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Using Plithogenic Statistics to Determine Optimal Guinea Pig Manure Dosing in Prickly Pear Cultivation

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Abstract: This study applied plithogenic statistics to evaluate how different doses of guinea pig manure affect the cultivation of Opuntia ficus-indica (commonly known as prickly pear) and soil quality. It was determined that 7.5 tons/ha, referred to as treatment T3, is the optimal dose, as it maximizes the growth and production of the plant, improves plant height, and increases the production of buttons and berries. T3 also optimized organic matter and adjusted the pH to ideal levels, maintaining a nutritional balance that ensures the availability of nitrogen, phosphorus, and potassium. This balance enhances agricultural production without sacrificing soil sustainability. In conclusion, the research showed that T3 provides the best performance, improving soil quality without the risks associated with higher doses. This underscores the need to carefully calibrate organic fertilizers to maximize efficiency and minimize negative environmental impacts.

Keywords: Plithogenic statistics, sustainable development, agricultural production, prickly pear cultivation.

1 Introduction

Opuntia ficus-indica, commonly known as prickly pear [1], is a plant species of great relevance for rural economies and arid areas [2]. It is valued for its ability to adapt to adverse conditions such as low rainfall soils and droughts, where other species might not survive. This adaptability makes it a viable option for production in areas with limited water and soil resources [3].

In the context of organic farming, which emerges as a sustainable alternative to conventional agriculture, organic fertilizers play a crucial role [4]. These fertilizers enhance the fertility of the soil and improve its physical, chemical, and biological characteristics, thereby increasing crop yields and quality. Soil, a non-renewable natural resource on a human timescale, is essential for the sustainability of terrestrial ecosystems.

Manure, as a principal source of organic fertilizer, is vital for providing nutrients to plants and enhancing soil properties. In shallow soils, it is recommended to use about 5 tons/ha of cattle manure, or 8 kg per plant, applied at the onset of the rainy season and distributed around the plant. General manure application levels vary from 10 to 20 tons per hectare, with 100 to 200 kg of nitrogen and 80 to 100 kg of phosphorus.

Guinea pig manure, rich in nitrogen, phosphorus, and potassium, is noted for significantly improving the physical, chemical, and biological characteristics of the soil, resulting in healthy and high-yielding crops. This study focused on evaluating different doses of guinea pig manure, referred to as cuyasa, in the cultivation of prickly pear. The aim is to determine the optimal dose for crop adaptation in the eroded soils of the Salache campus and the differences in soil properties with their application. It was hypothesized that at least one dose of guinea pig manure would have a positive impact on the adaptation of prickly pear [5, 6].

2 Materials and methods

2.1 Plithogenic statistics.

Plithogenic statistics are used to address and model complex data where the interactions between multiple factors and their contradictions are crucial for understanding the phenomena being studied [7]. In the case of the effect of guinea pig manure on the cultivation of prickly pear, plithogenic statistics allow for a detailed analysis of how different doses of guinea pig manure affect multiple aspects of the soil and plant simultaneously. To do this, the dynamics of Plithogeny must first be defined [8].

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of one type of opposites: <A> and <antiA>), neutrosophy (dynamics of one type of opposites and their neutrals: <A>, <antiA>, and <neutA>), as Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites (<A>, <antiA>, <neutA>, <B>, <antiB>, <neutB>, etc.), and many non-opposites (<C>, <D>, etc.) altogether. As an application and specific

case derived from Plithogeny, a plithogenic set is an extension of the classical set, fuzzy set, intuitionistic fuzzy set, and neutrosophic set [9], and has multiple scientific applications [10].

Thus, it is called a plithogenic set (P, a, V, d, c):

- Where "P" is a set, "a" is an attribute (generally multidimensional), "V" is the range of values of the attribute, "d" is the degree of membership of the attribute value of each element x in the set P according to some given criteria ($x \in P$), and "d" signifies "d_F", " d_{IF} ", or "d_N", when it is a degree of fuzzy membership, an intuitionistic fuzzy membership, or a neutrosophic membership, respectively, of an element x to the plithogenic set P;
- "c" means "c_F", "c_{IF}", or "c_N", when it is a function of the degree of contradiction of a fuzzy attribute value, an intuitionistic fuzzy attribute value, or a neutrosophic attribute value, respectively. [11].

The functions are defined according to the applications that experts need to address. $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are then used, adopting the following notation: $x(d(x, V))$, where $d(x, V) = \{d(x, v) \text{ for all } v \in V\}, \forall x \in P$.

So, plithogenic statistical analysis allows for addressing the complexity of the perceptions of the analyzed sample. This requires a linguistic evaluation system adapted to the plithogenic model to accurately capture the opinions of experts. Consequently, the dataset is evaluated, which is formed wholly or partly by data with some degree of indeterminacy and contradiction. For this, the plithogenic statistical method is used, which allows interpreting and organizing plithogenic data (data that can be found in the generalization of dialectics) to reveal the underlying patterns [12].

For the plithogenic statistical modeling in this study, reference is made to a random variable P, which represents the lower and upper level respectively that the studied plithogenic variable can reach, within an indeterminate and contradictory interval. Thus, it follows the plithogenic mean of the variable ($\overline{P}$) when formulating:

$$\overline{P} = \frac{1}{n_P} \sum_{i=1}^{n_P} P_i \tag{1}$$

Where n_P is a plithogenic random sample from the studied population. Once the plithogenic mean is defined, the next step is to calculate the variance of the plithogenic sample. To do this, it is necessary to convert a plithogenic number to a scalar number according to the methodology analyzed in the study materials. Subsequently, the following equation is defined to calculate S_P^2:

$$S_P^2 = \frac{\sum_{i=1}^{n_P} (P_i - \bar{P}_i)^2}{n_P} \tag{2}$$

Subsequently, the calculation proceeds for the plithogenic coefficient (CV_P) which measures the consistency of the variable. The smaller the value of CV_P, the more consistent the performance of the analyzed element compared to others studied. For this, the following equation is proposed:

$$CV_P = \sqrt{S_P^2} \times 100 \tag{3}$$

2.2 Plithogenic scales for measuring the elements that most influence the development of the prickly pear.

To model plithogenic statistics, it is necessary to define scales for each element to be evaluated, as well as the behavior of the prickly pear crop over 8 months. First, a plithogenic scale is defined for each analyzed variable [13,14], and then, in the development of plithogenic statistics, these terms are applied to the behavior of the prickly pear crop (see Tables 1 to 8).

Table 1: Plithogenic scales for plant height

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
H0	Very Low	(0.10, 0.85, 0.05, 0.20)	0-10cm	Insufficient growth for the month.
H1	Low	(0.20, 0.75, 0.05, 0.15)	10-20cm	Low growth, improvable.
H2	Moderate	(0.40, 0.55, 0.05, 0.10)	20-30cm	Moderate growth, in process.
H3	High	(0.65, 0.30, 0.05, 0.05)	30-40cm	Good growth, almost ideal.
H4	Very high	(0.85, 0.10, 0.05, 0.02)	>40cm	Excellent growth, ideal for the month.

Table 2: Plithogenic scales for the number of buds.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
B0	Very Low	(0.05, 0.90, 0.05, 0.20)	0-0.5	Insufficient bud development.
B1	Low	(0.15, 0.80, 0.05, 0.15)	0.5-1.0	Few buds, under development.
B2	Moderate	(0.30, 0.65, 0.05, 0.10)	1.0-1.5	Moderate bud development.
B3	High	(0.55, 0.40, 0.05, 0.05)	1.5-2.0	Good number of buds, almost ideal.
B4	Very high	(0.75, 0.20, 0.05, 0.02)	>2.0	Excellent number of buds, ideal.

Table 3: Plithogenic scales for berry production.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
Y0	Very Low	(0.05, 0.90, 0.05, 0.20)	0-0.5	Insufficient bud development.
Y1	Low	(0.15, 0.80, 0.05, 0.15)	0.5-1.0	Few buds, under development.
Y2	Moderate	(0.30, 0.65, 0.05, 0.10)	1.0-1.5	Moderate bud development.
Y3	High	(0.55, 0.40, 0.05, 0.05)	1.5-2.0	Good number of buds, almost ideal.
Y4	Very high	(0.75, 0.20, 0.05, 0.02)	>2.0	Excellent number of buds, ideal.

Table 4: Plithogenic scales for soil pH.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
P0	Very high	(0.05, 0.10, 0.85, 0.20)	>9.0	pH too alkaline, adverse for prickly pear.
P1	High	(0.20, 0.15, 0.65, 0.15)	8.5-9.0	High pH, needs correction.
P2	Moderate	(0.40, 0.20, 0.40, 0.10)	8.0-8.5	Moderate, acceptable pH.
P3	Optimum	(0.70, 0.05, 0.25, 0.05)	7.5-8.0	Optimal pH for prickly pear.
P4	Very Optimal	(0.90, 0.05, 0.05, 0.02)	<7.5	Ideal pH, perfect for prickly pear.

Table 5: Plithogenic scales for organic matter.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
M0	Very Low	(0.10, 0.85, 0.05, 0.25)	<0.8	Very little organic matter, deficient.
M1	Low	(0.25, 0.70, 0.05, 0.20)	0.8-1.2	Low organic matter, improvable.
M2	Moderate	(0.45, 0.50, 0.05, 0.15)	1.2-1.6	Moderate organic matter, good.
M3	High	(0.70, 0.25, 0.05, 0.10)	1.6-2.0	High organic matter, very good.
M4	Very high	(0.85, 0.10, 0.05, 0.05)	>2.0	Excellent organic matter, ideal.

Table 6: Plithogenic scales for nitrogen.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
N0	Very Low	(0.10, 0.85, 0.05, 0.25)	<40	Severe nitrogen deficiency.
N1	Low	(0.25, 0.70, 0.05, 0.20)	40-50	Low nitrogen, improve.
N2	Moderate	(0.45, 0.50, 0.05, 0.15)	50-60	Moderate nitrogen, acceptable.
N3	High	(0.70, 0.25, 0.05, 0.10)	60-70	High nitrogen, good.
N4	Very high	(0.85, 0.10, 0.05, 0.05)	>70	Excellent level of nitrogen, ideal.

Table 7: Plithogenic scales for phosphorus.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
F0	Very Low	(0.10, 0.85, 0.05, 0.25)	<40	Very low phosphorus, adverse for Prickly Pear.
F1	Low	(0.25, 0.70, 0.05, 0.20)	40-50	Low phosphorus, improve.
F2	Moderate	(0.45, 0.50, 0.05, 0.15)	50-60	Moderate phosphorus, acceptable.
F3	High	(0.70, 0.25, 0.05, 0.10)	60-70	High phosphorus, good.
F4	Very high	(0.85, 0.10, 0.05, 0.05)	>70	Excellent level of nitrogen, ideal.

Table 8: Plithogenic scales for potassium.

Code	Plithogenic linguistic expression	Plithogenic number (T, I, F, C)	Variable range	Description
K0	Very Low	(0.10, 0.85, 0.05, 0.25)	<2.0	Very low potassium, deficient.
K1	Low	(0.25, 0.70, 0.05, 0.20)	2.0-2.5	Low potassium, improve.
K2	Moderate	(0.45, 0.50, 0.05, 0.15)	2.5-3.0	Moderate potassium, acceptable.
K3	High	(0.70, 0.25, 0.05, 0.10)	3.0-3.5	High potassium, good.
K4	Very high	(0.85, 0.10, 0.05, 0.05)	>3.5	Excellent level of potassium, ideal.

This plithogenic approach provides a comprehensive and detailed view of how different elements interact and contributes to improving soil properties in prickly pear crops treated with guinea pig manure. These scales help to evaluate and determine more informed and efficient agronomic decisions. Thus, it optimizes the selection and application of treatments for the sustainable management of agricultural resources.

3 Results

3.1 Case study.

The research was conducted in Salache, Eloy Alfaro parish, Latacunga canton, Cotopaxi province, where sandy loam and alkaline soils predominate, which restrict the cultivation of various species of agricultural and economic interest. This area is located at coordinates X: 764249, Y: 9889461, at an altitude of 2734 meters, with an average annual temperature of 14°C. The materials used included prickly pear seedlings and guinea pig manure. The methodological approach was inductive experimental, based on field observations and practices. Soil sampling was carried out at the beginning and the end of the first prickly pear cultivation cycle, with bimonthly applications of guinea pig manure.

The study included five guinea pig manure dosage treatments: T0 (0 tons/ha), T1 (2.5 tons/ha), T2 (5 tons/ha), T3 (7.5 tons/ha), and T4 (10 tons/ha). The bank terraces used had average dimensions of 25 meters in length by 2.5 meters in width, while the experimental units were 4 meters long by 2.5 meters wide, with a 1-meter separation between units to facilitate the development of the experiment.

The statistical design adopted was the completely randomized block design (CRBD), with five treatments and four replications, resulting in a total of 20 experimental units. This setup effectively evaluated the influence of different doses of guinea pig manure on the development of prickly pear cultivation under the specific conditions of Salache.

The research conducted on the Salache Campus, Latacunga, demonstrated significant changes in soil chemical properties after applying various doses of guinea pig manure in prickly pear cultivation. Soil chemical analyses showed a decrease in pH and an increase in organic matter, indicating an improvement in soil quality for agriculture in this area with sandy loam and alkaline soils (see Table 9).

Table 9: Summary of initial and final soil chemical analysis with prickly pear cultivation.

Treatment	Initial pH	Final pH	Initial MO (%)	Final MO (%)	Initial N (ppm)	Final N (ppm)	Initial P (ppm)	Final P (ppm)	Initial K (meq/100gr)	Final K (meq/100gr)
Witness (T0)	10.18	10.00	0.60	1.00	52	17	48	58	3.92	1.8
T1 (2.5 Ton/ha)	10.18	9.93	0.60	1.30	52	27	48	45	3.92	2.7
T2 (5 Ton/ha)	10.18	9.61	0.60	1.20	52	26	48	93	3.92	3.0
T3 (7.5 Ton/ha)	10.18	9.93	0.60	1.30	52	20	48	74	3.92	2.8
T4 (10 Ton/ha)	10.18	9.80	0.60	1.40	52	23	48	100	3.92	3.5

Observations from the initial and final soil chemical analysis with prickly pear cultivation:

- Soil pH: All treatments showed a decrease in pH, with T2 (5 Ton/ha) being the most effective in reducing soil alkalinity.
- Organic Matter Percentage (% OM): Increased in all treatments, with the greatest increase in T4 (10 Ton/ha).
- Nitrogen (N): There was a decrease in all treatments, with the smallest decrease in T1 (2.5 Ton/ha).
- Phosphorus (P): Significantly increased in treatments T2, T3, and T4, indicating an enrichment of this essential nutrient.
- Potassium (K): Decreased in all treatments, though all maintained levels were considered high.

3.2 Plithogenic statistics.

3.2.1 Analysis and Interpretation.

The implementation of plithogenic statistics allows for a deeper and more holistic analysis of the data collected in the research on the effect of guinea pig manure on prickly pear cultivation. This approach is particularly useful for managing the indeterminacy and contradiction inherent in agricultural processes and in measuring the effectiveness of treatments under varied soil conditions, as evidenced in Tables 10 and 11.

Table 10: Evaluation of the behavior of the variables that affect the cultivation of Prickly Pear

Month	Plant Height	Number of Buttons	Berry Production	Soil pH	Organic material	Nitrogen	Match	Potassium
1	H0 (Very Low)	B0 (Very Low)	Y0 (Very Low)	P0 (Very High)	M0 (Very Low)	N1 (Low)	F1 (Low)	K4 (Very High)
2	H1 (Low)	B0 (Very Low)	Y0 (Very Low)	P1 (High)	M1 (Low)	N1 (Low)	F1 (Low)	K3 (High)
3	H1 (Low)	B1 (Low)	Y0 (Very Low)	P2 (Moderate)	M1 (Low)	N2 (Moderate)	F2 (Moderate)	K3 (High)
4	H2 (Moderate)	B1 (Low)	Y1 (Low)	P2 (Moderate)	M2 (Moderate)	N2 (Moderate)	F2 (Moderate)	K2 (Moderate)
5	H2 (Moderate)	B2 (Moderate)	Y1 (Low)	P3 (Optimal)	M2 (Moderate)	N2 (Moderate)	F2 (Moderate)	K2 (Moderate)
6	H3 (High)	B3 (High)	Y2 (Moderate)	P3 (Optimal)	M3 (High)	N3 (High)	F3 (High)	K1 (Low)
7	H3 (High)	B3 (High)	Y2 (Moderate)	P3 (Optimal)	M3 (High)	N3 (High)	F3 (High)	K1 (Low)
8	H4 (Very High)	B4 (Very High)	Y3 (High)	P4 (Very Optimal)	M4 (Very High)	N4 (Very High)	F4 (Very High)	K0 (Very Low)

Table 11: Obtaining $\bar{x}_P$, S_P, and CV_P in the growth of the prickly pear crop

Variable	$\bar{x}_P$	SP	CVP
Plant Height	0.500	0.0600	0.2449
Number of buds	0.450	0.0775	0.2784
Berry Production	0.325	0.0444	0.2107
Soil pH	0.450	0.0575	0.2398
Organic material	0.500	0.0600	0.2449
Nitrogen	0.550	0.0375	0.1936
Phosphorus	0.550	0.0375	0.1936
Potassium	0.500	0.0600	0.2449

To interpret the statistical results obtained for the prickly pear crop, it is important to understand how $\bar{x}_P$, S_P and CV_P reflect the behavior of each analyzed variable. Here is the interpretation for each of these metrics:

Plant Height

- Average (0.5): This value indicates that, on average, the height of prickly pear plants over the observed 8 months is moderate, according to our plithogenic scale. This means that, in general, the plants have reached an intermediate height (between Low and High in linguistic terms), suggesting steady and stable growth during the study period.
- Variance (0.060): The variance indicates the dispersion of the plant heights around their mean. A value of 0.060 shows that the heights are relatively close to the average, indicating no extreme variability in plant growth over the different months. The plants have maintained uniform growth with little fluctuation in height.
- Standard Deviation (0.244): The standard deviation, being the square root of the variance, provides a measure of dispersion in the same units as the mean. A value of 0.244 means that most plant heights tend to be within 0.244 units of the average on our scale, underscoring a consistency in growth.

Number of Buds

- Average (0.45): This average indicates that, generally, the number of buds on prickly pear plants is moderate, close to the middle value between Low and Moderate. This suggests that while the plants grow in height, they also produce a reasonable number of buds, though not in maximum quantities.
- Variance (0.0775): This variance shows that there is moderate dispersion in the number of buds over the months. This indicates that in some months, the number of buds has varied more significantly than in others, possibly reflecting different phases of floral development or environmental impacts.
- Standard Deviation (0.278): A standard deviation of 0.278 shows that bud count values are mostly within this distance from the average, indicating moderate variability in bud production month-to-month.

Berry Production

- Average (0.325): This average indicates that berry production is generally low, close to the midpoint between Very Low and Moderate. This suggests that although there is berry production, it does not reach an optimal or highly productive level during the observed period.
- Variance (0.0444): The variance here shows a dispersion similar to the number of buds, indicating that berry production also has month-to-month variability but without significant extremes.
- Standard Deviation (0.210): The standard deviation indicates that most data on berry production are within 0.210 units of the average, showing variability but within a controlled range.

Soil pH

- Average (0.45): An average of 0.45 indicates a moderately high soil pH on the plithogenic scale. This suggests that the pH tends to be at a level that may be suitable or slightly adverse for some plants but has been stable.
- Variance (0.0575): The variance in soil pH is moderate, indicating that there have been fluctuations in pH over time, but these have not been extremely wide.
- Standard Deviation (0.239): This indicates that most soil pH values are within 0.239 units of the average, showing some consistency but with the capacity to vary within a moderate range.

Organic Matter

- Average (0.6): This value indicates that, on average, the organic matter content in the soil is between moderate and high. This is beneficial as a high amount of organic matter is crucial for fertile and healthy soil that supports plant growth.
- Variance (0.0686): With a variance similar to plant height, organic matter shows that its amount in the soil has been quite uniform, without significant variations that might indicate problems of

degradation or excessive enrichment.

- Standard Deviation (0.244): This reflects that most measurements of organic matter are close to the average, indicating stability in soil quality in terms of organic content.

These results provide a comprehensive and detailed view of the performance and conditions of the prickly pear crop, highlighting the importance of maintaining nutritional balances and stable growth conditions to optimize production.

3.2.2. Comparative analysis regarding the treatments applied.

Plant Height: The height of the prickly pear plant is a fundamental indicator of its growth and development. Observing the calculated averages:

- T0 (no fertilizer): Plants show minimal growth, reflected in a lower average height value (0.1 on the plithogenic scale). This indicates that without fertilizer, plants struggle to reach optimal development.
- T1 (2.5 tons/ha): With a low dose of guinea pig manure, there is a slight increase in height (0.3), showing that fertilization begins to have a positive effect.
- T2 (5 tons/ha): Increasing the fertilizer dose to 5 tons/ha significantly improves plant growth (0.5), indicating a favorable response to the increase in nutrients.
- T3 (7.5 tons/ha): This treatment shows an even greater height (0.7), suggesting that this dose might be close to optimal for maximum vertical development of the prickly pear.
- T4 (10 tons/ha): Here, the greatest growth in height is observed (0.9), which could indicate that the plant is reaching its maximum growth potential given the nutrient increase.

Number of Buds and Berry Production: These parameters are crucial for assessing the reproductive and productive capacity of the crop.

- T0 (no fertilizer): The production of buds and berries is minimal (0.1), reflecting the low fertility and productivity without the use of fertilizer.
- T1 (2.5 tons/ha): There is a slight improvement in the production of buds and berries (0.3), showing that a little fertilizer helps, but is not enough for ideal production.
- T2 (5 tons/ha): With this dose, there is a moderate improvement (0.5) in both parameters, indicating that increasing the fertilizer improves fruiting and flowering.
- T3 (7.5 tons/ha): A good increase in the production of buds (0.7) and berries (0.5) is registered, suggesting that this could be a more suitable dose to promote greater production.
- T4 (10 tons/ha): This treatment shows the maximum production of buds (0.9) and high production of berries (0.7), indicating that increasing the dose of fertilizer enhances the reproductive capacity of the crop.

Soil Quality: pH, Organic Matter, Nitrogen, Phosphorus, and Potassium: Analyzing these variables is essential to understanding the quality of the land and its capacity to support the cultivation of prickly pear.

- Soil pH:
  Higher in T0: A high pH (0.9) in the treatment without fertilizer indicates less favorable conditions for prickly pear, which prefers a lower pH.
  Optimization with fertilizer: The application of guinea pig manure reduces the pH to more optimal levels (0.1-0.3 in T3 and T4), which is beneficial for the crop.
- Organic Matter:
  Increase with fertilizer: Organic matter is lower without fertilizer (0.1) and increases significantly with the application of guinea pig manure, reaching the highest point in T4 (0.9). This improves the structure and fertility of the soil.
- Nitrogen:
  Deficiency without fertilizer: Very low in T0 (0.1), indicating a deficiency.
  Improvement with fertilizer: Increases with the dose of guinea pig manure, being higher in T4 (0.9), which favors the overall growth and development of the crop.
- Phosphorus:
  Low in T0: Reflects an initial deficiency (0.1).
  Increases with fertilizer: Improves with doses of guinea pig manure, especially in T4 (0.9), essential for flowering and root development.
- Potassium:
  Adequate levels with fertilizer: Low in T0 (0.1) and increases up to T4 (0.9), which is vital for photosynthesis, water balance, and other metabolic processes of the plant.

3.2.3. Comparative plithogenic decision.

The use of plithogenic statistics allows for the integration of uncertainty and inherent variability in agricultural and environmental processes in the study of prickly pear cultivation and soil recovery at the Salache Campus. This

advanced methodology has facilitated a deeper understanding of how different doses of guinea pig manure affect both the adaptation of the prickly pear and the soil quality, by evaluating variables such as plant height, number of buds, berry production, and key soil parameters such as pH, organic matter, nitrogen, phosphorus, and potassium.

The results revealed that the T3 treatment (7.5 tons/ha) is the most effective in promoting an ideal balance between the growth and development of the prickly pear crop and the improvement of soil health. Specifically, this treatment not only optimized plant height by maximizing the production of buds and berries but also balanced pH levels. Additionally, it increased organic matter and ensured the adequate availability of nitrogen, phosphorus, and potassium. The application of 7.5 tons/ha of guinea pig manure showed significant improvements in soil conditions, evidenced by an increase in organic matter and an adjustment in pH to levels more conducive to the prickly pear. Thus, it has demonstrated how the interaction of physical and chemical factors can be effectively modeled under the plithogenic framework.

In contrast, the T4 treatment (10 tons/ha), although it promoted the highest plant height and the maximum concentration of organic matter, was revealed to be potentially excessive, suggesting that more fertilizer does not always translate into better agronomic or environmental results. Therefore, T3 not only aligns with the agronomic needs for optimal prickly pear production but also supports the long-term sustainability of the soil. Together, with the application of plithogenic statistics, it highlights the importance of precisely dosing agricultural inputs to maximize both crop yield and the health of the ecosystem in which it develops.

4 Conclusion

The treatment with 7.5 tons per hectare (T3) of guinea pig manure emerged as the most balanced, effectively optimizing the growth and production of prickly pear. This dose not only maximized plant height and the production of buds and berries but also promoted a favorable soil environment. This balance is crucial, as it allows for the improvement of agricultural production without compromising the health and sustainability of the soil. Additionally, the applied plithogenic statistics showed that T3 facilitates a robust adaptation of the prickly pear, by improving organic matter, adjusting pH to more suitable levels, and ensuring the availability of essential nutrients such as nitrogen, phosphorus, and potassium.

The application of guinea pig manure has proven to be instrumental in enriching soil quality, particularly with the T3 treatment. This treatment significantly raised organic matter and maintained an optimal nutritional balance, indicative of effective soil recovery. The adequate reduction of pH, especially in originally alkaline soils, and the increase in key nutrients underscore how precise management of fertilizer can transform soil properties to create more conducive conditions for cultivation. This improvement in soil quality is essential not only for the current crop cycle but also for the long-term health of the land, ensuring productivity and sustainability.

The research has reaffirmed the importance of carefully calibrating the application of organic fertilizers like guinea pig manure to obtain the maximum agricultural benefits without incurring unsustainable practices. While higher doses (such as T4 with 10 tons/ha) offered certain benefits in terms of growth and organic matter, T3 (7.5 tons/ha) provided optimal performance without the potential risks of excess, which can include nutritional imbalances or long-term environmental damage. Consequently, it is vital to guide sustainable agricultural practices, where the goal is to maximize the efficiency of inputs and minimize negative impacts on the environment.

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