,

respectively. In addition, the values of physical-chemical properties such as pH, electrical conductivity and organic matter were also favorable and acceptable.

This biofertilizer has similar properties to biofertilizers made from the manure of other animals, and it is advisable to carry out more research focused mainly on the doses of the inputs to demonstrate their feasibility of elaboration and efficiency in improving soil fertility.

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