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Banana cavendish seedling growth affected by corm size

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ABSTRACT

The propagation of banana seedlings in nurseries is an essential practice to increase productivity in a shorter period. This study aimed to determine the influence of corm size on the initial growth of Williams banana seedlings. The research was conducted at the "La María" Campus of the Universidad Técnica Estatal de Quevedo, Ecuador, between November 2022 and February 2023. A total of 150 corms were planted in controlled conditions using a specific substrate. The corms were classified into three categories: small, medium, and large. Growth parameters such as height, diameter, fresh and dry biomass, number of leaves, and phyllochronic index were evaluated. Results indicated that larger corms significantly increased plant height and diameter compared to smaller and medium-sized corms. Additionally, larger corms contributed more to biomass accumulation in seedlings. However, no significant differences were observed in the number of leaves among treatments. The phyllochronic index was influenced by corm size, with an average of 7.72 days to produce a new leaf. The use of larger corms resulted in more vigorous and uniform banana seedlings, facilitating their adaptation to the field in less time.

Keywords: propagation; crop; fruit; biomass; pseudostem.

1. Introducción

The production of banana plants (*Musa* AAA) in the nursery is a crucial stage in the chain of this tropical fruit that is in high demand worldwide (Franco et al., 2023). In this process, the basis for a successful crop is established, since banana seedlings are generated that will later be transplanted to the field or to the defined production areas (Capa et al., 2016). One of the highlights that deserves special attention in this process is the selection and use of corms with different weights (Monterrosa & Bejarano, 2022). In addition, it allows you to select those that are free of pests and diseases, allowing you to obtain seedlings with good vegetative development (Manzo et al., 2014).

Bananas are one of the most consumed fruits in the world, and their production arouses constant interest in global agriculture (Martínez et al., 2023). To maintain the high demand for this fruit, it is essential to have healthy and vigorous banana plants that can withstand climatic challenges and biological threats in the field (Anchundia et al., 2021). The nursery stage plays an important role in obtaining quality seedlings that can ensure optimal performance in commercial production. One of the factors that significantly influence the quality of banana seedlings is the weight of the corms used in the propagation process (Galan et al., 2018). These organs are responsible for storing the nutrients necessary for the growth of new banana plants (Vargas, 2015).

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The careful selection of corms based on their weight is a practice that has gained recognition in the banana industry. Heavier ones tend to contain a higher amount of nutrients and reserves, which can accelerate the initial growth of seedlings and allow them to reach greater height and develop faster (Tigasi, 2017). These robust seedlings are beneficial for both marketing and subsequent planting in the field (Barrezueta et al., 2022). On the other hand, lighter corms may require a longer growing period in the nursery to reach proper size and development before being transplanted (López et al., 2021). Variation in weight can influence crop uniformity, affecting flowering timing and ultimately crop yield (Manju & Pushpalatha, 2022). Therefore, the selection of vegetative material is a critical decision that must be carefully addressed in the production of banana seedlings in nursery (Alcívar & Tuárez, 2021).

The implementation of nurseries for the propagation of banana seedlings has become an increasingly widespread practice to increase productivity in a shorter period (Martínez et al., 2021). This approach makes it possible to obtain plants with a vigorous vegetative development, while preserving optimal conditions of health and homogeneity, factors that make them ideal for subsequent transplantation in the open field (Ramos et al., 2016). A critical aspect in this initial phase of propagation is the choice of a suitable substrate, with structural and chemical properties that favor root growth (Ugarte et al., 2022; García et al., 2022). Consequently, the production of banana plants at the nursery level with different corm weights is a highly strategic and crucial process in the banana industry (González et al., 2022). The meticulous choice and classification of these vegetative organs, considering their weighting, and the implementation of proper fertilization, irrigation, and management practices are essential to obtain vigorous, high-quality seedlings that lay the foundation for successful banana cultivation in the field (Challam et al., 2023). This methodical and personalized strategy at the nursery stage is critical to maximizing productivity, efficiency, and sustainability in the banana industry, thus driving strong and fruitful growth in the agricultural sector (Romero et al., 2023).

The objective of this work was to determine the influence of corm size on the initial growth of banana Cavendish seedlings.

2. Methodology

2.1. Location of the experimental site

The research was carried out at the "La María" Campus of the "Universidad Técnica Estatal de Quevedo", located in Ecuador, during the period between November 2022 and February 2023. This experimental site is located in a region characterized by its Tropical Humid Forest, located in the upper part of the Guayas River basin, within the following geographical coordinates: 79°27'49" west longitude and 01°01'43" south latitude, with an altitude of 73 meters above sea level. The climate in this area is characterized by an average annual temperature of 25.2 °C and an annual rainfall of 2162 mm.

2.2. Preparation of plant material

Within the framework of an established banana plantation, specifically with the Williams variety, 150 corms were selected. These were divided into three groups, each composed of 50 corms, and were characterized by having an approximate fresh weight of 200, 400, and 600 g/corm, respectively. Selection was based on the absence of signs of disease or insect damage to the selected corms. A fundamental stage in this process consisted of cleaning and disinfecting the corms. In order to do this, they were immersed in a solution to 0.6% v/v, containing a formula of Carboxin + Thiram (Carbovax®), for an immersion period of 10 minutes. This rigorous procedure was aimed at ensuring that the corms were free of potential pathogens or harmful agents.

Once the corms were subjected to this cleaning and disinfection process, they were planted in polyethylene sleeves of dimensions 15 x 25 cm. These casings had previously been filled with a substrate composed of a mixture of dry outdoor soil and rice seed husks (*Oriza sativa* L.), in a ratio of three parts soil to one part rice seed husks in terms of volume. This substrate was carefully selected to provide the optimal growth and development conditions for banana seedlings.

2.3. Experiment management and treatments under study

The process of budding the corms and the subsequent growth of the banana seedlings was carried out in a controlled environment, using a structure covered with mesh that allowed 50% of sunlight to pass through. To ensure uniform development, all plants were irrigated equally, maintaining the substrate at an adequate moisture level throughout the investigation period. In addition, weed control was carried out manually to avoid any interference in the growth of seedlings.

In order to establish meaningful comparisons, the plants were organized into fifteen groups, each composed of ten plants. Three different treatments were randomly assigned to five of these groups, once the budding of the corms was recorded. The treatments were based on the weight of the corms used: small corms (100 to 200 g), medium corms (200 to 400 g) and large corms (400 to 600 g). In addition, during the growth and development phase, a fertilizer containing nitrogen, phosphorus and potassium (NPK) was applied in doses of 6 g/plant. This fertilization approach was implemented to ensure that all seedlings received the nutrients needed for optimal and vigorous development.

2.4. Variables evaluated

Various evaluations of banana seedlings were carried out within 45 days after the budding of the corms. These evaluations included measuring plant height, which was defined as the distance from the soil surface to the highest point of the last "v" formed by the leaves. In addition, the diameter of the pseudostem was measured at a height of 5 cm from the soil surface. The number of fully formed leaves on each plant was also counted. Using this information, together with the calculation of the accumulated thermal time in degree-days (Equation 1), the phyllochronic index was determined (Equation 2). To evaluate the fresh and dry biomass of the roots, pseudostem and leaves of the seedlings, the plants were dried. Each of the plant parts was placed in a forced-air stove, previously set to a temperature of 65 °C, until they reached a constant weight.

$$GDA = \frac{Tmax + Tmin}{2} - Tbase \quad \text{(Equation 1)}$$

$$IF = GDA \times \frac{Nd}{Nh} \quad \text{(Equation 2)}$$

Where GDA, accumulated degree days; Tmax, maximum temperature (°C); Tmin, minimum temperature (°C); Tbase, base temperature (10°C was considered as base temperature); FI, phyllochronic index in thermal time; Nd, number of days the study lasted; Nh, number of leaves issued during the time the research lasted.

2.5. Statistical analysis

Within the framework of the present study, a completely randomized design with three treatments and five replications was adopted for the purpose of investigating the impact of corm size on the development of seedlings of the Williams variety in a nursery environment. The data obtained during the experiment were subjected to an analysis of variance, followed by a comparative analysis of the means of the treatments using the Tukey test, using a significance level of 0.05.

3. Results and discussion

When assessing the height and initial diameter of banana seedlings, significant differences were observed between the groups, with different average height and diameter for corms of different weights. The results show that seedlings from small corms had an average of 12.32 cm and 1.70 cm, those from medium corms with 10.88 cm and 1.69 cm, and those from large corms with 16.90 cm and 2.28 cm/plant. However, when it came to the final height, no significant differences were observed between the groups, as all seedlings reached an average of 24.32 cm/plant at the end of the study. In contrast, in the final diameter, significant differences were observed between the different weights of corms evaluated. Seedlings from small corms averaged 2.19 cm, medium corms with 2.30 cm, and large corms with 2.76 cm/plant. (Table 1). Therefore, the results of the research indicate that corms weighing between 400 and 600 g are the most suitable for obtaining banana seedlings with greater height and diameter in the nursery phase. These corms promote more robust and vigorous seedling development, which can have a positive impact on their future productivity in the field.

Numerous previous studies have shown a significant relationship between corm weight and seedling dimensions, such as height and diameter, during the nursery stage. Corms with weights of 400 and 500 g produce plants of greater height and diameter, reaching plants with good vegetative development (Moreta, 2019), which also allows banana seedlings to be in suitable conditions for transplantation in the field (Patiño et al., 2019).

Likewise, the acclimatization of seedlings plays a crucial role in the nursery stage, facilitating their effective adaptation to the soil and the surrounding environment (Ramos et al., 2016).

Meanwhile, the need to apply chemical fertilization to banana seedlings at the nursery stage contributes to the growth and increase in the thickness of the diameter of the pseudostem, which in turn improves the quality of the seedlings (García et al., 2021). In addition, a larger diameter of the pseudostem is an indicator of the increase in dry biomass in plants (Schiller & Magnitskiy, 2019).

On the other hand, it has been established that the optimal height that banana seedlings should reach in the nursery stage, for transplanting to the field should be in the range of 20 to 25 cm (Alfaro, 2016; Ruíz & García, 2022).

Table 1
Height and diameter of banana seedlings (Williams cultivar) in the nursery stage originating from corms of different sizes

Treatments	Height				Diameter			
	Initial		Final		Initial		Final	
	g/plant							
Small Corm	12.32	a*	23.82	a	1.70	a	2.19	a
Medium Corm	10.88	a	22.00	a	1.69	a	2.30	a
Large Corm	16.90	b	27.15	a	2.28	b	2.76	b
Average	13.37		24.32		1.89		2.42	
EEM	1.81		1.51		0.20		0.17	

EEM = standard error of the mean, * Averages with equal letters vertically do not differ statistically according to Tukey's test ($p > 0.05$).

When analyzing the variable of fresh and dry biomass in the different parts of the banana seedlings, such as roots, pseudostem, and total biomass, significant differences were observed between treatments. It is evident that the heavier corms generated a greater amount of fresh biomass, with values of 37.00, 135.60 and 290.40 g/plant, respectively. Likewise, dry biomass also followed the same trend, with values of 5.58, 5.68 and 23.78 g/plant, respectively. However, it is important to note that numerically, the heaviest corms had a higher fresh and dry biomass in the leaves, with values of 117.80 and 12.50 g/plant for everyone (Table 2). On the other hand, smaller corms generated a lower amount of fresh biomass in the roots, pseudostem and total biomass, with values of 15.80, 78.60 and 181.40 g/plant, in the order given. In addition, the dry biomass in the roots and the total biomass was lower for these corms, with values of 2.14 and 14.04 g/plant. On the other hand, medium-sized corms had a lower fresh biomass in the leaves, with a value of 86.40 g/plant, and a lower dry biomass in the pseudostem and leaves, with values of 2.84 and 8.94 g/plant, correspondingly (Table 2). In contrast, the significant influence of corm size on the biomass of the different parts of banana seedlings in the nursery stage stands out. Larger corms contribute to a substantial increase in root biomass, pseudostem, and total biomass, while smaller and medium-sized corms result in lower biomass values in these parts of the plant.

At the nursery stage, banana seedlings are observed to exhibit a higher accumulation of fresh biomass on the pseudostem and leaves, while fresh root biomass is lower (Alcudia et al., 2019). The pseudostem is the organ that shows the highest percentage of accumulation of fresh biomass in banana plants in the nursery phase (Arias et al., 2015). Whereas roots contribute the lowest percentage of the total fresh biomass in these seedlings (Boschini et al., 2021).

Table 2
Fresh and dry biomass at the roots, pseudostem and leaves of banana seedlings (Williams cultivar) in the nursery stage originating from corms of different sizes

Treatments	Fresh biomass							
	Roots		Pseudostem		Leaves		Total	
	g/plant							
Small Corm	15.80	b*	78.60	b	87.00	a	181.40	b
Medium Corm	19.80	ab	87.40	b	86.40	a	193.60	ab
Large Corm	37.00	a	135.60	a	117.80	a	290.40	a
Average	24.20		100.53		97.07		221.80	
EEM	6.50		17.72		10.37		34.48	
Treatments	**Dry biomass**							
	Roots		**Pseudostem**		**Leaves**		**Total**	
	g/plant							
Small Corm	2.14	b	2.98	b	8.96	a	14.04	b
Medium Corm	2.60	ab	2.84	b	8.94	a	14.34	b
Large Corm	5.58	a	5.68	a	12.50	a	23.78	a
Average	3.44		3.83		10.13		17.39	
EEM	1.08		0.92		1.18		3.20	

EEM = standard error of the mean, * Averages with equal letters vertically do not differ statistically according to Tukey's test ($p > 0.05$).

In addition, the production of root biomass is directly related to the weight of the corm, i.e. the higher the weight of the corm, the greater the root mass of the plant (Moreta, 2019). These results, as presented by the authors, are consistent with the findings presented in this research, where treatment with heavier corms presented a higher percentage of weight in fresh roots.

Regarding the accumulation of dry biomass in the different treatments using corms of different weights (small, medium and large), it was observed that vegetative organs, such as the pseudostem and leaves, generate the largest amount of dry matter. Eventually, the pseudostem and leaves contribute more than 60% of the dry biomass in the banana crop (Murgueitio et al., 2019). In the same of way, the increase in biomass production is influenced by the photosynthetic radiation present in the crop, as well as by the moisture and availability of nutrients, such as nitrogen in the soil (Ruíz & García, 2022). Therefore, dry biomass values vary according to the plant organs, with a higher percentage of dry biomass in the leaves and a lower production of biomass in the roots (Arias et al., 2015). These results support the findings presented in this research, where a lower amount of biomass was observed at the root level and a higher dry biomass in the leaves.

When analyzing the number of leaves and phylochronic index of banana seedlings, significant differences were observed between treatments. It was highlighted that small corms showed a greater number of initial leaves, with an average of 4.12 leaves/plant. However, they required more time and temperature accumulation for each new leaf to be emitted, with values of 8.54 days/plant and 132.96 GDA/leaf, respectively (Table 3).

In contrast, no significant differences were observed in the number of final leaves, with an average of 7.14 leaves/plant. The present findings can be attributed to the addition of soil fertilizers that included nitrogen, phosphorus, and potassium (NPK), which supplied at the beginning of initial leaf formation. Fertilization may have influenced the development of additional leaves and the equalization of the number of final leaves between treatments. In addition, it was observed that medium-sized corms required less time and temperature accumulation for plants to emit a new leaf, with values of 6.80 days/leaf and 105.74 GDA/leaf, correspondingly (Table 3).

When banana seedlings reach approximately 5 true leaves in the nursery, they are in a condition to be transplanted into the field, as this phenological stage allows the plant to carry out the process of photosynthesis (Alfaro, 2016). It has been observed that there are no significant differences in the number of leaves when corms of different sizes are used in the reproduction of banana seedlings at the nursery stage, especially when they reach the appropriate phenological stage to be transplanted into the field (Guimarães et al., 2014). Whereas, the application of fertilizers is beneficial for the average number of leaves emitted by seedlings in the nursery stage (Patiño et al., 2019). The results obtained in this study confirm the previous findings, since no significant differences were detected in the number of leaves between the different treatments evaluated.

The minimum interval between the successive appearance of leaves, also known as phyllocron, is 7.33 days/leaf and the maximum of 10.08 days/leaf (Meghwal et al., 2021). In addition, it has been established that a banana plant requires a minimum of 7 days to emit a new functional leaf, and it has been observed that this interval can be reduced with the application of biofertilizers (NPK), in optimal amounts during the growth stage of the plants (Sarkar & Longkumtsr, 2021).

Table 3

Number of leaves and phyllochronic index of banana seedlings (Williams cultivar) in the nursery stage originating from corms of different sizes

Treatments	Leaves per plant		Phyllochronic index	
	Initial	Final	Calendar (days/leaf)	Thermal (GDA/leaf)
Small Corm	4.12 a*	7.40 a	8.54 a	132.96 a
Medium Corm	2.78 b	6.92 a	6.80 b	105.74 b
Large Corm	3.52 ab	7.12 a	7.82 ab	121.34 ab
Average	3.47	7.15	7.72	120.01
EEM	0.39	0.14	0.50	7.89

EEM = standard error of the mean, * Averages with equal letters vertically do not differ statistically according to Tukey's test (p > 0.05).

This is consistent with the results obtained in this study, where the application of fertilizer in the nursery stage contributed to a leaf emission in fewer days, with a minimum phylocron interval of approximately 7 days/leaf and a maximum of approximately 9 days/leaf.

Thermal time, expressed in degree-days acumulate (GDA), is a critical factor influencing the emergence of new leaves in banana cultivars. The Williams cultivar exhibits optimal leaf production at maximum temperatures around 34°C (Turner et al., 2016). Furthermore, the GDA required for leaf emergence can vary significantly across planting seasons (Nunes et al., 2019). These findings underscore the importance of considering temperature and thermal time dynamics in optimizing banana leaf production within nursery environments.

4. Conclusions

By using corms weighing 400 to 600 g in the multiplication of seedlings in the nursery, it was possible to obtain banana plants with the desired height and diameter, exhibiting a vigorousness and uniformity in their development that makes them ideal for subsequent establishment in the field in a shorter period. In addition, seedlings generated from larger corms showed higher fresh and dry biomass in the pseudostem and leaves, while root biomass was lower. The number of leaves of seedlings is influenced by both the size of the corms and the vegetative development achieved by the plants. However, it was observed that the time required for the banana seedlings produced in the nursery to emit a new leaf was approximately 7.72 days.

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