ORIGINAL ARTICLE

Effects of the Application of Mountain Microorganisms on Coffee Seedling Production

Efectos de la aplicación de microorganismos de montaña en la producción de plántulas de café

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ABSTRACT: This research aimed to assess the impact of applying mountain microorganisms (MM) on coffee seedling production. Two nurseries (A and B) were used with weekly and bi-weekly treatment applications. Plant height, leaf and root lengths, and dry matter content (DM) were measured. Results showed that Nursery A, with weekly treatments, exhibited greater height and leaf length growth compared to Nursery B. In the initial measurement, Nursery A accumulated more leaf DM than Nursery B. However, over time, both nurseries experienced a decline in DM. Root length variability was observed in both nurseries throughout the measurements. Treatments with MM from forest and coffee systems in Nursery A showed higher leaf DM accumulation in the initial measurement. In conclusion, MM application, especially with higher frequency, promoted coffee seedling growth. The results emphasize the need for detailed analysis to understand optimal root development conditions. The decline in DM over time is a natural response to active growth, indicating increased nutritional requirements. These findings support MM-based strategies for sustainable coffee seedling production.

Keywords: Nursery, Treatment, Forest, Growth, Agroecosystems.

RESUMEN: La investigación tuvo como objetivo evaluar el efecto de la aplicación de microorganismos de montaña (MM) en la producción de plántulas de café. Se utilizaron dos viveros (A y B) con aplicaciones de tratamientos semanales y quincenales. Se midió la altura de las plantas, la longitud de las hojas y raíces, así como el contenido de materia seca (MS). Los resultados mostraron que el Vivero A, con tratamientos semanales, tuvo un mayor crecimiento en altura y longitud de hojas en comparación con el Vivero B. En la primera medición, el Vivero A acumuló más MS foliar que el Vivero B. Sin embargo, a medida que avanzaba el tiempo, ambos viveros experimentaron una disminución en el MS. En la longitud de las raíces, se observó variabilidad en ambos viveros a lo largo de las mediciones. Los tratamientos con MM de bosque y café en el Vivero A mostraron una mayor acumulación de MS foliar en la primera medición. En conclusión, la aplicación de MM, especialmente con mayor frecuencia, promovió el crecimiento de las plántulas de café. Los resultados muestran la necesidad de análisis detallados para comprender las condiciones óptimas para el desarrollo de raíces. La disminución del MS con el tiempo es una respuesta natural al crecimiento activo y por tanto el aumento del requerimiento nutricional de las plántulas. Estos resultados respaldan estrategias basadas en MM para una producción sostenible de plántulas de café.

Palabras clave: Microorganismos, producción, efectos, plántulas, café, agroecosistemas.

INTRODUCTION

Mountain microorganisms, naturally found in various environments, play a crucial role in agriculture, demonstrating highly beneficial effects on crops (Campo-Martínez *et al.*, 2014). They contribute to crop protection against pathogens and pests through antagonistic processes, resulting in more resilient and healthy crops. Additionally, their involvement in soil fermentation improves soil conditions, enhancing nutrient assimilation and promoting vigorous plant growth (Umaña *et al.*, 2017).

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These microorganisms actively participate in organic matter decomposition, essential for nutrient availability. They also contribute to nutrient mineralization, facilitating the release of vital minerals for plant growth (Ararat, 2013; Apraez-Muñoz, 2016; Gil & Díaz, 2016; Flechas-Bejarano, 2020). Their role in nitrification, converting ammonia into nitrates, increases nitrogen availability, a crucial plant nutrient (Campo-Martínez *et al.*, 2014).

To ensure coffee quality and traceability in perennial crops like coffee, implementing best practices and technologies from early stages, such as germination and seedbeds, is crucial. This not only reduces costs but also provides better control over seedling management, ensuring high productivity in fields (Farfan *et al.*, 2015).

Agronomic management of coffee seedbeds is vital for a healthy and productive crop. Various alternatives, from organic to chemical management, exist, and using mountain microorganisms as biofertilizers could be an interesting option (Arcila *et al.*, 2007).

This research evaluates the effect of mountain microorganisms (MM) from coffee and natural forest agroecosystems on coffee seedling production. This offers an organic management alternative using resources from the region, potentially reducing production costs and promoting a more sustainable approach in coffee cultivation (Farfan *et al.*, 2015).

MATERIALS AND METHODS

Location

Microorganism capture occurred at Sinaí farm in Betania, La Argentina Huila, in two regional agroecosystems: a secondary forest with typical jungle vegetation and a 15-year-old coffee system in association with macadamia, leucaena, plantain, and guamos, certified under the Rain Forest Alliance seal.

Microorganism Capture

Microorganisms were collected using a substrate-based method involving cooked, unseasoned rice distributed in disposable containers, covered with nylon, and secured with elastic bands. These containers were taken to different agricultural systems for organism colonization (Collazos-Romo, 2011).

Microorganism Activation

After 20 days, system-specific mixtures were separately liquefied, incorporating one kilogram of molasses and six liters of boiled water into each treatment. These mixtures fermented for 15 days, applied to crops using a pump on leaves and soil (Collazos-Romo, 2011).

Coffee Seedbeds (Castilla Variety)

Two nurseries were established for Castilla variety coffee seedling production at Buenos Aires farm in El Retiro, La Plata Huila, at an altitude of 1460 m.a.s.l., with a temperature range of 22°C-25°C, warm climate, average daily precipitation of 3.5 mm, nighttime precipitation of 1.8 mm, and relative humidity between 97%-99%.

Treatment Application

Table 1 displays the different treatments applied, including their compositions. Treatments T1 and T2 are expressed as a 1:1 dilution (1 part MM from the forest or coffee system, 1 part molasses, 2 parts water). Treatments T3 and T4 are based on solid concentration in water, not expressible in the same manner as T1 and T2.

Variable Measurement

Three measurements of physiological development variables were conducted every 15 days from 70 days post-establishment:

Plant Height: Measured in centimeters from the soil to the highest point of each naturally positioned plant.

Leaf Length: Maximum length from one end to the other, covering the entire leaf length (Toledo, 1982).

Root Length: Measured in centimeters from the stem base to the longest point of the taproot (Toledo, 1982).

Dry Matter (Leaves and Roots): Three plants per treatment were weighed, dried in a microwave oven at 80°C for 1 hour, and re-weighed. Dry matter percentage was calculated using the formula:

% Dry Matter = (Dry Weight / Fresh Weight) * 100 (Ararat, 2013).

Research Type

Figure 1 illustrates the experimental design field layout, with nurseries organized based on application

TABLE 1. Composition of treatments

Treatment	Composition
T1	50 ml of forest + 50 ml of molasses + 1 lt of water
S2	50 ml of MM of Coffee System + 50 ml of molasses + 1 lt of water
S3	20 g of Safer Soil + 50 ml of molasses + 1 lt of water
S4	Control (20gr Regrowth/Master + 1 lt of water)

Source: Lizcano (2023) .

frequency (weekly and bi-weekly). Each nursery was subdivided into 3 blocks, each containing three repetitions of four different treatments (Lizcano, 2023). Statistical analysis was performed using the SAS program.

RESULTS

Figure 2 compares the average height of plants between Nursery A and Nursery B. The results indicate that the plants in Nursery A, where treatments were applied each week, are taller than those in Nursery B.

In Figure 3, the leaf lengths of the seedlings are contrasted between Nursery A and Nursery B. The data reveal that Nursery A has higher leaf length measurements compared to Nursery B.

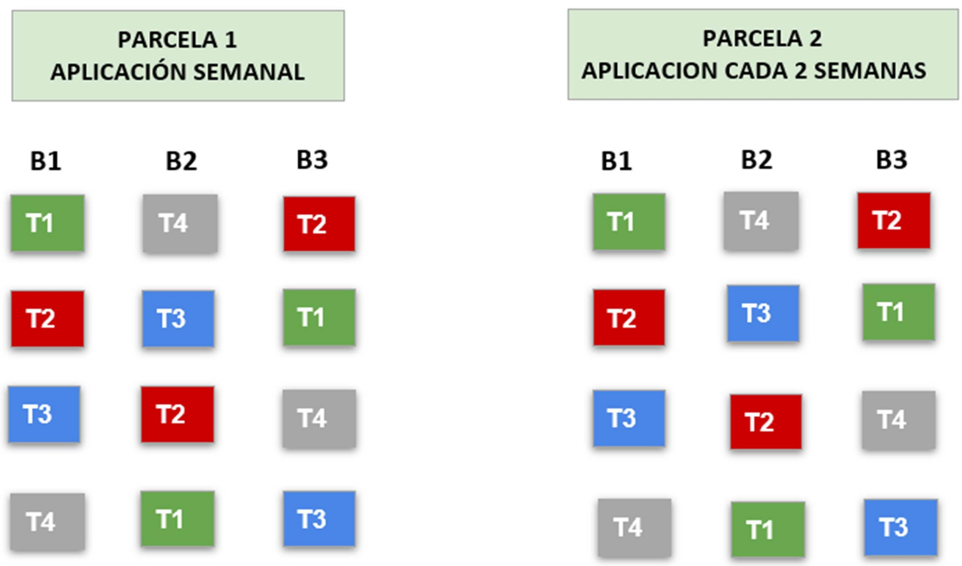
Figure 4 compares the root length of seedlings between Nursery A and Nursery B. It is observed that in Nursery A there is a growth of root length from the second measurement, while in Nursery B its growth is lower.

Figure 5 compares dry matter measurements at different times, and shows that as time passes, dry matter averages decrease in both Nursery A and Nursery B.

Figure 6 shows that foliar dry matter values in Nursery A tend to be higher compared to Nursery B in all three measurements. In Nursery A, treatments T1 and T2 show the highest foliar dry matter values at measurement 1. Nursery B shows greater variability in dry matter values between measurements and treatments compared to Nursery A.

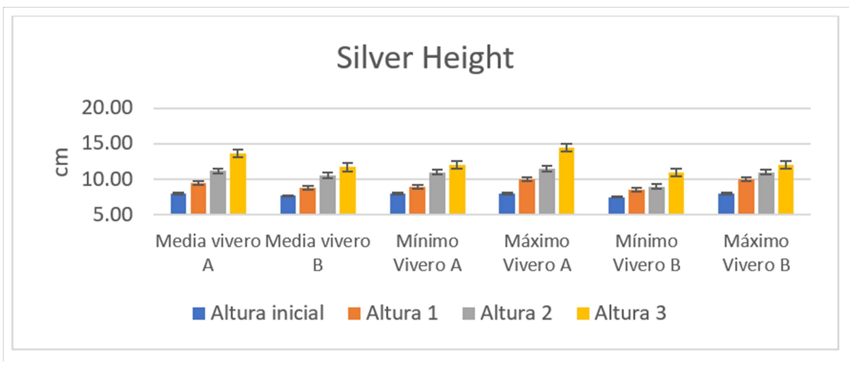
DISCUSSION

The results of this research suggest that seedlings in Nursery A tend to grow faster and reach higher average heights compared to Nursery B; they also tend to develop longer leaves over time. These findings support the idea that the frequency and type of treatments applied in Nursery A have a positive impact on the growth of coffee seedlings. However, it is important to consider the variability in the



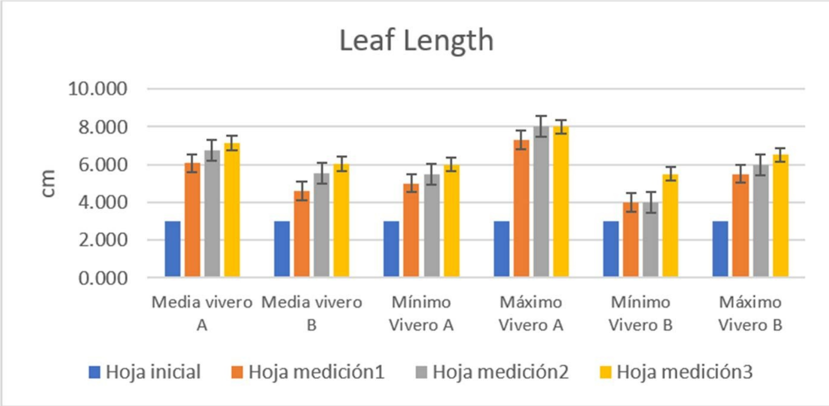
Source: Lizcano (2023) .

FIGURE 1. Experimental Design Field Layout:



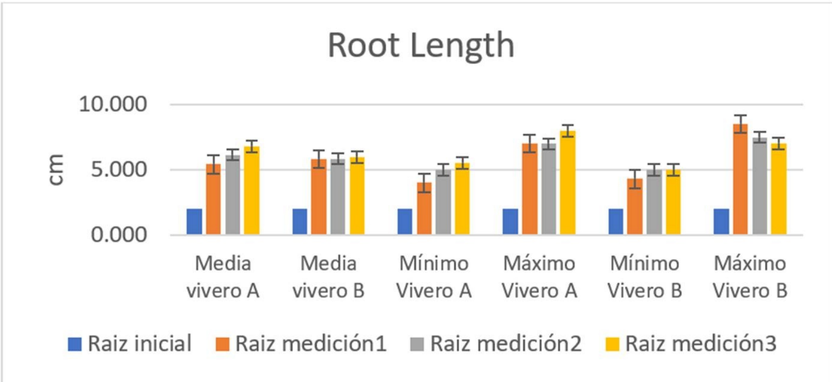
Source: Lizcano (2023) .

FIGURE 2. Silver Height Chart.



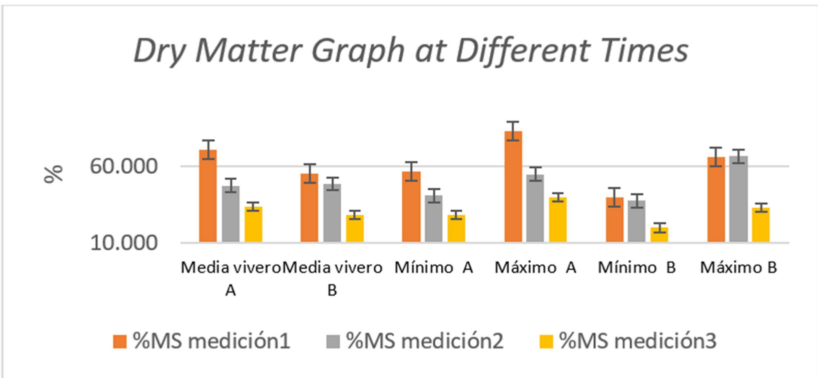
Source: Lizcano (2023) .

FIGURE 3. Leaf Length Graph.



Source: Lizcano (2023) .

FIGURE 4. Root Length Graph.



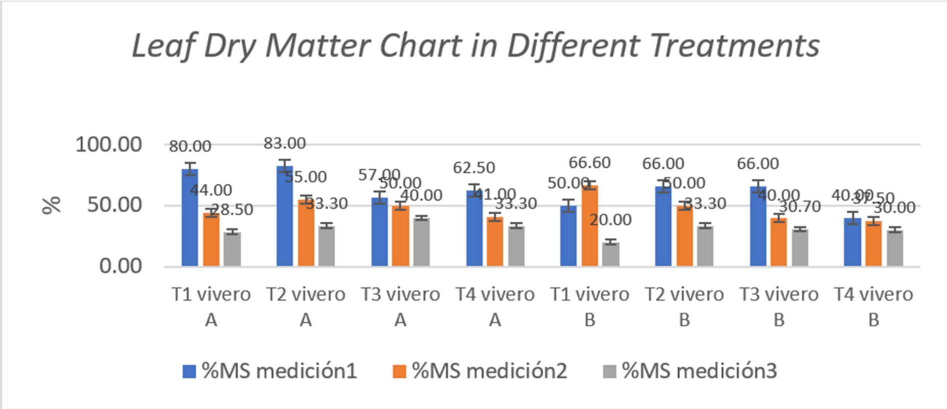
Source: Lizcano (2023)

FIGURE 5. Dry Matter Graph at Different Times.

results and conduct a more detailed analysis to fully understand the optimal conditions affecting the growth of coffee seedlings.

Moreover, there is variability in the growth of the roots of the seedlings in both nurseries over the measurements, suggesting that this process does not follow a constant pattern. While in some measurements, Nursery A shows longer roots, in the initial measurement.

These findings underscore the complexity of coffee seedling root growth and suggest that multiple factors may be influencing this process, such as the applied treatments, soil conditions, nutrient availability, and other environmental factors. Therefore, a more detailed analysis and a thorough evaluation of these factors are required to fully understand the optimal conditions impacting the development of coffee seedling roots in both nurseries. This information is



Source: Lizcano (2023) .

FIGURE 6. Leaf Dry Matter Chart in Different Treatments.

crucial for making informed decisions on cultivation practices and management in coffee production to achieve optimal seedling growth.

Measurements of dry matter provide important information about the solid content in coffee seedlings, which can be related to their health and growth status. Overall, seedlings in Nursery A show higher dry matter percentages in the first measurement (70.625%) compared to Nursery B (55.500%). This indicates that, at the beginning of the study, seedlings in Nursery A accumulate drier matter in their tissues.

However, in subsequent measurements, a decrease in dry matter percentages is observed in both Nursery A and Nursery B. In the third measurement, Nursery A has a %DM of 33.775%, while Nursery B has a %DM of 28.500%. This suggests that over time, seedlings in both nurseries are losing dry matter in their tissues.

The decrease in dry matter percentages as time progresses is a natural response to the active growth and development of coffee seedlings, as well as the interaction of multiple factors, including treatments, environmental conditions, and changing developmental phases. This is a common dynamic in plants and reflects the redistribution of resources and nutrients as plants adapt to their changing needs.

The results of leaf dry matter percentages in different treatments and measurements in Nurseries A and B show some interesting trends. In measurement 1, treatments in Nursery A show significantly higher leaf dry matter values compared to Nursery B. This indicates that in Nursery A, where treatments were applied weekly, seedlings had a greater accumulation of leaf dry matter in the initial stage of the study. In subsequent measurements, although values decrease in both Nursery A and Nursery B, Nursery A continues to maintain higher values overall. This suggests that over time, seedlings in Nursery A continue to have a higher concentration of leaf dry matter compared to Nursery B, despite the decrease in both cases.

In Nursery A, treatments T1 and T2 show the highest leaf dry matter values in measurement 1. These treatments include microorganisms captured in a forest system and a coffee system, respectively. This suggests that the introduction of these microorganisms may have stimulated the accumulation of leaf dry matter in the early stage. In Nursery B, there is greater variability in leaf dry matter values between measurements and treatments compared to Nursery A; this could be due to the variable response of seedlings to treatments or other factors influencing dry matter content.

These results indicate that the frequency of treatment application and their composition have an impact on the concentration of leaf dry matter in coffee seedlings. Additionally, Nursery A shows higher dry matter values overall, suggesting that the weekly application of treatments could be more effective in promoting the accumulation of leaf dry matter. The variability in the results of Nursery B suggests that the response to treatments may be more variable in that environment. These findings are relevant to understanding how to improve the growth and development of coffee seedlings in nurseries and can guide nutritional management strategies in coffee production.

CONCLUSIONS

In general, seedlings in Nursery A show higher dry matter percentages in the first measurement (70.625%) compared to Nursery B (55.500%). This indicates that, at the beginning of the study, the seedlings in Nursery A accumulate drier matter in their tissues.

However, in subsequent measurements, a decrease in the percentages of dry matter is observed in both Nursery A and Nursery B. In the third measurement, Nursery A has a %DM of 33.775%, while Nursery B It has a %MS of 28,500%. This suggests that as time passes, seedlings in both nurseries are losing dry matter in their tissues.

The application of mountain microorganisms, especially with greater frequency, promoted the growth of coffee seedlings.

The results support strategies based on mountain microorganisms for sustainable production of coffee seedlings.

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