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APPLICATION OF THE SLOW-RELEASE FERTILIZER "SILABAAL" ON COFFEE AND PASSION FRUIT CROPS AT SANTA ANA FARM, SANTA CRUZ DE MORA, MÉRIDA STATE - VENEZUELA
(Six weeks of application)

APLICACIÓN DEL FERTILIZANTE DE LIBERACIÓN LENTA "SILABAAL" EN CULTIVOS DE CAFÉ Y PARCHITA DE LA FINCA SANTA ANA, SANTA CRUZ DE MORA, ESTADO MÉRIDA - VENEZUELA
(Seis semanas de aplicación)

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ABSTRACT

The effectiveness of the slow-release foliar fertilizer Silabaal (20-8-5) was evaluated over a six-week period at the Santa Ana farm in Mérida, Venezuela, on coffee crops (Monte Claro and Araguaney varieties) and passion fruit. Using an experimental design featuring treated plots and control groups, physiognomic and qualitative variables were monitored. The results demonstrate that the application of Silabaal, supplemented with efficient microorganisms (EM-1) every 15 days, significantly accelerated vegetative development compared to the control groups. For Monte Claro coffee, the average height increased from 83.45 to 87.20 cm, and for Araguaney from 85.20 to 89.20 cm; the plants exhibited greater robustness, vigorous leaf sheen, and an absence of disease. In the nursery, treated seedlings showed a substantial increase in height (up to 18.50 cm) and stem collar diameter, achieving zero mortality. Similarly, in the passion fruit crop, the fertilizer induced early flowering and promoted uniform fruiting. It is concluded that Silabaal efficiently optimizes early agricultural yield and mitigates physical limitations caused by soil compaction in mountainous areas.

RESUMEN

Se evaluó la efectividad del fertilizante foliar de liberación lenta Silabaal (20-8-5) en la finca Santa Ana, Mérida, Venezuela, sobre cultivos de café (variedades Monte Claro y Araguaney) y parchita durante seis semanas. Mediante un diseño experimental con parcelas tratadas y testigos, se monitorearon variables fisonómicas y cualitativas. Los resultados demuestran que la aplicación de Silabaal, complementada con microorganismos eficientes (EM-1) cada 15 días, aceleró significativamente el desarrollo vegetativo en comparación con los testigos. En café Monte Claro, la altura media aumentó de 83,45 a 87,20 cm, y en Araguaney de 85,20 a 89,20 cm, exhibiendo mayor robustez, un vigoroso brillo foliar y ausencia de enfermedades. En el vivero, las plántulas tratadas mostraron un incremento sustancial en altura (hasta 18,50 cm) y diámetro al cuello, logrando una mortalidad nula. Así mismo, en el cultivo de parchita, el fertilizante indujo una floración precoz y anticipó una fructificación uniforme. Se concluye que Silabaal optimiza eficientemente el rendimiento agrícola temprano y mitiga las limitaciones físicas por compactación edáfica en zonas de montaña.

I. STUDY OBJECTIVES

General Objective

To evaluate the effectiveness of the slow-release fertilizer Silabaal in increasing the development and yield of crops across two plots of coffee (Monte Claro and Araguaney varieties) and one plot of passion fruit, as well as in the initial development of Monte Claro variety coffee seedlings (in the nursery).

Specific Objectives

- ✓ To compare the effectiveness of Silabaal fertilizer on the development of Monte Claro and Araguaney coffee plants during their pre-flowering stage, with and without application.
- ✓ To compare the effectiveness of Silabaal fertilizer on the initial development of Monte Claro coffee seedlings in the nursery, with and without application.
- ✓ To evaluate the effectiveness of Silabaal fertilizer on the development of passion fruit crops and the increase in plant yield, with and without application.}

II. CHARACTERISTICS OF THE PRODUCT SILABAAL 20 – 8 – 5

Silabaal is an ecological slow-release foliar fertilizer based on calcite (calcium carbonate), designed to optimize photosynthesis and improve crop health. It also contains **clinoptilolite**, which is the most abundant and widely used natural **zeolite** in the agricultural sector, acting as a soil conditioner that contributes to the retention of nutrients such as nitrogen (N), potassium (K), as well as water (Silabaal, 2026).

This improves soil structure, reducing nutrient leaching and maximizing agricultural production yield.

It is widely used in areas near Mérida, Venezuela, to enhance production in coffee, vegetable, and fruit crops (Silabaal, 2026).

Its application is based on “Air 2 Air” technology, so that from a uniform granulation of calcite (enriched with zeolite), using backpack sprayers or atomizers, microparticles measuring between 0.1 and 1 micrometer (μm) can be applied via foliar spray, aimed at achieving the maximum possible absorption through the existing stomata on plant leaves (100 to 400 stomata per mm^2).

For foliar application, it is recommended to dilute 1 kilogram (kg) per 200 liters (L) of water, based on a ratio of 10 g of product per liter of water (10 g/L), along with 1 drop of liquid soap per liter (L) of water to improve product adherence.

III. METHODOLOGY

3.1. Location and Description of the Study Area

3.1.1. Location

The 'Santa Ana' farm is located in the Santa Marta Alta sector, between the towns of Mesa de Las Palmas and Santa Cruz de Mora, Antonio Pinto Salinas Municipality, Mérida State, Venezuela, in a mid-mountain area of the lower-middle section of the Mocotíes River basin (Figure 1).

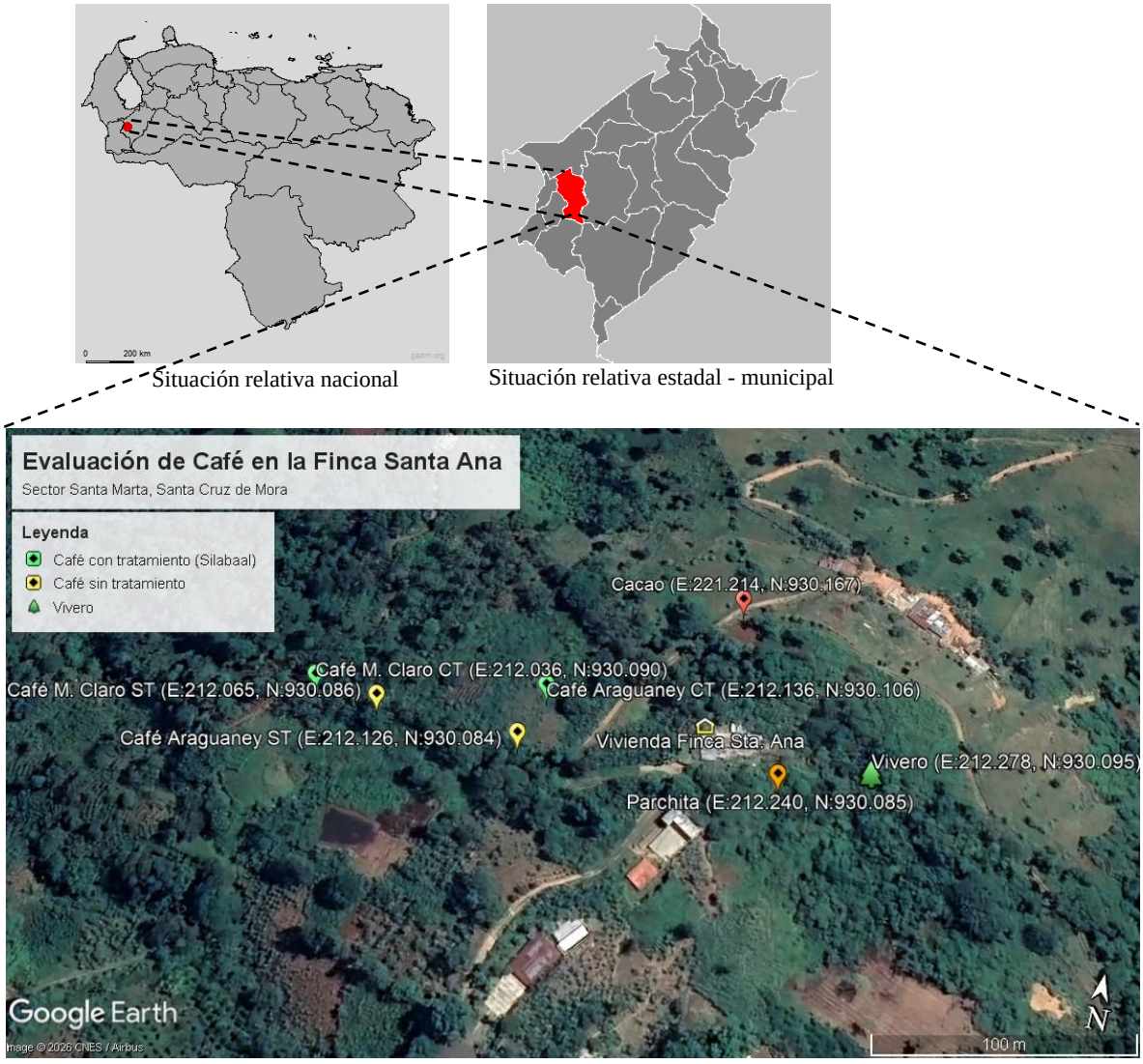

Figure 1. Location of the 'Santa Ana' Farm, Santa Bárbara Alta sector, Antonio Pinto Salinas Municipality, Mérida State, Venezuela.
Source: Prepared based on web images and Google Earth (2026).

3.1.2. Characterization of the Biophysical Environment

(a) Climate. The climate of the study area is classified as **Cool and Mildly Rainy**, with an average annual temperature ranging between 18°C and 23°C, and average precipitation ranging between 700 mm/year and 1,200 mm/year (Silva, 2010). The Santa Marta sector where the Santa Ana farm is located has a rainfall pattern with a bi-seasonal bimodal maximum regime (B2a), meaning a semi-dry or dry season and a rainy season, with a peak following each equinox (Silva, 2010).

(b) Geology. The geology of the region tends to be unstable, as in most mid-mountain zones of the Venezuelan Andean range, containing outcrops of sedimentary and metamorphic rocks belonging to various formations of the Andean system. Schists, phyllites, limestones, and detrital sediments predominate (Guerrero et al., 2017).

(c) Geomorphology. Due to its rugged topography and proximity to river basins, the area is subject to strong soil denudation. Slope processes and chemical weathering are active, shaping its unique relief of terraces or 'mesas' with a certain gradient of slope (Rivas, 2008). Specifically, the study area features an irregular topography defined by moderate to steep slopes, ranging between 5° and 45°.

(d) Soils. The soils of the sector have a clay-loam (CL) texture, predominantly on slopes, and a silty-clay-loam (SCL) texture, mainly in areas with gentle to moderate slopes, abundant in organic matter but susceptible to compaction. They possess good fertility and are moderately drained due to the abundance of clay. These are slightly acidic to neutral soils, with a pH ranging between 6.0 and 7.3.

Figuras 1 y 2. ***Left:*** Clay-loam textured soil in the Araguaney coffee plot (moderate to steep slope zone, 30° - 45°). ***Right:*** Silty-clay-loam textured soil in the Monte Claro coffee plot (gentle to moderate slope zone, 15° - 25°).

(e) Hydrography. The farm is part of the lower-middle basin of the Mocotíes River, located on its right bank, in a mountainous zone with variable altitude ranging from 1,020 to 1,080 meters above sea level (masl). This basin drains into the lower-middle section of the Chama River basin, which in turn forms part of the Lake Maracaibo watershed.

(f) Vegetation. The local agroecosystem is influenced by the Lower Montane Semi-Deciduous Forest ecological unit (900 – 1,300 masl), according to the classification of ecological units of Mérida State by Ataroff and Sarmiento (2003). Indicator tree species of the seasonal or semi-deciduous montane level include: Erythrina poepigiana (mountain immortelle, ceibo), Cedrela montana (mountain cedar), Inga spectabilis (machete inga), Cordia alliodora (Spanish elm), Piptocoma acuminata (zamurito), and Cecropia peltata (snakewood).

(g) Fauna. Faunal species reported in the sector include the following (some classified under various threat levels by the Red Book of Venezuelan Fauna (2026)): Mammals: Cuniculus taczanowskii (mountain paca -vulnerable-), Dasyprocta leporina (red-rumped agouti), Didelphis marsupialis (common opossum), and bats; Birds: king eagle, flycatchers, smooth-billed ani, owls, black thrush, and swallows; Amphibians: Espadarana andina (Andean glass frog), Atelopus sorianoi (San Francisco stubfoot toad -critically endangered-); Ichthyofauna: Trichomycterus emanueli (Chama and Mocotíes catfish -endangered-); and various insects (butterflies, bees, bumblebees, ladybugs, stink bugs, kissing bugs, ants, among others).

3.2. Materials and Equipment

- ✓ Silabaal 20 – 8 – 5 product (powder form).
- ✓ Measuring tape for measuring foliage diameter and height of coffee plants.
- ✓ "Mitutoyo" vernier caliper for measuring the stem collar diameter of coffee seedlings in the nursery.
- ✓ 20-liter capacity backpack sprayer system.

3.3. Application Specifications of the Silabaal Treatment

The slow-release fertilizer Silabaal was applied to permanent crops of Araguaney and Monte Claro coffee varieties, Monte Claro coffee seedlings in the nursery, and semi-permanent passion fruit crops, aiming to enhance the agricultural yield of Santa Ana farm. A base fertilization method for initial plant development using NPK mineral fertilizer (15-15-15) had previously been applied; in this evaluation, Silabaal was applied using pest biocontrollers such as EM-1 or efficient microorganisms (Table 1).

Table 1. Summary sheet of fertilization with Silabaal and complementary products in crops at Santa Ana farm.

ATRIBUTE	DESCRIPTION
Farm Name:	"Santa Ana".
Location:	Santa Marta sector, between Santa Cruz de Mora and Mesa de Las Palmas, Antonio Pinto Salinas Municipality, Mérida State – Venezuela.
Applied Product:	Silabaal 20 – 8 – 5, at a ratio of 10 g/L of water.
Additional Applied Products:	Efficient Microorganisms (EM-1), at a ratio of 1 liter / 200 liters of water.
Application Frequency:	Every 15 days.
Date of 1st Measurement (Silabaal Start):	18/05/2026.
Date of 2nd Measurement:	06/06/2026.
Date of 3rd Measurement:	02/07/2026.

Source: Owner of the Santa Ana estate.

3.4. Methodological Stages

Among the established crops at Santa Ana farm aiming to advance toward an integrated multi-crop farming model, the following stand out: two (2) coffee plots (one Araguaney plot and one Monte Claro plot), one (1) passion fruit plot with trellises and wire rows, one (1) cocoa plot, and one (1) nursery with Monte Claro coffee seedlings.

Because the cocoa plot is older and currently undergoing renovation, the slow-release fertilizer Silabaal was applied to the Araguaney and Monte Claro coffee plots, the passion fruit crop, and the Monte Claro coffee nursery seedlings.

For the purpose of this study, the following methodological stages were established:

3.4.1. Stage 1. Comparison of Development in Monte Claro and Araguaney Coffee Varieties, With and Without Silabaal Application

For the coffee crops, two (2) varieties with different planting dates were evaluated: 11 months old for the Monte Claro coffee and nine (9) months old for the Araguaney coffee at the date of the first Silabaal application.

The plots were distributed as follows:

Plot No. 1: Monte Claro Variety.

Planting date: 03/06/2025 to 12/06/2025.

Quantity: 2,500 plants.

Plot No. 2: Araguaney Variety.

Planting date: 02/08/2025 to 09/09/2025.

Quantity: 1,500 plants.

To compare early effects of Silabaal across both plots, specific rows were designated as control plots (without product application), while the product was applied to the remaining rows.

Qualitative aspects evaluated included vigor/robustness, leaf sheen/lustrousness, and disease presence/absence. Comparative measurements were taken on ten (10) untreated control plants and ten (10) Silabaal-treated plants per variety for: foliage diameters (cm) and height (cm).

For the measurements, ten untreated coffee plants of both varieties and ten (10) plants of both varieties treated with the fertilizer were selected. Additionally, certain qualitative variables were monitored (robustness, leaf sheen, and the presence or absence of diseases).

3.4.2. Stage 2. Comparison of Initial Development of Monte Claro Coffee Seedlings in Nursery, With and Without Silabaal Application

This stage involved comparative sampling of Monte Claro coffee seedlings that had been transplanted into bags approximately two (2) months prior to the first measurement.

Plot No. 3: Monte Claro Coffee Nursery.

Transplant to bags date: 09/03/2026 to 15/04/2026.

Quantity: 3,500 seedlings.

A group of seedlings was kept as a control sample (without Silabaal application), while Silabaal was applied to the remaining seedlings. Measurements evaluated on ten (10) control and ten (10) treated seedlings included: stem collar diameter (cm), foliage diameters (cm), and height (cm), along with qualitative monitoring.

3.4.3. Stage 3. Qualitative Evaluation of Development and Yield in Passion Fruit Crops, With and Without Silabaal Application

Given the climbing and irregular growth habit of passion fruit plants, qualitative evaluations were conducted focusing on plant vigor, presence/absence of diseases, and crop yield post-fruiting (currently in flowering and early fruiting phase).

The passion fruit plot was three (3) months old at the initial evaluation and consisted of twelve (12) trellis rows.

One row of 10 plants served as the control group (without Silabaal), while plants in the remaining eleven (11) rows received Silabaal applications.

IV. RESULTS AND DISCUSSION

4.1. Stage 1. Development of Monte Claro and Araguaney Coffee Plants, With and Without Silabaal Application

Following crosswise foliage measurements from aerial view (diagonals 1 and 2) and plant height measurements from ground level, mean values were calculated for both evaluated coffee plots (Tables 2–5; Figures 3 – 14; tables with the complete data in the Appendices):

Plot No. 1: Monte Claro Coffee Variety

Table 2. Mean values (μ) of foliage diameters and plant height for Monte Claro coffee (Control).

	AVERAGE DIAMETER 1 (cm)	AVERAGE DIAMETER 2 (cm)	AVERAGE HEIGHT (cm)
First Measurement (Day 0):	**58.05**	**51.20**	**55.70**
Second Measurement (Day 20):	**58.50**	**51.90**	**56.20**
Third Measurement (Day 46):	**59.60**	**52.70**	**57.10**

Source: Data obtained in the field.

Table 2 reflects a sustained but slight and slow increase in the physiognomic characters evaluated in juvenile Monte Claro coffee plants (prior to first harvest) without Silabaal application.

The same is evident in the representation in Figures 3, 4, and 5.

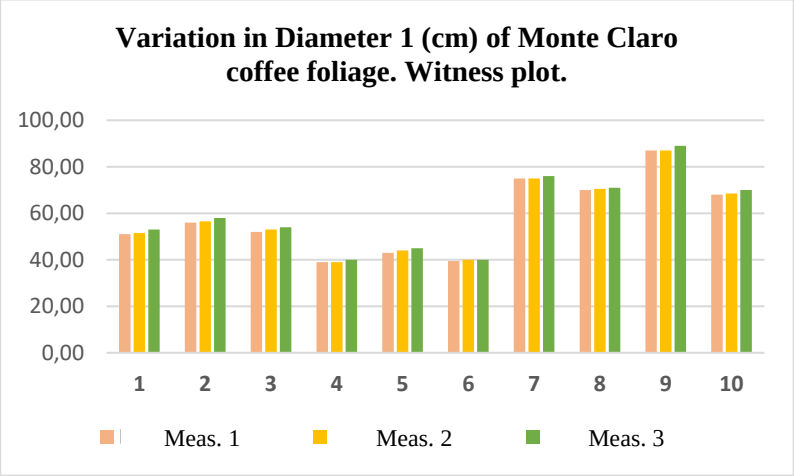

Figure 3. Gradual increase in foliage (Diameter 1) of Monte Claro coffee in the control plot..

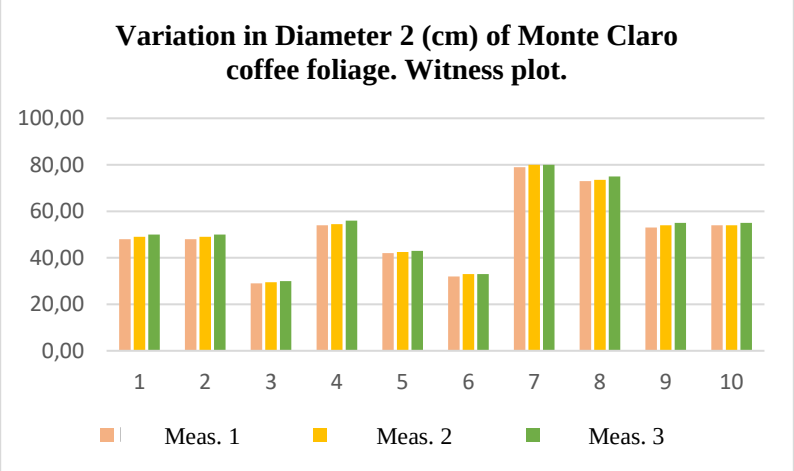

Figure 4. Gradual increase in foliage (Diameter 2) of Monte Claro coffee in the control plot.

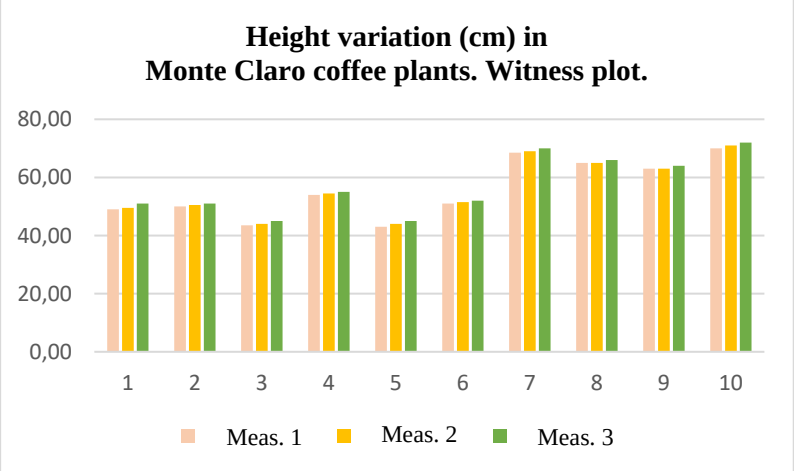

Figure 5. Gradual increase in the height of Monte Claro coffee plants in the control plot.

Table 3. Mean values (μ) of foliage diameters and plant height for Monte Claro coffee (With Silabaal application).

	AVERAGE DIAMETER 1 (cm)	AVERAGE DIAMETER 2 (cm)	AVERAGE HEIGHT (cm)
First Measurement (Day 0):	**90.20**	**74.20**	**83.45**
Second Measurement (Day 20):	**92.65**	**76.45**	**85.20**
Third Measurement (Day 46):	**96.30**	**78.90**	**87.20**

Source: Data obtained in the field.

Table 3 indicates a considerable and more accelerated increase compared to control samples, resulting from the growth-promoting effect provided by Silabaal fertilizer over the six-week evaluation period.

This is also corroborated by observing the growth patterns of the ten (10) plants measured in the Monte Claro variety coffee plot where the product was applied (Figures 6, 7, and 8).

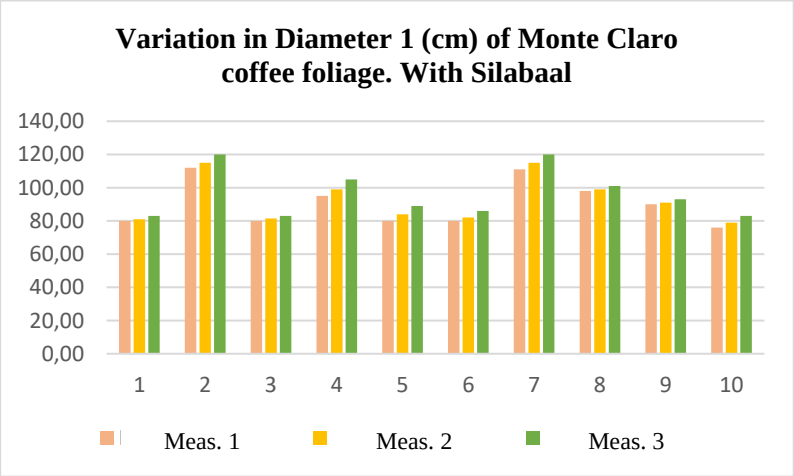

Figure 6. Significant increase in foliage (Diameter 1) of Monte Claro coffee, with Silabaal.

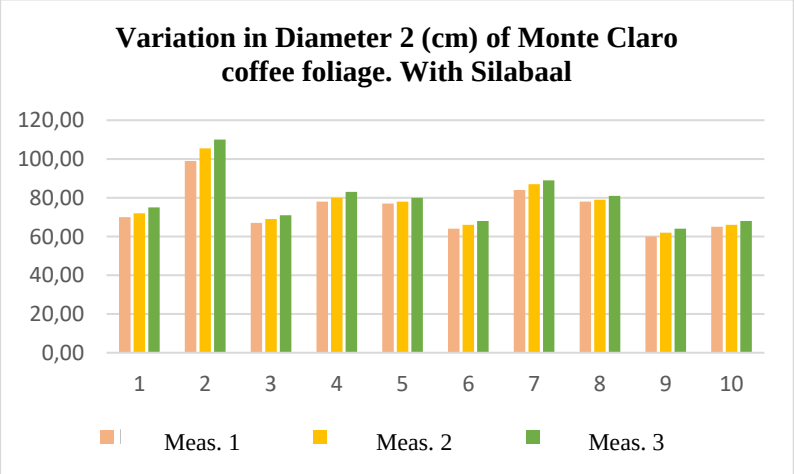

Figure 7. Significant increase in foliage (Diameter 2) of Monte Claro coffee, with Silabaal.

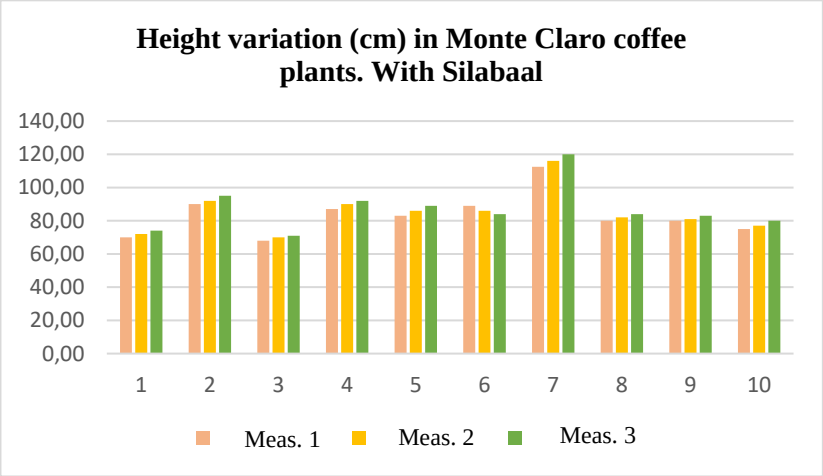

Figure 8. Significant increase in the height of Monte Claro coffee plants, with Silabaal.

Plot No. 2: Araguaney Coffee Variety

Table 4. Mean values (μ) of foliage diameters and plant height for Araguaney coffee (Control).

	AVERAGE DIAMETER 1 (cm)	AVERAGE DIAMETER 2 (cm)	AVERAGE HEIGHT (cm)
First Measurement (Day 0):	**87.65**	**82.15**	**88.60**
Second Measurement (Day 20):	**88.40**	**83.00**	**89.70**
Third Measurement (Day 46):	**89.70**	**84.30**	**91.10**

Source: Data obtained in the field.

Table 4 shows a slight increase in physiognomic traits for Araguaney coffee plants in the control plot without Silabaal application. This is also evident in the representation in Figures 9, 10, and 11.

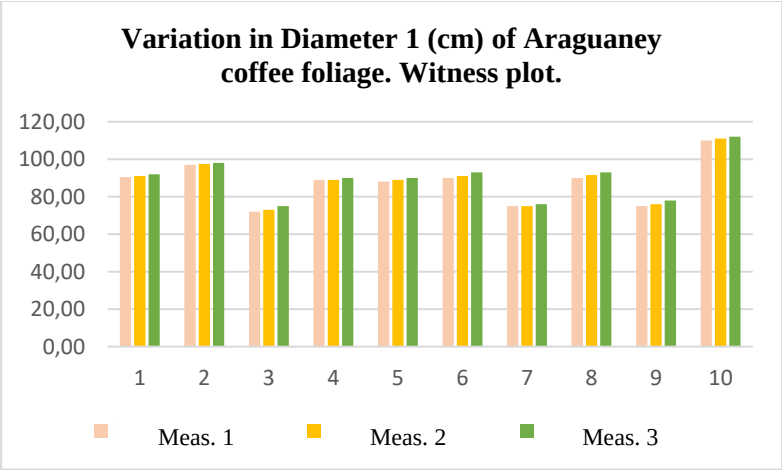

Figure 9. Gradual increase in foliage (Diameter 1) of Araguaney coffee in the control plot.

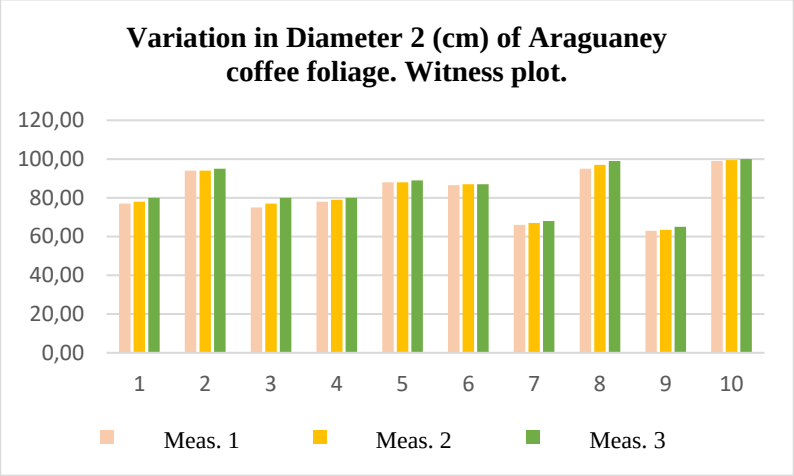

Figure 10. Gradual increase in foliage (Diameter 2) of Araguaney coffee in the control plot.

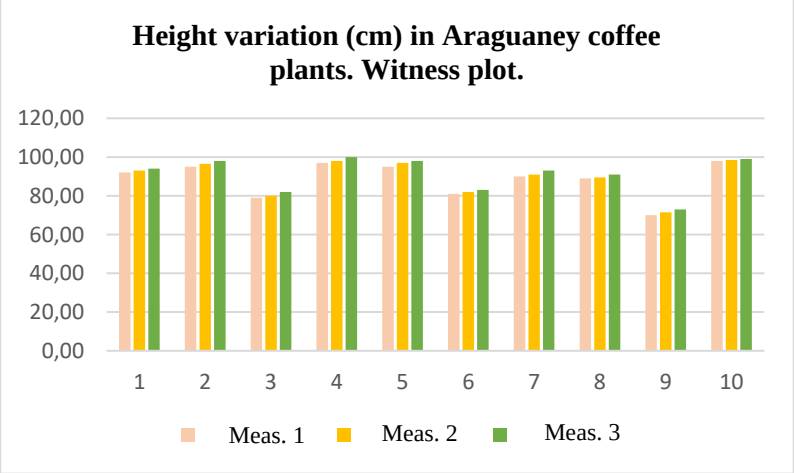

Figure 11. Gradual increase in the height of Araguaney coffee in the control plot.

Table 5. Mean values (μ) of foliage diameters and plant height for Araguaney coffee (With Silabaal application).

	AVERAGE DIAMETER 1 (cm)	AVERAGE DIAMETER 2 (cm)	AVERAGE HEIGHT (cm)
First Measurement (Day 0):	**81.00**	**81.80**	**85.20**
Second Measurement (Day 20):	**82.50**	**83.15**	**86.90**
Third Measurement (Day 46):	**85.20**	**85.20**	**89.20**

Source: Data obtained in the field.

Table 5 shows a significant and faster increase compared to control samples, demonstrating the growth enhancement in Araguaney coffee plants treated with Silabaal over six weeks.

Also, this is confirmed by observing the development of the ten (10) plants measured in the Araguaney variety coffee plot where the product was applied (Figures 12, 13, and 14).

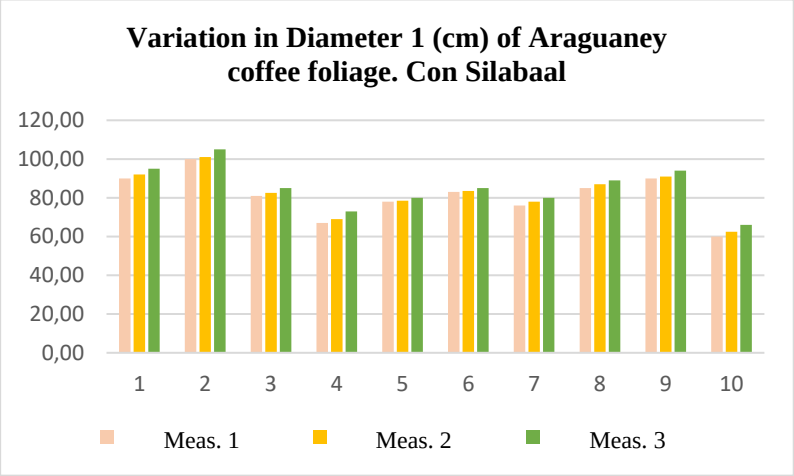

Figure 12. Significant increase in foliage (Diameter 1) of Araguaney coffee, with Silabaal.

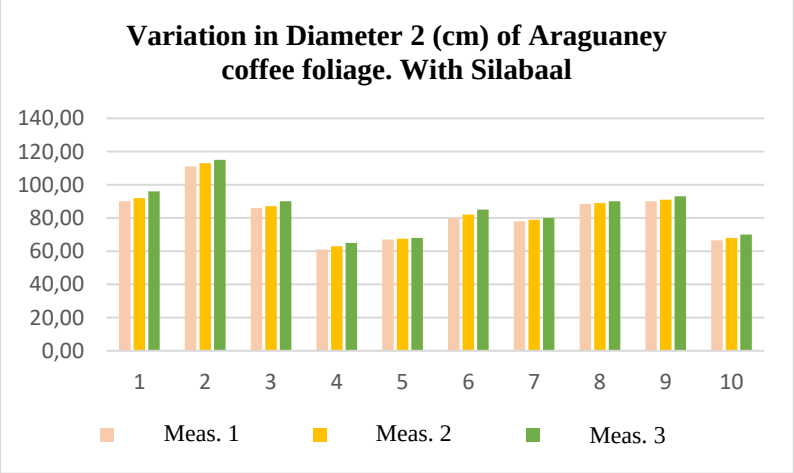

Figure 13. Significant increase in foliage (Diameter 2) of Araguaney coffee, with Silabaal.

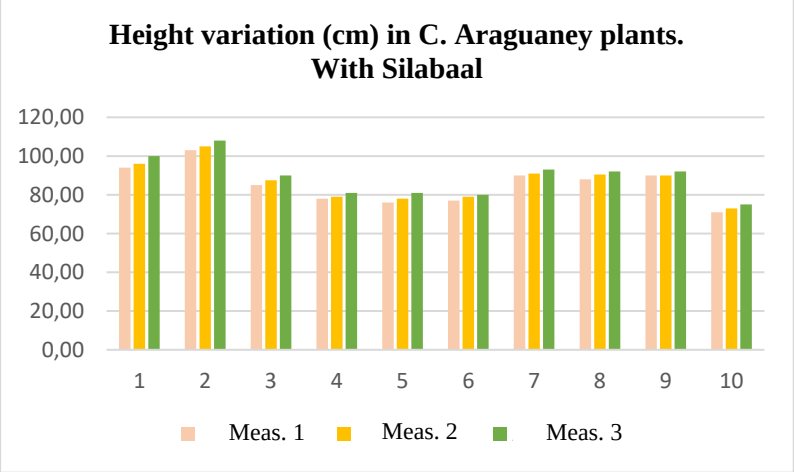

Figure 14. Significant increase in the height of the Araguaney coffee, with Silabaal.

Furthermore, the following qualitative variables were evaluated; although the evaluation period was short, they confirm the significance of the positive effects on the increased vegetative development of both coffee varieties included in the study (Tables 6 and 7; Figures 15, 16, 17, and 18).

Table 6. Observations based on qualitative variables in Plot No. 1 (Monte Claro Coffee).

PLOT	Qualitative Variable Evaluations for Monte Claro Coffee Plots					
	VIGOR / ROBUSTNESS (Start)	**VIGOR / ROBUSTNESS (6 Wks)**	**LEAF SHEEN (Start)**	**LEAF SHEEN (6 Wks)**	**DISEASE PRESENCE (Start)**	**DISEASE PRESENCE (6 Wks)**
Control	Good, except areas with soil compaction	Good, except areas with soil compaction	Good, green & bronze apex, typical of variety	Good, green & bronze apex, typical of variety	Small % of plants with root malformation (replaced), dark spots on leaves	Very small % with chewing insect damage on some leaves
With Silabaal	Good, except areas with soil compaction	Very good, except areas with soil compaction	Good, green & bronze apex, typical of variety	Very good, green & bronze apex, typical of variety	Small % of plants with root malformation (replaced)	Very small % with leaf scorching from direct sun exposure

Source: Data obtained in the field.

Figures 15 and 16. Growth habit and characteristic sheen of Monte Claro coffee plants.

Figure 17. Leaf-edge darkening on some leaves of a small percentage of M. Claro coffee plants.

Table 7. Observations based on qualitative variables in Plot No. 2 (Araguaney Coffee).

PLOT	Qualitative Variable Evaluations for Araguaney Coffee Plots					
	VIGOR / ROBUSTNESS (Start)	**VIGOR / ROBUSTNESS (6 Wks)**	**LEAF SHEEN (Start)**	**LEAF SHEEN (6 Wks)**	**DISEASE PRESENCE (Start)**	**DISEASE PRESENCE (6 Wks)**
Control	Good, except areas with soil compaction	Good, except areas with soil compaction	Good, green & bronze apex, typical of variety	Good, green & bronze apex, typical of variety	Small % of plants with root malformation (replaced)	Small % with insect leaf perforations
With Silabaal	Good, except areas with soil compaction	Very good, except areas with soil compaction	Good, green & bronze apex, typical of variety	Very good, intense green color	Small % of plants with root malformation (replaced)	Some fully exposed plants with leaf sunscald

Source: Data obtained in the field.

Figures 18 and 19. Habit and characteristic sheen of Araguaney coffee plants.

Figure 20. Perforation of some leaves on a small percentage of Araguaney coffee plants.

4.2. Stage 2. Initial Development of Monte Claro Coffee Seedlings in Nursery, With and Without Silabaal Application

Plot No. 3: Monte Claro Coffee Nursery, Initial Development Measurements

Table 8 shows a slight increase in the physiognomic characteristics evaluated in Monte Claro variety coffee seedlings during their initial development phase (nursery) without the application of Silabaal.

Table 8. Mean values (μ) of stem collar diameter, foliage diameters, and height of Monte Claro coffee seedlings in Nursery (Control).

	STEM COLLAR DIAMETER (cm)	AVERAGE DIAMETER 1 (cm)	AVERAGE DIAMETER 2 (cm)	AVERAGE HEIGHT (cm)
First Measurement (Day 0):	**0.26**	**10.50**	**9.90**	**8.25**
Second Measurement (Day 20):	**0.27**	**12.80**	**12.60**	**9.50**
Third Measurement (Day 46):	**0.29**	**16.75**	**16.10**	**11.50**

Source: Data obtained in the field.

Likewise, the slight growth in the seedlings is evident in Figures 21 and 22, which show the variations in stem collar diameter (cm) and seedling height (cm).

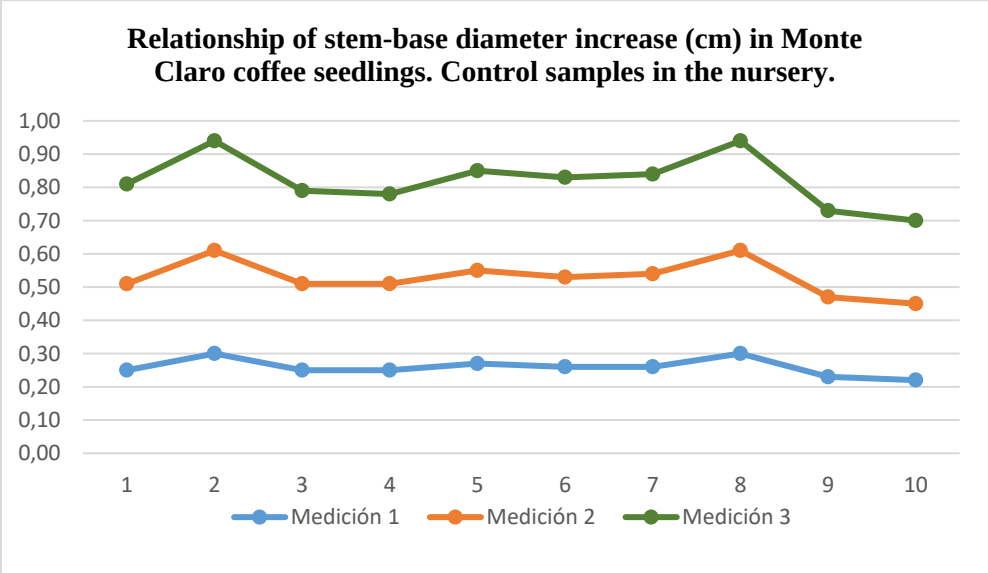

Figure 21. Variation in the stem base diameter of Monte Claro coffee seedlings from the start of the study (without Silabaal).

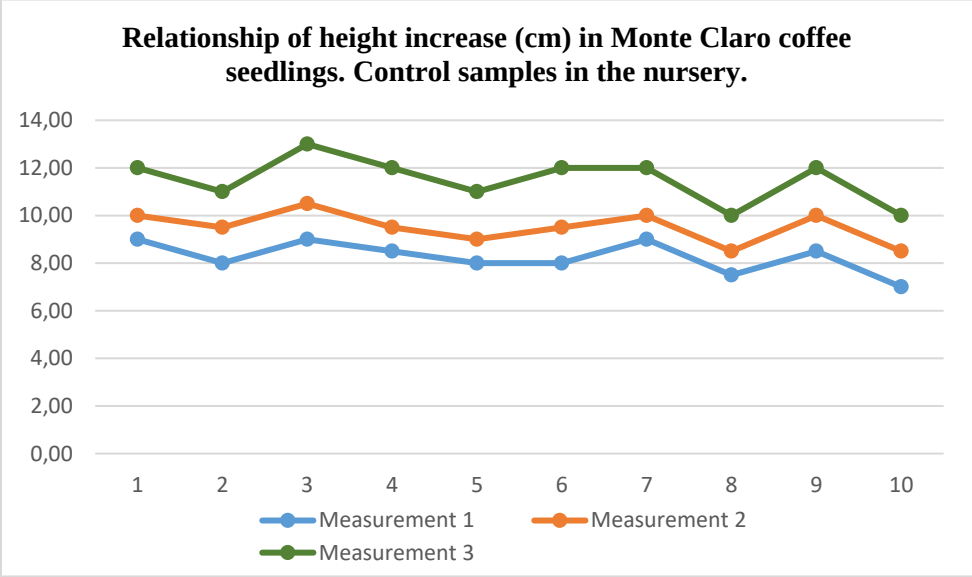

Figure 22. Variation in the height of Monte Claro coffee seedlings (without Silabaal).

Sustained though slow growth without Silabaal application represents the natural response of seedlings to environmental conditions and available soil bag substrate nutrients (sand and fertilized soil).

Table 9 shows a more rapid increase in seedling development in the nursery compared to the control samples, due to the advantages provided by the slow-release fertilizer Silabaal.

Table 9. Mean values (μ) for root-collar diameter (cm), foliage diameters, and height of Monte Claro coffee seedlings in the nursery (with Silabaal application).

	STEM COLLAR DIAMETER (cm)	AVERAGE DIAMETER 1 (cm)	AVERAGE DIAMETER 2 (cm)	AVERAGE HEIGHT (cm)
First Measurement (Day 0):	**0.26**	**11.70**	**9.60**	**11.15**
Second Measurement (Day 20):	**0.29**	**15.15**	**13.00**	**14.30**
Third Measurement (Day 46):	**0.33**	**20.60**	**17.50**	**18.50**

Source: Data obtained in the field.

Similarly, Figures 23 and 24, showing variations in seedling root-collar diameter and seedling height (cm), respectively, demonstrate substantial, accelerated growth; an increase of 0.05 to 0.07 cm in root-collar diameter and a significant increase of 5.00 to 10.00 cm in height were observed following six weeks of Silabaal fertilizer application.

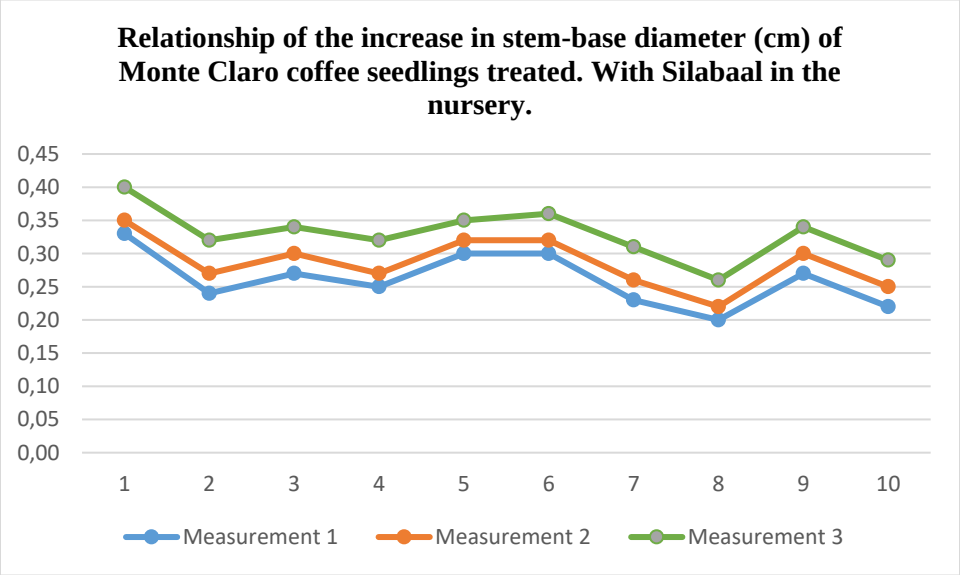

Figure 23. Variation in the stem base diameter of Monte Claro coffee seedlings from the start of the study (with Silabaal application).

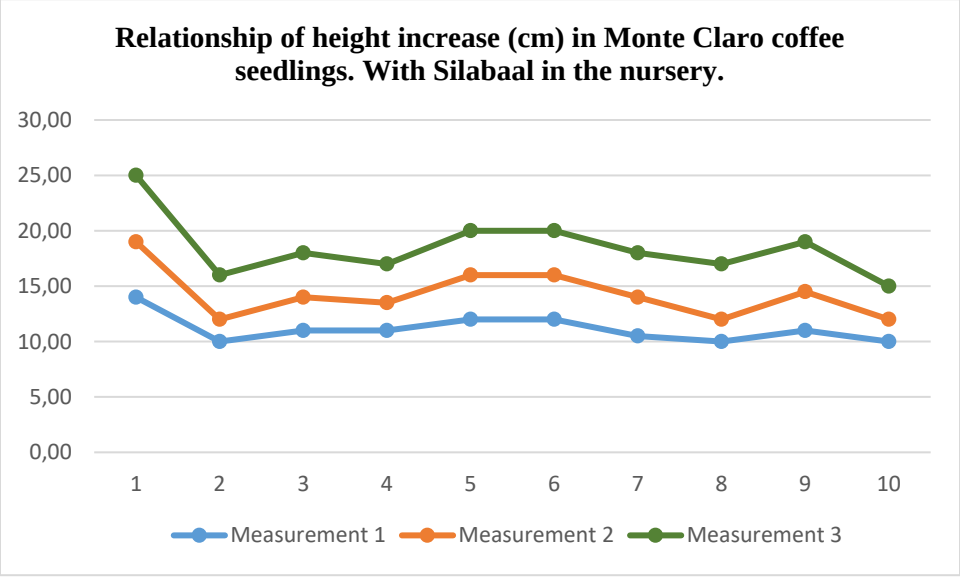

Figure 24. Variation in the height of Monte Claro coffee seedlings (with Silabaal application).

Regarding qualitative observations of variables such as size, leaf sheen, and the presence or absence of disease, all nursery seedlings exhibit favorable conditions—featuring good structural architecture, healthy leaf sheen, and no signs of disease or pathogens—with the only noticeable differences being size variations resulting from the application of Silabaal (Figures 25 - 28).

This has also resulted in zero mortality during the initial seedling development phase (mortality rate = 0%).

Control plot (without Silabaal). Pre-trial.	Control plot (without Silabaal). Six weeks into the trial.
	

Figures 25 and 26. Slow or gradual progression of seedling development in the nursery (without Silabaal).

Flowerbeds treated with Silabaal. Prior to the trial.	Flowerbeds treated with Silabaal. Six weeks into the trial.
	

Figures 27 and 28. Significant progress in seedling development in the nursery (with Silabaal).

4.3. Stage 3. Qualitative Evaluation of Development and Yield in Passion Fruit Crops, With and Without Silabaal Application

Overall, since the trial began, the passion fruit plants have demonstrated great adaptability to the environment, alongside favorable physical characteristics—specifically a 100% survival rate (0% mortality), good plant architecture, and healthy, glossy foliage—with no persistent pest infestations or signs of disease (Figures 29 and 30).

However, during the first six weeks of the trial, the passion fruit plants treated with Silabaal exhibited more rapid growth and entered the flowering stage earlier than the plants in the control rows (where no Silabaal was applied) (Figures 31 and 32).

Likewise, fruiting began in most of the rows treated with Silabaal, indicating that the product helped accelerate the harvest (Figures 33 and 34).

Figures 29 and 30. Visual view of passion fruit crops prior to the first application of Silabaal fertilizer (left) and six weeks after the product's application (right).

Incipient flowering (without Silabaal)

Full flowering (with Silabaal)

Figures 31 and 32. ***Left:*** Flowering on a passion fruit plant (without Silabaal). ***Right:*** Flowering on a passion fruit plant (with Silabaal).

Plants without fruit (without Silabaal)

Fruiting
(Six weeks with Silabaal application)

Figures 33 and 34. ***Left:*** Passion fruit plants (control row, without Silabaal) showing no fruiting. ***Right:*** Plant with fruit six weeks after the start of fertilization with Silabaal.

V. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Santa Ana farm is situated in an area with a rich tradition for growing permanent crops such as coffee, cocoa, and banana, and semi-permanent crops like passion fruit, sweet pepper, bell pepper, and long-cycle tubers (cassava and celery), favored by favorable climate and soil fertility. However, physical soil limitations exist, specifically slope compaction and high clay content on steeper gradients, whereas lower slopes feature looser, less compacted soils.

These constraints highlight the need for agronomic soil conservation and amendment practices to enhance fertility in compaction-prone areas. Implementing intercropping, such as shade-grown coffee and cocoa along contour lines, is essential for improving land capability.

Continuous fertilization using eco-friendly natural products like Silabaal 20–8–5 (compatible with efficient microorganisms) represents an excellent option for enhancing plant nutrition and productivity, as demonstrated over the six-week evaluation period.

Although the evaluation period was short, significant developmental gains were observed in established coffee plots (Monte Claro and Araguaney). Comparative differences were most pronounced in passion fruit crops and in the nursery stage of Monte Claro coffee seedlings, proving Silabaal's rapid action during early plant development stages.

5.2. Recommendations

It is necessary to continue the evaluations outlined in this study for at least another month to ensure the effectiveness of the Silabaal fertilizer on crops with mature plants, as well as to obtain comparative measurements of the quantity and weight of the fruit soon to be harvested from the passion fruit plot.

It is also recommended to monitor seedling field survival rate (%) post-transplant and maintain biweekly measurements synchronized with product application frequency.

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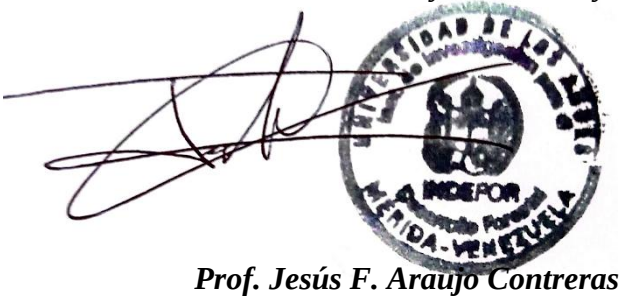
Study endorsed by:



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ANNEXES

Table 10. Data from the control plot (Without Silabaal) of Monte Claro coffee.

	First measurement			Second measurement			Third measurement		
Plant N°	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diámetro 1 (cm)**	**Diámetro 2 (cm)**	**Height (cm)**
1	51.00	48.00	49.00	51.50	49.00	49.50	53.00	50.00	51.00
2	56.00	48.00	50.00	56.50	49.00	50.50	58.00	50.00	51.00
3	52.00	29.00	43.50	53.00	29.50	44.00	54.00	30.00	45.00
4	39.00	54.00	54.00	39.00	54.50	54.50	40.00	56.00	55.00
5	43.00	42.00	43.00	44.00	42.50	44.00	45.00	43.00	45.00
6	39.50	32.00	51.00	40.00	33.00	51.50	40.00	33.00	52.00
7	75.00	79.00	68.50	75.00	80.00	69.00	76.00	80.00	70.00
8	70.00	73.00	65.00	70.50	73.50	65.00	71.00	75.00	66.00
9	87.00	53.00	63.00	87.00	54.00	63.00	89.00	55.00	64.00
10	68.00	54.00	70.00	68.50	54.00	71.00	70.00	55.00	72.00
μ =	**58.05**	**51.20**	**55.70**	**58.50**	**51.90**	**56.20**	**59.60**	**52.70**	**57.10**

Source: Data obtained in the field.

Table 11. Data from the treated plot (With Silabaal) of Monte Claro coffee.

	First measurement			Second measurement			Third measurement		
Plant N°	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**
1	80.00	70.00	70.00	81.00	72.00	72.00	83.00	75.00	74.00
2	112.00	99.00	90.00	115.00	105.50	92.00	120.00	110.00	95.00
3	80.00	67.00	68.00	81.50	69.00	70.00	83.00	71.00	71.00
4	95.00	78.00	87.00	99.00	80.00	90.00	105.00	83.00	92.00
5	80.00	77.00	83.00	84.00	78.00	86.00	89.00	80.00	89.00
6	80.00	64.00	89.00	82.00	66.00	86.00	86.00	68.00	84.00
7	111.00	84.00	112.50	115.00	87.00	116.00	120.00	89.00	120.00
8	98.00	78.00	80.00	99.00	79.00	82.00	101.00	81.00	84.00
9	90.00	60.00	80.00	91.00	62.00	81.00	93.00	64.00	83.00
10	76.00	65.00	75.00	79.00	66.00	77.00	83.00	68.00	80.00
μ =	**90.20**	**74.20**	**83.45**	**92.65**	**76.45**	**85.20**	**96.30**	**78.90**	**87.20**

Source: Data obtained in the field.

Table 12. Data from the control plot (Without Silabaal) of Araguaney coffee.

	First measurement			Second measurement			Third measurement		
Plant N°	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**
1	90.50	77.00	92.00	91.00	78.00	93.00	92.00	80.00	94.00
2	97.00	94.00	95.00	97.50	94.00	96.50	98.00	95.00	98.00
3	72.00	75.00	79.00	73.00	77.00	80.00	75.00	80.00	82.00
4	89.00	78.00	97.00	89.00	79.00	98.00	90.00	80.00	100.00
5	88.00	88.00	95.00	89.00	88.00	97.00	90.00	89.00	98.00
6	90.00	86.50	81.00	91.00	87.00	82.00	93.00	87.00	83.00
7	75.00	66.00	90.00	75.00	67.00	91.00	76.00	68.00	93.00
8	90.00	95.00	89.00	91.50	97.00	89.50	93.00	99.00	91.00
9	75.00	63.00	70.00	76.00	63.50	71.50	78.00	65.00	73.00
10	110.00	99.00	98.00	111.00	99.50	98.50	112.00	100.00	99.00
μ =	87.65	82.15	88.60	88.40	83.00	89.70	89.70	84.30	91.10

Source: Data obtained in the field.

Table 13. Data from the treated plot (With Silabaal) of Araguaney coffee.

	First measurement			Second measurement			Third measurement		
Plant N°	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**
1	90.00	90.00	94.00	92.00	92.00	96.00	95.00	96.00	100.00
2	100.00	111.00	103.00	101.00	113.00	105.00	105.00	115.00	108.00
3	81.00	86.00	85.00	82.50	87.00	87.50	85.00	90.00	90.00
4	67.00	61.00	78.00	69.00	63.00	79.00	73.00	65.00	81.00
5	78.00	67.00	76.00	78.50	67.50	78.00	80.00	68.00	81.00
6	83.00	80.00	77.00	83.50	82.00	79.00	85.00	85.00	80.00
7	76.00	78.00	90.00	78.00	79.00	91.00	80.00	80.00	93.00
8	85.00	88.50	88.00	87.00	89.00	90.50	89.00	90.00	92.00
9	90.00	90.00	90.00	91.00	91.00	90.00	94.00	93.00	92.00
10	60.00	66.50	71.00	62.50	68.00	73.00	66.00	70.00	75.00
μ =	81.00	81.80	85.20	82.50	83.15	86.90	85.20	85.20	89.20

Source: Data obtained in the field.

Table 14. Seedling data from Nursery (Without Silabaal).

	First measurement				Second measurement				Third measurement			
Seedling N°	**Stem Collar Diameter (cm)**	**Diameter 1 (cm)**	**Dameter 2 (cm)**	**Height (cm)**	**Stem Collar Diameter (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Stem Collar Diameter (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**
1	0.25	11.00	11.00	9.00	0.26	13.00	16.00	10.00	0.30	18.50	19.00	12.00
2	0.30	10.00	10.50	8.00	0.31	12.00	12.00	9.50	0.33	14.00	15.00	11.00
3	0.25	10.00	11.00	9.00	0.26	12.50	14.50	10.50	0.28	16.00	18.00	13.00
4	0.25	12.00	9.00	8.50	0.26	15.00	11.00	9.50	0.27	19.00	14.00	12.00
5	0.27	9.00	9.50	8.00	0.28	10.50	11.50	9.00	0.30	13.00	14.00	11.00
6	0.26	11.00	11.50	8.00	0.27	13.50	14.00	9.50	0.30	17.00	18.00	12.00
7	0.26	11.00	10.00	9.00	0.28	13.00	12.00	10.00	0.30	18.00	16.00	12.00
8	0.30	9.50	9.00	7.50	0.31	11.50	12.00	8.50	0.33	16.00	16.00	10.00
9	0.23	12.50	9.50	8.50	0.24	15.00	12.50	10.00	0.26	20.00	16.00	12.00
10	0.22	9.00	8.00	7.00	0.23	12.00	10.50	8.50	0.25	16.00	15.00	10.00
μ =	0.26	10.50	9.90	8.25	0.27	12.80	12.60	9.50	0.29	16.75	16.10	11.50

Source: Data obtained in the field.

Table 15. Seedling data from Nursery (With Silabaal).

	First measurement				Second measurement				Third measurement			
Seedling N°	**Stem Collar Diameter (cm)**	**Diameter 1 (cm)**	**Dameter 2 (cm)**	**Height (cm)**	**Stem Collar Diameter (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**	**Stem Collar Diameter (cm)**	**Diameter 1 (cm)**	**Diameter 2 (cm)**	**Height (cm)**
1	0.33	10.00	10.50	14.00	0.35	13.50	14.00	19.00	0.40	18.00	18.00	25.00
2	0.24	12.50	9.00	10.00	0.27	16.00	11.00	12.00	0.32	22.00	15.00	16.00
3	0.27	12.00	9.50	11.00	0.30	15.50	12.00	14.00	0.34	22.00	18.00	18.00
4	0.25	13.50	10.00	11.00	0.27	16.50	13.50	13.50	0.32	23.00	18.00	17.00
5	0.30	11.00	8.00	12.00	0.32	15.00	13.50	16.00	0.35	20.00	16.00	20.00
6	0.30	14.00	10.00	12.00	0.32	18.00	14.00	16.00	0.36	24.00	20.00	20.00
7	0.23	13.50	11.50	10.50	0.26	17.00	16.00	14.00	0.31	23.00	20.00	18.00
8	0.20	10.00	9.50	10.00	0.22	13.00	12.00	12.00	0.26	17.00	17.00	17.00
9	0.27	10.00	9.00	11.00	0.30	13.00	12.00	14.50	0.34	18.00	17.00	19.00
10	0.22	10.50	9.00	10.00	0.25	14.00	12.00	12.00	0.29	19.00	16.00	15.00
μ =	0.26	11.70	9.60	11.15	0.29	15.15	13.00	14.30	0.33	20.60	17.50	18.50

Source: Data obtained in the field.

SUPPLEMENTARY PHOTOGRAPHIC EVIDENCE

Coffee seedlings in the nursery: control (left) and treated with Silabaal (right).
Image taken one (1) month after the treatment application began.

Batch of Monte Claro variety coffee, one (1) month after the application of Silabaal fertilizer began.

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