Morphological response of the 'Barraganete' plantain (*Musa* AAB) to magnesium levels under dryland conditions

Respuesta morfológica del plátano 'Barraganete' (*Musa* AAB) con niveles de magnesio en condiciones de secano

Resposta morfológica da banana 'Barraganete' (*Musa* AAB) aos níveis de magnésio em condições de sequeiro

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Abstract

Plantain (*Musa* AAB) is a crop of great economic importance in Ecuador due to its extensive planting area, high production, and job creation. Considering its high nutrient requirement, this research was conducted to evaluate the response of morphological variables in 'Barraganete' plantain (*Musa* AAB) to the application of different levels of magnesium. An experiment was carried out in 'El Carmen' canton, province of Manabí, Ecuador (-0,259503 S, -79,427558 W), which included six levels of Mg application (0, 25, 50, 75, 100, and 125 kg.ha^{-1}), under a randomized complete block design with three replications. The variables evaluated (plant height, pseudostem circumference, leaf length and width, leaf area, and total leaves) were subjected to repeated measures analysis over time, with weekly measurements. Statistical analyses showed that the morphological variables evaluated did not present significant differences between Mg doses; however, the temporal analysis highlighted that the highest doses promoted greater growth of vegetative organs. Overall, the results suggest that Mg application at doses equal to or greater than 50 kg.ha^{-1} could be considered. This finding supports the need for future studies to compare morphological variables with yield, as well as evaluate profitability, to provide useful information for improving crop production under the study conditions.

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Resumen

El plátano (*Musa* AAB) es un cultivo de gran importancia económica en Ecuador debido a su extensa superficie de siembra, alta producción y generación de empleos. Considerando su elevado requerimiento de nutrientes, se condujo esta investigación para evaluar la respuesta de variables morfológicas en plátano 'Barraganete' (*Musa* AAB) ante la aplicación de diferentes niveles de Mg. Se realizó un experimento en el cantón "El Carmen", provincia de Manabí, Ecuador (-0,259503 S, -79,427558 O), que incluyó seis niveles de aplicación de Mg (0, 25, 50, 75, 100 y 125 kg.ha^{-1}), bajo un diseño de bloques completos al azar con tres repeticiones. A las variables evaluadas (altura de la planta, perímetro del pseudotallo, largo y ancho de la hoja, área foliar y hojas totales) se les aplicó un análisis de medidas repetidas en el tiempo, con mediciones semanales, Los análisis estadísticos demostraron que las variables morfológicas evaluadas no presentaron diferencias significativas entre dosis de Mg; sin embargo, el análisis temporal destacó que las dosis más altas promovieron mayor crecimiento de los órganos vegetativos; en general, los resultados indican que la aplicación de Mg en dosis iguales o superiores a 50 kg.ha^{-1} podrían considerarse, lo que sugiere estudios futuros en donde se compare variables morfológicas con el rendimiento, así como también la evaluación de la rentabilidad en aras de proporcionar información útil para mejorar la producción del cultivo en la zona bajo las condiciones de estudio.

Palabras clave: fertilización mineral, *Musa* AAB, crecimiento.

Resumo

A banana-da-terra (*Musa* AAB) é uma cultura de grande importância econômica no Equador devido à sua extensa área de plantio, alta produção e geração de empregos. Considerando sua alta necessidade de nutrientes, esta pesquisa foi conduzida para avaliar a resposta de variáveis morfológicas na banana-da-terra 'Barraganete' (*Musa* AAB) à aplicação de diferentes níveis de Mg. Um experimento foi conduzido no cantão "El Carmen", província de Manabí, Equador (-0,259503 S, -79,427558 O), em um projeto de blocos completos aleatórios e três repetições que incluíram seis níveis de aplicação de Mg (0, 25, 50, 75, 100 e 125 kg.ha^{-1}). As variáveis avaliadas (altura da planta, perímetro do pseudocaule, comprimento e largura da folha, área foliar e total de folhas) foram analisadas ao longo do tempo, com medições semanais, usando a metodologia de medidas repetidas. As análises estatísticas mostraram que as variáveis morfológicas avaliadas não apresentaram diferenças significativas entre as doses de Mg; no entanto, a análise temporal evidenciou que doses maiores promoveram maior crescimento dos órgãos vegetativos; de forma geral, os resultados indicam que a aplicação de Mg em doses iguais ou superiores a 50 kg/ha^{-1} pode ser considerada, sugerindo estudos futuros que comparem variáveis morfológicas com a produtividade, bem como avaliem a rentabilidade, a fim de fornecer informações úteis para melhorar a produção da cultura na área nas condições de estudo.

Palavras-chave: fertilização mineral, *Musa* AAB, crescimento.

Introduction

Worldwide, the production of the plantain crop (*Musa* sp.) in 2022 was distributed across Africa, America, Asia, and Oceania, with 51.63, 13.11, 7.0, and 0.03 %, respectively (Food and Agriculture Organization of the United Nations, FAOSTAT, 2022). Ramos *et al*. (2016) pointed out that, in 2011, Latin America produced 25 % of the nearly 38 million tons of plantain worldwide, with the main producers being Colombia, Peru, Cuba, Ecuador, the Dominican Republic, Bolivia, Venezuela, and Honduras.

The plantain crop represents a significant contribution to Ecuador's socioeconomics and food security, generating both permanent and seasonal employment, as well as providing a steady supply of energy-rich food to most of the population (Álvarez *et al*., 2020). The National Institute of Statistics and Census (INEC, 2023) reported a total of 1.4 million hectares with permanent crops for Ecuador in 2022, which represented 9.3 % of the total area for Musaceae. Of that area, 133,145 hectares correspond to the plantain crop; of these, 52,476 hectares are planted in the province of Manabí.

The average crop yield in Ecuador was 7.24 t.ha^{-1}.year^{-1}, which is relatively low compared to the yields obtained in other countries; the low productivity recorded is a consequence of biotic (pests and diseases), abiotic (drought) and technological (nutrition, low densities, irrigation, among others) problems; of the total planted area, only 14,33 and 34 %, receive irrigation, fertilization and phytosanitary treatments, respectively; that is, more than 60 % of the national surface does not have access to technology, which could be the origin of the low yields obtained (Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP), 2015).

The absence of fertilization plans that consider critical stages of the crop, soil types, water conditions, among other aspects, is one of the important factors that affect low yields. This requires an evaluation of the effect that certain key minerals may have on production parameters, under the specific conditions of each region where plantain are a potential crop. For this reason, magnesium has been considered an important element for plantain growth and production, which is reflected in the large quantities extracted in the field, which at harvest time is approximately 140 kg.ha^{-1}.year^{-1} (Avellán-Vásquez *et al*., 2020; Cobeña-Loor *et al*., 2020).

The response to mineral nutrition of morphological variables allows improving the production of Musaceae (plantains and bananas). The evaluation helps identify nutritional deficiencies and understand the interactions between nutrients, as well as develop fertilization strategies that optimize plant growth and yield (Rodrigues *et al*., 2021).

Magnesium (Mg^{2+}) is an essential macronutrient in crop physiology since it plays a key role in chlorophyll synthesis, photosynthesis, nutrient metabolism, cell membrane stability, and enzymatic activation (Ferreira *et al*., 2023). In addition, its role in plant resistance to various environmental stressors has been widely documented (Chen *et al*., 2018; Kumari *et al*., 2022). Even with advances in understanding its impact on agricultural crops, its influence continues to be explored (Crusciol *et al*., 2019; Qin *et al*., 2020; Heidari *et al*., 2021; Sharma *et al*., 2022). This information is relevant since Mg^{2+}, by contributing to plant growth and development, also improves quality attributes such as flavor, texture, and post-harvest shelf life (Adnan *et al*., 2021).

Considering the above, this research aimed to evaluate different doses of magnesium in the 'Barraganete' plantain crop (*Musa* AAB) in the canton of El Carmen, Province of Manabí, Ecuador, under dryland conditions and its effect on the morphological response.

Materials and methods

The trial was carried out at the Río Suma Experimental Farm, Eloy Alfaro Lay University of Manabí (ULEAM), El Carmen extension, located in El Carmen Canton, Province of Manabí, UTM coordinates -0.259503 S, -79.427558 W, and an altitude of 263 meters above sea level, during the period April 2018-May 2019. The study area has an average temperature of 24.15 ºC, annual rainfall of 2684 mm.year$^{-1,}$ relative humidity equal to 85.6 %, a heliophany of 553 h.light^{-1}.year$^{-1,}$ and average annual evapotranspiration of 1,089.65 mm.

Mother plants of 'Barraganete' plantain were selected considering morphological and phytosanitary characteristics and yield, such as a greater number of leaves, pseudostem with good diameter, low presence of black sigatoka (*Mycosphaerella fijiensis*), reduced presence of black palm weevil (*Cosmopolites sordidus*), and bunches with a greater number of exportable hands and fingers. In the first nursery phase, corms with an approximate weight between 300 and 400 g were selected from them and were planted in 10" x 12" bags containing sawdust as substrate. Cultural practices and phytosanitary control were followed according to the methodology of Sánchez-Urdaneta *et al*. (2022). After 12 weeks, when the plants had reached a height of more than 20 cm and had approximately four developed leaves, they were planted in their final place in the field (May-2019). The planting distance was 2.5 m x 1.80 m, for a population of 2,222 plants.ha^{-1}.

The research was conducted under dryland conditions, and all the cultural practices required in the management of the crop were applied, such as weeding, removal of dry or damaged parts of the stem, phytosanitary control (pests, diseases, and weeds), and fertilization (Sánchez-Urdaneta *et al.*, 2022). In this last practice, a balanced fertilization of NPK was applied, with N = 100, P_2O_5 = 40, and K_2O = 150 kg.ha^{-1}, using urea (46 % N), phosphate urea (17 % N, 44 % P_2O_5), and potassium oxide (60 % K_2O) as sources. The applications were made fractionally at three key moments of the vegetative cycle, which coincided with the formation of 6, 12, and 18 leaves, in order to optimize nutrient absorption and reduce losses due to leaching or volatilization, as indicated by Avellán-Vásquez *et al.* (2020) and Cobeña-Loor *et al.* (2020).

Prior to planting in the field, a soil analysis was carried out to determine the amount of nutrients available, which revealed a moderately acidic pH (5.76), suitable for the development of plantain crops, accompanied by a high content of organic matter (6.47 %) and a low electrical conductivity (0.28 dS.m^{-1}), which indicated the absence of salinity. Potassium (0.69 meq.100 g^{-1}), calcium (9.00 meq.100 g^{-1}), and zinc (8.90 ppm) levels were optimal, favoring good plant nutrition. However, deficiencies of boron (0.17 ppm) and manganese (1.90 ppm) were detected, as well as suboptimal Mg/K and (Ca+Mg)/K cation ratios, which could affect the efficiency in nutrient absorption. The soil presented a loamy texture, favorable for root development and moisture retention.

The following vegetative variables were evaluated: plant height (from the base of the pseudostem to the intersection of the last level of unfolded leaves, in m); pseudostem circumference (at 1 m from the soil surface, in cm); leaf length (on the third leaf, from the junction of the petiole with the lamina to the apex, in m); leaf width (on the third leaf, in the middle of the leaf lamina, in m); leaf area (which was estimated based on the length and width of the most recently emerged third leaf; Kumar *et al*., 2002) and total number of leaves (leaves fully expanded at the time of assessment, including the youngest leaf with approximately 80 % leaf expansion; completely dry or fallen senescent leaves were not counted). These variables were measured weekly from week 10 until the time of the inflorescence emission.

The experiment was carried out under a randomized complete block design, where six treatments were applied, corresponding to the doses of MgO: 0, 25, 50, 75, 100, 125 kg.ha^{-1}. The first application was made in week 14 (6th leaf emitted), 2nd application in week 20 (12 leaf emitted), and 3rd application in week 26 (18 leaf). They were applied in three fractions, together with the base fertilization. Each treatment consisted of three replications and 16 plants per experimental unit for a total of 288 plants. From each plot, 4 plants were taken as a sampling unit, for a total of 72 plants evaluated during the research.

Analysis of variance and Tukey's mean tests were performed. The variables evaluated were analyzed over time, with weekly measurements, using the methodology of repeated measures over time (SAS® statistical program, version 9.1.3 (Statistical Analysis System, 2023), selecting the polynomial models that best explained their behavior. For data processing, the GLM and MIXED procedures of the SAS statistical program were used; the verification of the assumptions of normality and homogeneity of variances was carried out using the Shapiro-Wilk and Levene tests, respectively.

Results and discussion

Plant height and pseudostem circumference

The analysis of repeated measures over time showed statistically significant differences (P<0.0001) in plant height and pseudostem circumference of the 'Barraganete' plantain throughout the evaluations. However, this analysis did not determine significant differences for the variables mentioned due to the fertilization with Mg. The differences became evident when statistical analyses were performed in particular weeks according to the phenological stages of the crop, which for both variables were presented in weeks 30 and 40 (P<0.046 and P<0.02, respectively for height and P<0.05 and P<0.043, respectively for the circumference), reflected in figures 1A and 1B by the separation of the curves.

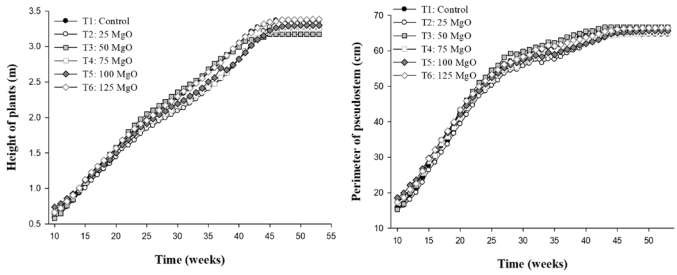

Figure 1. Plant height (A) and pseudostem circumference (B) of 'Barraganete' plantain (*Musa* AAB), under different doses of Mg fertilization, in El Carmen, Ecuador.

Plant height increased progressively over time, which is an expected behavior due to the natural growth of the crop (Figure 1A). This variable presented a characteristic pattern, a progressive growth that was rapid at the beginning of the research and later stabilized towards the end of it, agreeing with the phenological stages of the crop. The decrease in the elongation rate occurred between weeks 40 and 46, which coincided with the beginning of the flowering stage. During this phase, the photoassimilates are redirected towards the formation of the fruits, limiting vegetative growth.

The average height of the plants in all treatments at the end of the evaluations was 3.28 m, with a range between 2.99 and 3.39 m, corresponding to the doses of 50 and 125 kg.ha^{-1} of Mg, respectively. The absence of effect of Mg fertilization for all the phenological stages on plant height may indicate that, within the dose range studied, the amount of mineral applied had little influence on the vertical growth of the plant. However, Ahmed *et al.* (2023) have pointed out that Mg should be considered to have other beneficial effects for the plant, such as improving soil quality, nutrient absorption, increasing resistance to pests and diseases, among others, which may not be reflected in the plant height.

In contrast to the results obtained, Vivas-Cedeño *et al*. (2023), whose experimental plantation was also in dryland conditions, noted that fertilization with Mg influenced plant height and the number of functional leaves at harvest, where plants fertilized with 20 kg.ha^{-1} reached an average height of 4.10 m, and with 60 kg.ha$^{-1,}$ the height increased to 4.27 m, differing by approximately 80 cm from the height of the plants evaluated in this research.

Concerning the pseudostem circumference, an initial phase of rapid expansion was observed in the first weeks, followed by a deceleration as the plant reached the state of structural maturity. This pattern is characteristic of the plantain crop, in which the initial growth is dominated by cell division and elongation, while in later stages it stabilizes as the plant prioritizes flowering and progress in the development of the fruit. The increase in pseudostem circumference over time is a reflection of the plant's vegetative development and is influenced by the accumulation of biomass and cell expansion in response to the availability of nutrients, water, and environmental conditions. The average of this variable was 65.72 cm, with values at the end of the evaluations of 64.61 and 66.69 cm for 50 and 75 kg.ha^{-1} of Mg, respectively (Figure 1B).

González-García *et al.* (2021) found that the pseudostem circumference of the 'Hartón' plantain varied between 59.44 and 66.86 cm, slightly resembling the results obtained in this research. On the other hand, Delgado *et al*. (2008) in the state of Barinas, Venezuela, indicated that the pseudostem circumference of the 'Hartón' plantain reached 55.9 cm, which suggests that the soil and climatic conditions where the plants grow have a marked influence on their growth and development. Meanwhile, Rodríguez *et al.* (2018) indicated that the plant height and its circumference depend on the clone evaluated and will subsequently be influenced by its vigor according to the phenological stage of its growth. While it is true that the genetic constitution of crops plays a major role in their growth and development, factors related to the physical, chemical, and mineralogical composition of soils also influence crop behavior.

Length, leaf width, and leaf area

The analysis of repeated measures over time showed statistically significant differences (P<0.0001) in the variables leaf area, length, and leaf width of the 'Barraganete' plantain because of the evaluation time. In contrast, no differences were detected in the variables mentioned due to the effect of the Mg application. However, when performing statistical analyses in specific weeks according to the phenological stages of the crop, statistically significant differences were found for the effect of the Mg dose applied. For leaf length, these differences corresponded to weeks 25 to 40 (P<0.04; P<0.001, P<0.002, and P<0.03; respectively), where the curves showed a pronounced separation between treatments (Figure 2A).

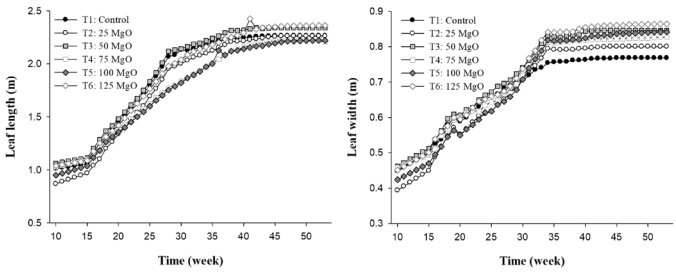

Figure 2. Length (A) and width (B) of the third leaf of the 'Barraganete' plantain plants (*Musa* AAB), under different doses of Mg fertilization, in El Carmen, Ecuador.

The longest leaf length was recorded in the treatments of 50 kg.ha^{-1} (2.34 m) and 125 kg.ha^{-1} Mg (2.38 m) at 53 weeks. In contrast, treatments with 75 and 100 kg.ha^{-1} Mg showed the lowest leaf lengths from week 21 to the end of the experiment in week 53. These results suggest that the effect of Mg on leaf elongation was not linear but presented an optimal point in the applied dose range.

In general, from week 15 to week 30, leaf growth was accelerated, with an average rate of increase of 1.88 times compared to the initial period. Subsequently, from week 30 to week 50, the rate of elongation decreased significantly, with an increase of only 1.04 times (Figure 2A). This trend suggested that in the initial stage of leaf development, there was greater cell division and elongation, which drove more pronounced growth. In the advanced stages, growth slowed due to the redistribution of resources to other physiological processes, such as the formation of reproductive organs and the maturation of the pseudostem.

Regarding the leaf width, it was evident that it presented two well-defined phases: an accelerated growth phase (week 10-30), during which the leaf width experienced an average increase of 1.85 times with respect to its initial value. The second phase considered stabilization (week 30-53), where the rate of increase in leaf width was reduced, showing a less pronounced slope in the growth curve. This deceleration could be related to the transition from vegetative to reproductive growth, which prioritizes the redistribution of resources towards the pseudostem and the formation of the inflorescence. Statistically significant differences were found because of the Mg dose from week 23 to week 40 (P<0.05), where the curves showed a pronounced separation between treatments. Treatments with Mg applications were statistically different from the control (Figure 2B).

Between weeks 10 and 20, the leaf width was progressive, reaching the highest values in the treatments 50 and 75 kg.ha^{-1} Mg. From week 21, a sustained increase was recorded until reaching its maximum value in week 42 in the 125 and 50 kg.ha^{-1} Mg treatments, with values of 0.85 and 0.84 m, respectively. In contrast, treatments with 0 and 25 kg.ha^{-1} Mg showed the lowest leaf widths from week 21 until the end of the study (Figure 2B). These results suggest that the response of leaf width to Mg fertilization was not linear but exhibited an optimal effect within the range of doses evaluated.

In a study comparing the agronomic characteristics of two plantain genotypes (Prata and PA 42-44), it was determined that there were no differences for the variables length (170.42 cm and 165.40 cm, respectively) and width of the third leaf (67.93 cm and 66.14 cm,

respectively) for the first crop cycle at the time of flowering; while for other vegetative variables such as pseudostem circumference, number of leaves and leaf area 'Prata-Anã' presented values higher than those of PA42-44 in more than one cycle, which demonstrates the variability between genotypes, despite being the parent and progeny, respectively (Rocha *et al*., 2011). Ferreira *et al.* (2020), estimating the leaf area of 'Prata-Anã' and 'BRS Platina' plantain plants with lanceolate leaves, determined that the average leaf length was 32.93 and 35.23 cm, respectively, while for the width it was 5.20 and 6.18 cm, respectively. The width, length, and width/length ratio of lanceolate leaves of the 'Prata-Anã' and 'BRS Platina' plantain plants were significantly correlated with leaf area, with the highest correlation being for 'BRS Platina'.

In previous research, the average leaf length and width were lower than those found in this research, although plantain and banana are not fully comparable, both are AAB triploids, sharing a similar genome. Another aspect to consider is the environmental effect that determines growth patterns derived from climatic, edaphic, and plantation management conditions.

Concerning the leaf area variable, the values ranged from: 1.51 to 2.59 m² (25 and 75 kg.ha^{-1} Mg) in week 10; from 6.69 to 9.82 m² (25 and 50 kg·ha^{-1} Mg) in week 20; from 18.25 to 23.93 m² (25 and 50 kg·ha^{-1} Mg) in week 30; from 30.15 to 35.40 m² (control and 50 kg·ha^{-1} Mg) in week 40; and from 32.34 to 38.12 m² (control and 50 kg·ha^{-1}) in week 46 (Figure 3A).

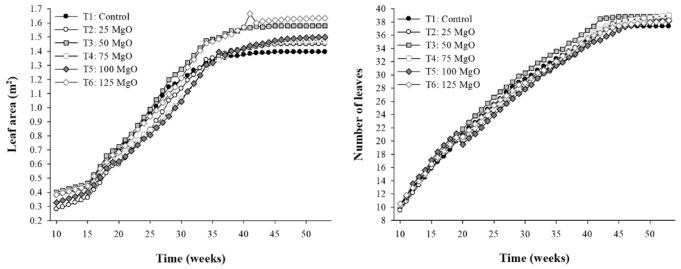

Figure 3. Leaf area of the third leaf (A) and number of total leaves (B) of 'Barraganete' plantain (*Musa* AAB), under different doses of fertilization with Mg, in El Carmen, Ecuador.

When evaluating specific weeks corresponding to the main phenological stages of the crop, statistical differences (P<0.045) were found in weeks 30 and 40; in week 30 between treatments 0, 25, 50, and 125 kg.ha^{-1} Mg regarding the 75 and 100 kg.ha^{-1} treatments Mg. Finally, in week 40, these statistical differences (P<0.03) occurred between the treatments with higher doses (50, 75, 100, and 125 kg.ha^{-1} Mg), compared to the lowest doses (0 and 25 kg.ha^{-1} Mg). During these phenological stages, the leaf growth curves showed a clear separation between treatments (Figure 4A), which indicated a differentiated response of the plant to Mg fertilization at all stages of development, establishing that the influence of Mg on this variable depends on both the phenological stage and the doses of Mg applied. These results suggest that the effect of Mg on leaf growth is not necessarily proportional to the dose applied and suggest that the optimal point is between 50 and 75 kg.ha^{-1} Mg.

Another important aspect to highlight is that the dynamics of the leaf area over time responded according to what has already been described, its magnitude decreased as the plant approached the emission of the inflorescence; this could be due to a lower rate of leaf emission, a reduction in leaf lamina size, a reduction in the longevity of the last leaves, or a combination of all these factors.

Sahu *et al*. (2023) in plantaind with Ca and a dose of nutrients-NPK (RDN), on growth and production variables, demonstrating that the application of calcium levels (150 and 300 g.plant^{-1}) and magnesium (75 and 150 g.plant^{-1}) had a significant effect on leaf area (LA) compared to the control. The highest LA (10.19 m^2) was found with the RDN + calcium treatment (150 g.plant^{-1}), similar to the RDN + magnesium treatment (150 g.plant^{-1}) + calcium (150 g.plant^{-1}) and RDN + magnesium (150 g.plant^{-1}) + calcium (300 g.plant^{-1}), while the minimum leaf area (6.07 m^2) was recorded with the control. These treatments differed from those obtained in the present study, where the application of Mg did not have a significant effect on this variable.

Number of total leaves

For the number of total leaves of the 'Barraganete' plantain, the analysis of repeated measures over time showed significant differences (P<0.04). On the contrary, when evaluating specific weeks that corresponded to phenological stages of the crop, no statistically significant differences (P>0.6276) were found due to the dose of Mg applied. The total number of leaves on the plantain plant averaged approximately 38 leaves throughout the entire crop cycle. Leaf emission was approximately 0.7 leaves.week^{-1}, and between weeks 43 and 44, the emission of new leaves ceased; the average number of leaves towards the end of the observations was 36 leaves (Figure 3B). It is highlighted that fertilization with Mg did not determine the number of total leaves during the crop cycle, which leads to the presumption that this variable has more to do with the genetic constitution of the plant than with the application of this mineral.

Vivas-Cedeño *et al.* (2023) indicated that the highest number of leaves at flowering was obtained with the doses of 40 and 60 kg.ha^{-1} Mg (8.5 leaves), and with the dose of 20 kg.ha^{-1}, the lowest number was produced at harvest (7.56 leaves), these values being higher than those achieved in this research. Likewise, Sahu *et al.* (2023) in plantain (*M. paradisiaca*), where different doses of Mg combined with Ca and a recommended dose of nutrients-NPK (RDN) were evaluated, determined that the application of different levels of Ca (150 and 300 g.plant^{-1}) and Mg (75 and 150 g.plant^{-1}) exerted a significant effect on the number of leaves·plant^{-1} compared to the control. The maximum number of leaves·plant^{-1} (27.11) was found with RDN + Ca 150 g.plant^{-1} treatment), as well as with RDN + Mg (150 g.plant^{-1}) + Ca (150 g.plant^{-1}); The lowest number of leaves. plant^{-1} (14.22) was recorded with the control treatment.

Conclusions

The morphological variables evaluated did not show a clear response to Mg doses, as there was no reaction to their application during the crop cycle, except in specific stages, depending on the vegetative organ and its quality. The differences observed in these variables were related to the time of evaluation, determined by genetic and environmental factors that, in combination, determined the expected growth pattern. In general, the results suggest that applying Mg at doses equal to or greater than 50 kg.ha^{-1} could be considered, suggesting future studies to compare morphological variables with yield, as well as evaluate profitability, to provide useful information for improving crop production under the study conditions.

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