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IN SITU SOIL CHEMICAL AND PHYSICAL ANALYSIS OF THE SWEETEST CARABAO MANGOES OF ZAMBALES

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A B S T R A C T

The study was conducted to analyze some of the soil's physical and chemical properties in situ, where the sweetest carabao mangoes of Zambales were found.

Soil samples in three different soil depths were taken within the canopy coverage of the sweetest carabao mangoes from San Marcelino, Masinloc, and Sta. Cruz before the analysis. The test was focused on the soil's potassium content being linked and assumed to be responsible for the sweetness of the mango fruits.

As a result of the soil analysis from the three study areas, high potassium concentrations in three sampling depths from all the areas were found, particularly in Sta. Cruz. Also, a favorable pH range in all the sites and soil depths was observed and so the potassium present in the soil was presumed to be at its optimum level of availability and hence, acted in enhancing the sweetness of the fruits. Considerable amounts of nitrogen, phosphorus, calcium, and magnesium were also found in the soil, a manifestation that suggests that potassium's role in the sucrose formation was favored.

Undoubtedly, the result of this study in correlation to another study on leaf tissue analysis of the same mango trees from the same sites further confirmed that potassium was the nutrient element responsible for the sweetness of the mango fruits of Zambales. The mango leaves were found to contain a high concentration of potassium absorbed from the soil leading simultaneously to the formation of fruit sugar, the prime function of potassium through metabolic processes in the mango tree.

K E Y W O R D S

In situ, carabao mango, soil analysis, potassium

INTRODUCTION

Mango (*Mangifera indica*) is the Philippines' national fruit, and there is only one variety that stands among the rest: the "Carabao Mango". This variety is delicious compared with Pico, another species of mango from the Philippines. Lamao, one of the famous strains in the country, was named after a place in Bataan where it was originated, and it was the most planted carabao mango in the country until other strains came out (Rare Fruit News, 2006).

In the Philippines, there are 14 different strains of carabao mango that are approved and registered by the National Seed Industry Council (NSIC). In 1991, there were five strains, one in 1997, which is the MMSU Gold, Fresco in 2000, Talaban and Sweet Elena in 2002, Tanaleon and Galla in 2004, Efondo in 2005, JTA Sweet, and P-1 King Rodolfo, 2008. Hence, BAR of DA in 2003 found that Sweet Elena of Zambales is the sweetest Carabao Mango strain (Philippine National Standard, 2009).

Shellany (2017) stated that Philippine regions take pride in their mango, and it serves as a competition on which mango is the sweetest among all. As of records, Super Galila from Guimaras has 22.3 TSS. Sweet Elena, a competitor of the Guimaras mango, is awarded as the sweetest in the world for three consecutive years. It has 18.98 TSS. Bx (Brix Index). MMSU Gold in the Province of Ilocos has a brix of 18. Talaban and Fresco have a lower brix index than Sweet Elena. More strains of carabao mangoes w/c include the Cebu, GES 73', GES 77', GES 84', GES 85', Efondo, Corcino, Prima, JTA Sweet, and P-1 King Rodolfo.

According to Dela Cruz (2006), in 1995 World Guinness Book of Record, the Zambales, Philippines was listed as the producer of the sweetest mango in the world. Researchers from the President Ramon Magsaysay State University (PRMSU), formerly known as Ramon Magsaysay Technological University-San Marcelino (RMTU-SM) Campus, Dr. Ma. Ester Mariñas and Prof. Remedios Lim discovered and identified Sweet Elena as a new strain of carabao mango originated from Sta. Cruz Zambales owned by Mrs. Penida M. Malabed.

The sweetness of the Zambales mango is determined through its local soluble solids attributed primarily to its potassium and magnesium contents. The natural occurrence and abundances of the said macro-elements in the soil of Zambales are yet to determine and their correlation to the absorbing capacity of the mangoes. The fact that soil fertility decreases due to continuous cropping, maintaining the sweetness of the mango, and retaining the prestige of the province of Zambales are concerns that this study looks into for possible options that might be needed in the future.

MATERIALS AND METHODS

Materials

In soil profile sampling, a shovel, tape measure, garden trowel, plastic bag, and marker were needed. A letter of request was given to the owner of the specific mango tree to allow the researchers to collect soil samples before the study.

Research Design

The research design is a descriptive study aimed to determine soil analysis in the site where the Sweetest Carabao Mango was found in Zambales. Establish a benchmark on the soil's physicochemical characteristics from the three sites in Zambales where the sweetest carabao mangoes are found. The study focuses on the soil pH, K, and Mg concentration in the soil concerning Mango absorption of such elements that promote the sweetness of the mango fruits. Collect samples in the mango-growing areas of the province, particularly the sampling of K in the 20-40 cm and 40-60 cm soil depths.

Research Procedure

Cleaning the Site Surface

Cleaning was done by scraping all foreign materials on top of the ground surface where sampling takes place.

Digging the Soil

The researchers dogged up the soil and created enough space of 1 meter by 1.5 meters wide hole that accommodated a researcher on taking the soil samples.

Collection of Soil Samples

The researchers collected soil samples in three different areas in Zambales. These are the sites that the researcher collected soil samples; Sta. Cruz, San Salvador Masinloc and San Marcelino Zambales. The collection was done beneath the tree canopy in different soil depth measurements required for sampling. It started from the bottom profile and proceeded upward to avoid mixing up the samples of different profiles. Each depth was taken 1kg weighed soil, started at 40-60 cm, 20-40 cm, 0-20 cm respectively. The collected samples were placed in a plastic container and sealed tightly.

Air Drying of Samples

Collected soil samples from three various sites of different depths were separately spread on a clean surface. Soil samples were dried within 7 days.

Labeling Bags

The bags filled with soils were properly and completely labeled. Location and depth of the samples were written per bag (e. Sta. Cruz Soil Sample, SCSS 0-20 cm, SCSS 20-40 cm, SCSS 40-60 cm).

Soil Analysis

Soil samples were submitted and analyzed in the Regional Soils Laboratory in the City of San Fernando, Pampanga.

Soil Color Determination

The soil color was determined using Munsell Soil Color Chart.

Soil Texture Determination

The soil texture was determined using the roll method. The moist soil sample rolled on the palm and molded into a ring.

RESULTS AND DISCUSSION

This chapter contains the results and discussion of the study conducted regarding the in-situ soil analysis of the sweetest carabao mangoes find in Zambales.

Table 1 shows the soil analysis taken from the three sites in Zambales: San Marcelino, Masinloc, and Sta. Cruz.

Table 1. Soil Analysis

Areas	Depth (cm)	pH (1:1 Soil:H20)	Organic Matter (OM), % (Walkley Black Method)	P	K	Ca (cmol/kg)	Mg (cmol/kg)
San Marcelino	0-20	6.65	0.63	0.1	60.0	5.35	5.04
	20-40	7.11	0.03	Trace	30.0	1.98	0.52
	40-60	7.52	0.03	4.5	30.0	1.54	1.06
Masinloc	0-20	7.54	0.09	0.3	90.0	2.27	6.87
	20-40	7.39	0.04	16.1	30.0	2.80	6.87
	40-60	7.22	0.19	1.0	40.0	2.09	4.72
Sta. Cruz	0-20	7.33	1.48	5.4	220.0	3.81	4.36
	20-40	7.17	1.19	30.0	360.0	1.80	1.81
	40-60	7.35	0.70	61.8	80.0	2.05	4.16

Potassium (K) and Magnesium (Mg) Concentration

As indicated in the table, potassium (K) in all soil samples had the highest concentration among other elements in all the soil sampled. The K content in all the three sites sampled showed that in the first two layers, 0 to 20 cm and 20 to 40 cm depth, the concentration of K is high, particularly in Sta. Cruz, and became lower in the third layer, 40 to 60 cm depth.

On the other hand, magnesium (Mg) in the first layer of all three sites was also high, while in the second layer (0.52 cmol/kg) and third layer (1.06 cmol/kg) in San Marcelino were lower. Similarly, the third layer (4.72 cmol/kg) of Masinloc and the second layer (1.81 cmol/kg) of Sta. Cruz also decreased in Mg content.

Comparing K in all the areas, it is evident that K is higher in concentration than Mg in all three areas. This can enhance the mango's sweetness and had high possibilities of absorption, as shown in the leaf tissue analysis. The leaf tissue analysis showed that available K content was the highest at Masinloc, which is 0.87%, and has a constant amount in San Marcelino and Sta. Cruz with 0.48%.

According to the adequacy level of nutrients in the soil, K content in soil analysis was proven to have a high concentration. The soil index determined the low, medium, and high concentration of nutrients in the soil.

Ganeshamurthy (2011) stated that K improves sugar production, texture, pungency, vitamin content, and weight in fruits in the same vein. K is extremely important for the production and quality of the fruit because it is one of the macronutrients most absorbed by the crop, especially in fruiting, participating in the initial formation of the fruits.

Furthermore, according to Stino (2011), K has an essential role in enzymatic activation, photosynthesis, water use efficiency, formation of starch, and protein synthesis.

Meanwhile, the excess of K can cause an imbalance in the levels of calcium and magnesium (Almeida et al., 2015) while Mg acts for sweet, tasty fruit; thus, Mg plays an important role for the mango quality, as the edible portion of the mango fruit contains approximately 15 % sugar. Hence, K with a high concentration provides the sweetness of the mango indicated in the analysis.

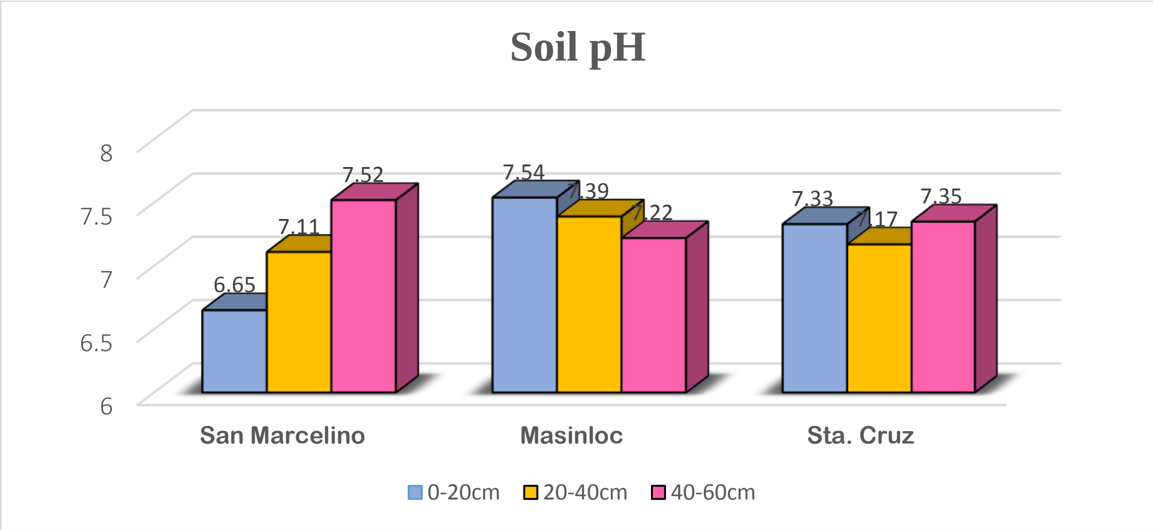

Figure 1. Soil pH level

As shown in Figure 1, the soil pH of the three areas was all slightly acidic to slightly alkaline. These are favorable to mango and can enhance the availability of the nutrient present in the soil. The pH in the three areas ranges from 6.65 up to 7.54. The soil pH in the first layer in San Marcelino (6.65 pH) is due to lahar soil accumulation in the area, which presumably brought by the Pinatubo eruption as the source of acidity of the lahar soil. In addition, soil pH on the remaining depths in San Marcelino has greater pH than the first layer.

The 0 to 20 cm depth in Masinloc contained the highest pH among all sites in all depths with a 7.54 corresponding value. The remaining depths in Masinloc 20 to 40 cm and 40 to 60 cm have near value to its first layer with 7.39 and 7.22 pH levels. The same goes for Sta. Cruz with 7.33, 7.17, and 7.35 respectively to the depths.

It was stated by Chico Enterprise-Record (2013) that nutrient availability is primarily determined by soil texture and pH. Soil texture is the amount of sand, silt, clay, and organic matter in the soil. Soil pH is a measurement of the degree of soil acidity or alkalinity; this measurement has the most significant effect on nutrient availability in the soil. Furthermore, the availability of nutrients was at the maximum level, especially at K, as reflected in soil analysis.

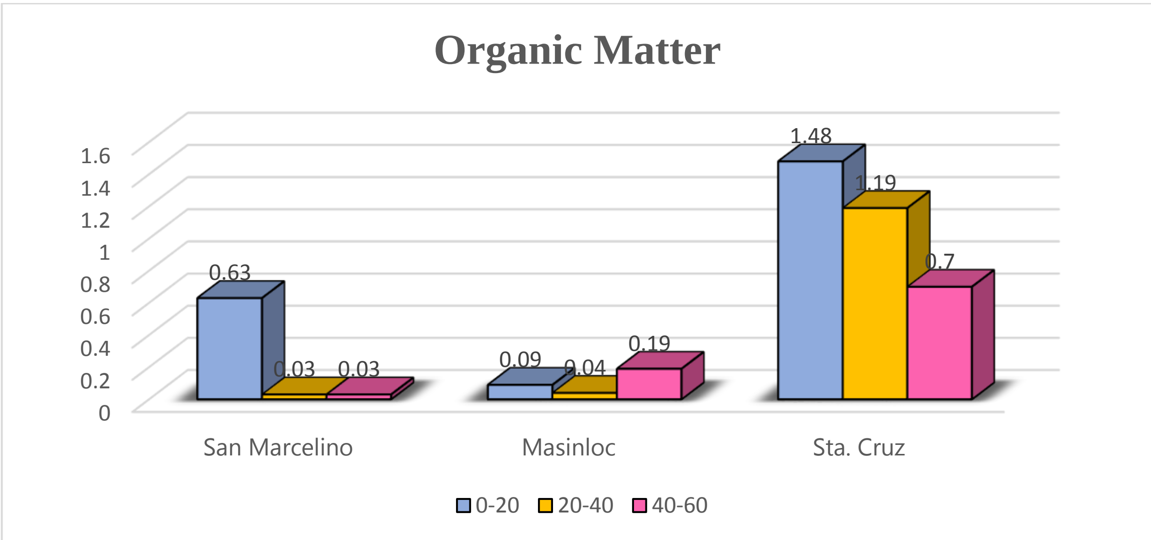

Figure 2. Organic matter in the soil

Figure 2 shows that the organic matter of both San Marcelino and Masinloc areas at all depths was deficient compared to Sta. Cruz. In San Marcelino, the amount in 0-20cm is 0.63, 20-40cm, and 40-60cm is 0.03 wherein not visible due to its minimal content. Likewise, Masinloc having low organic matter with 0.09, 0.04, and 0.19 content.

Otherwise, Sta. Cruz has a high amount in 0-20cm with 1.48, 20-40cm with 1.19 but then became less in 40-60 with 0.70. As cited, soil texture influences the rate of organic matter decomposition. Soils with high clay content generally have a high organic matter content due to the slower decomposition of organic matter. Additionally, soil pH influences organic matter decomposition. It was said that microbial activity at very low or very high soil pH would influence the rate of organic matter decomposition. It correlates with the soil color and texture. Therefore, soil texture affects the soil's ability to maintain nutrients, and soils with large amounts of clay or organic matter tend to hold nutrients more effectively than sandy soils.

According to Silva (1997), nitrogen is one of the most important nutrients for the growth of mango and it has a relevant role in the production and quality of the fruits. Its effects are seen principally in the vegetative phase of growth, and considering the relationship that exists between vegetative and reproductive flushes (development of floral buds and fruit formation), N deficiency may adversely affect yield. Mangoes adequately nourished with N regularly develop shoots, which when they reach maturity have viable panicles able to bear fruit.

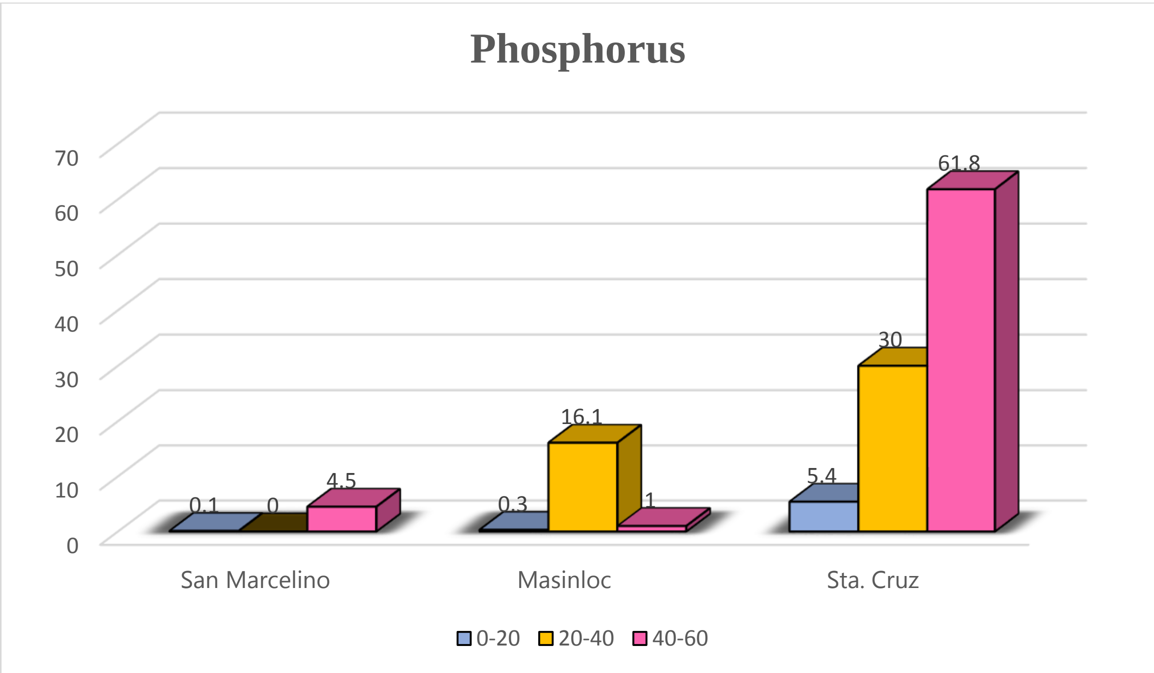

Figure 3. Phosphorus Concentration in soil

As shown in Figure 3, the concentration of phosphorus (P) is minimal at all depths in San Marcelino, Masinloc, and in 0-20 cm depth of Sta. Cruz. Based on the nutrient level range of phosphorus, 0-25 ppm is low. Phosphorus level in 20-40cm depth in Sta. Cruz is in the medium level range (30.0), while P's 40-60 cm concentration is high (61.8).

According to Parnes (2013), the primary function of phosphorus is the transfer of energy from plant leaves to its storage in sugar and starches. Its observable effect is to enhance root and flower development and seed size. However, soil pH affects the limitation on phosphorus availability. Low

pH reduces biological activity and limits the effectiveness of soil organisms in promoting the release of phosphorus. It was also stated that the optimum soil pH range for phosphorus is 6.0 to 7.0.
Meanwhile, lower pH level tends phosphate to bind with aluminum or iron compounds in the soil, making less available for plant uptake. In contrast, higher pH levels tend to precipitate with calcium. Also, higher organic matter levels tend to result in greater phosphorus availability.
The availability of P in Sta. Cruz is adequately high, considering that the pH level in the area is neutral with corresponding adequate organic matter.

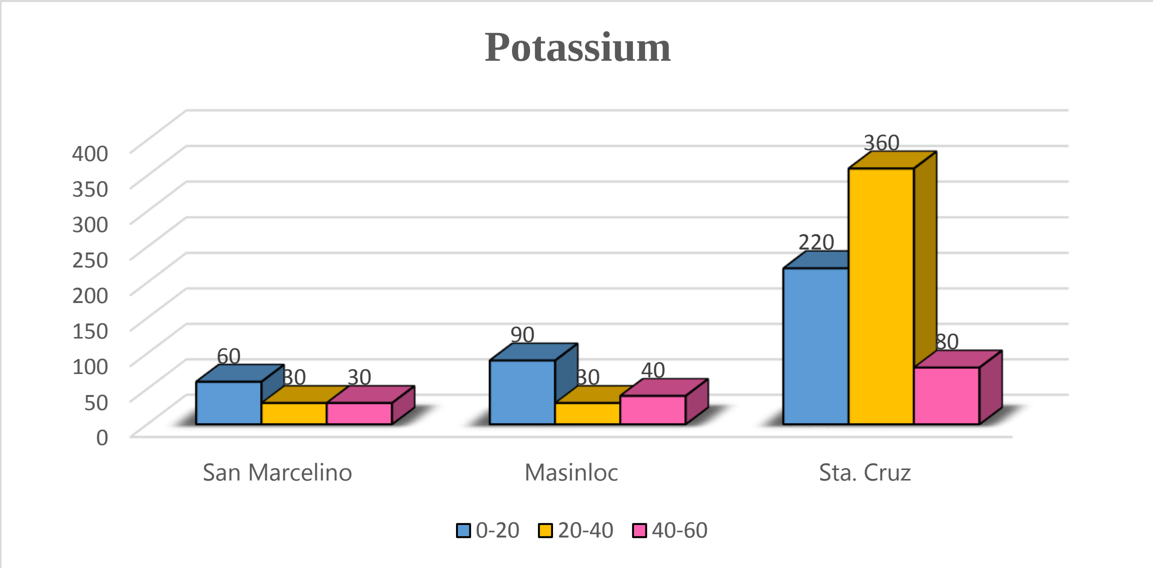

Figure 4. Potassium Concentration in soil

Figure 4 indicates the abundance of potassium (K) in Sta. Cruz's concentration of K in the first layer in San Marcelino is low, containing 60.0 ppm and became very low in 20-40cm, having the same amount of 30.0ppm.
Masinloc K concentration consists medium level at 0 to 20 cm depth (90.0 ppm) and became very low in 20 to 40 cm (30.0) and 40-60 cm depth (40.0). On the other hand, an abundance of K in Sta. Cruz was proven in the result. On the layers 0 to 20 cm and 20 to 40cm depth, the concentration is high with 220.0 ppm and 360.0 ppm, respectively. However, the K in 40-60 cm depth became low with only 80.0 ppm.
It was proven that potassium has a high concentration in Sta. Cruz provides the relationship between pH, color, and texture. The neutral pH level and goodness of soil color and texture contribute to its availability.
Cakmak (2005) stated that potassium is involved in numerous biochemical and physiological processes vital to plant growth, yield, quality, and stress. It also improves the fruit quality parameters, i.e., total soluble solids, total sugars, and coloration (Dutta, 2011)
These effects might be dedicated to the potassium role in increasing tolerance to stresses and improving the formation and accumulation rates of sugars (Saleh and Abd El-Moneim, 2003; Wahdan et al., 2011).
According to Stino (2011), an enhancement of mango productivity is a result of potassium application. It also improved the fruit quality of mango in terms of weight, TSS percentage, and total sugars. Generally, K plays a positive role on sucrose formation of the fruit.

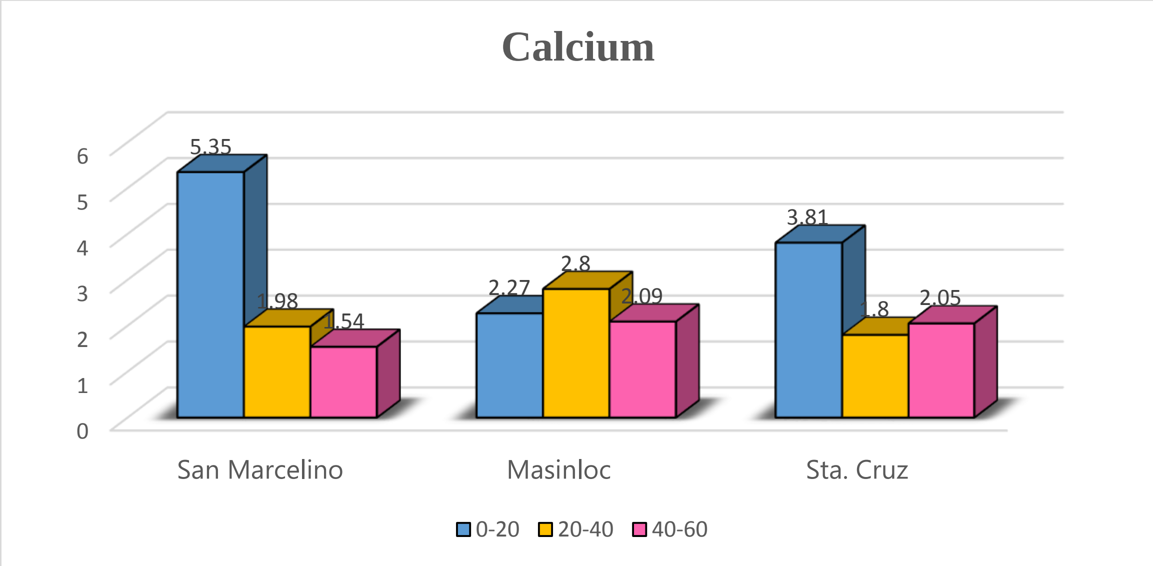

Figure 5. Calcium Concentration in soil

As shown in Figure 5, the calcium concentration wherein the first layer in San Marcelino is the highest among all sites in any depth with 5.35 cmol/kg.

According to Pinto et. al. (1994), calcium is essential in the assimilation of N and the transport of carbohydrates and amino acids. Calcium plays a vital role in the structural functions of the cellular membranes and walls throughout the entire plant. The fruits have an increased demand for Ca maintain pulp consistency during growth. Generally, the fruits are firmer, with a better appearance, better resist handling and transport and have a lower incidence of physiological disturbance that causes the internal collapse of the pulp.

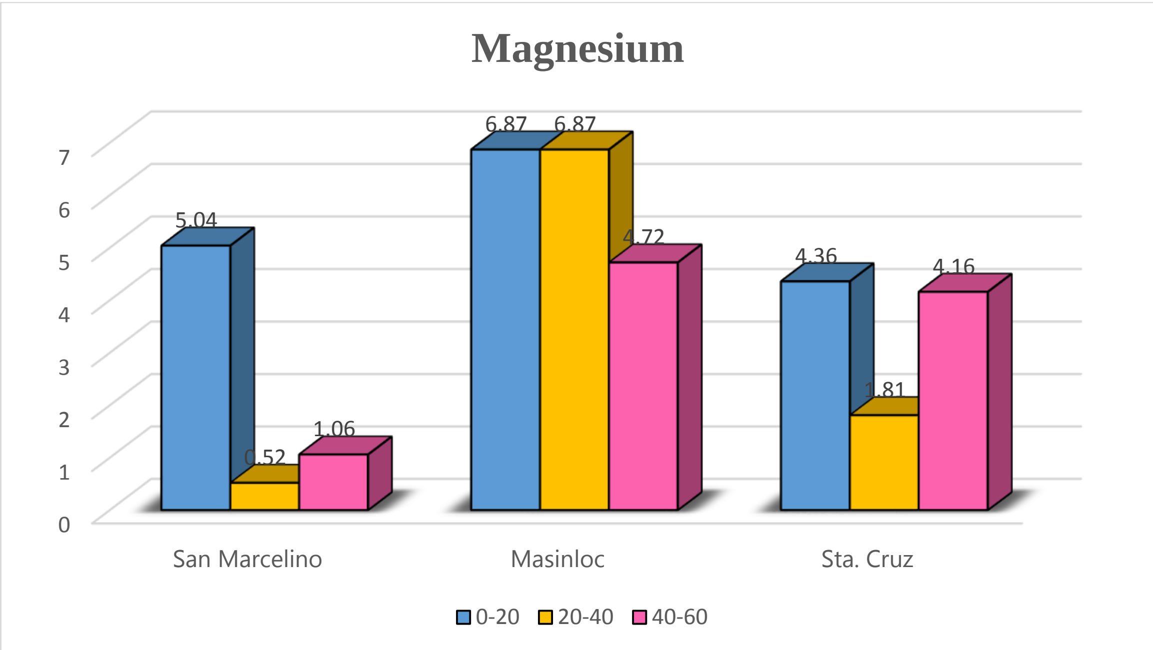

Figure 6. Magnesium concentration in soil

Figure 6 indicates that the Masinloc area has the highest amount of Mg among the sites. Although based on the adequacy level of magnesium, the amounts are in the low range.

The first layer in San Marcelino (0 to 20 cm) is high among the depths with 5.04 cmol/kg. The first and second layers in Masinloc contained 6.87, and the third layer contained 4.72, which seems lower. However, Sta. Cruz contained 4.36 on the first layer, 1.81 on the second layer, and 4.16 on the third layer.

Based on Parnes (2013), magnesium is the only metal that is a constituent of chlorophyll. In addition, magnesium influences nitrogen metabolism and is important in the assimilation of carbon dioxide during photosynthesis. An antagonistic relationship exists among calcium, magnesium, and potassium: all three are cations, and the total absorption of cations by plant roots is limited. Plants, however, have a built-in preference for potassium, the soil supply of which is usually adequate to excessive, and calcium is the predominant component of lime. Magnesium is rarely prominent in a soil amendment, and it often ends up short.

A conflict between balancing nitrogen and not overpowering magnesium should occur only with a depleted, weathered soil with low organic content; such a soil has a low cation exchange capacity and little ability to store magnesium. In order to preserve the proper magnesium/potassium balance, potassium and, consequently, nitrogen should be limited.

The Table 2 presents the soil color of the three various sites in different depths.

Table 2. Soil Color Determination

Area	Depth (cm)	Soil Color
San Marcelino	0-20	Very pale brown
	20-40	Light gray
	40-60	Light gray
Masinloc	0-20	Very pale brown
	20-40	Yellow
	40-60	Yellow
Sta. Cruz	0-20	Yellowish brown
	20-40	Dark yellowish brown
	40-60	Yellowish brown

Table 2 shows that in terms of 0-20 cm depth, the soil sampled in San Marcelino and Masinloc has an ashen brown color compared to the soil taken in Sta. Cruz is yellowish-brown. In the 20-40 cm depth, the three sample sites showed a variety of colors in terms of the soil, including light gray for San Marcelino, yellow for Masinloc, and dark yellowish-brown in Sta. Cruz. On the other hand, 40-60 cm depth, soil in San Marcelino indicated a light gray color, compared to Masinloc and Sta. Cruz with yellow and yellowish-brown, respectively.

According to Ecochem (1998), the soil color indicates the presence of elements in the soil that contribute to the mango's nutrients. The color of the soil is usually closely related to its organic matter content, with darker soils being higher in organic matter. Optimum levels for light-colored, coarse-textured soils may range from 90 to 125 ppm. On dark-colored heavy-textured soils, levels ranging from 125 to 200 ppm.

The Table 3 presents the soil texture of the three various sites in different depths.

Table 3. Soil Texture

Area	Depth (cm)	Soil Texture
San Marcelino	0-20	Sandy
	20-40	Sandy
	40-60	Sandy
Masinloc	0-20	Silty sand
	20-40	Silty
	40-60	Silty
Sta. Cruz	0-20	Clay loam
	20-40	Clay loam
	40-60	Clay loam

As shown in Table 3, the clay loam texture of the soil in Sta. Cruz determined the probable elements available in acquiring an adequate amount essential for the mango tree.
Based on the table, in terms of all depths, the soil sampled in San Marcelino has a sandy texture compared to the soil taken in Masinloc, which is silty sand in 0 to 20 cm. In the 20-40 and 40 to 60 cm depth, the soil samples have silty texture.

CONCLUSION AND RECOMMENDATIONS

This chapter contains the conclusions and recommendations of the study regarding the in situ soil analysis of the sweetest carabao mangoes found in Zambales.

Conclusions

Based on the soil analysis result, it was found that all the sites have favorable soil environments for the production of sweet mango fruits. The potassium content was sufficient, the pH range was normal, considerable amounts of N, P, Ca, and a little of Mg, and the silty soil texture, all of which were undeniably contributed to enhancing the sweetness of the mango fruits.
Since there are claims that magnesium acts in promoting the sweet taste characteristics of the mango fruits, the result of soil analysis and that of the mango leaf tissue analysis suggests that it is not. The magnesium contents in soil and mango leaf tissues are inadequate to sustain the mango fruit sweetness. Considering the abundance of potassium in the soil and higher concentration in the leaf tissues, among other elements analyzed, it was concluded that potassium has direct involvement in the metabolic processes that promote the sweetness of the fruits.

Recommendations

Since the study was limited to only three study sites and three soil sampling depths, it is recommended that continuing studies be done in some other areas nationwide, especially to those having potential mangoes. Broader coverage and deeper soil sampling should be considered aside from other environmental factors like day length, rainfall, and temperature in the area. Tissue analysis should not all so be limited only to the leaves but to the whole tree itself. Monitoring of the soil fertility status and the mango fruit sweetness should regularly be done, possibly within 3-5 years after, to maintain the prestigious asset of the province.

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APPENDIX A

TABLE

Table 4. Adequacy level of elements

	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Very low			0-40 ppm		
Low	0-15 ppm	0-25 ppm	41-80 ppm		2-5 ppm
Medium	15-30 ppm	25-50 ppm	81-120 ppm		5-10 ppm
High	30+	50+	121- 160 ppm		10-32.5 ppm