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Effect of two amendments on seedling growth of two cashew varieties

Efecto de dos enmiendas sobre el crecimiento de plántulas de dos variedades de marañón

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ABSTRACT

Cashew, *Anacardium occidentale* L., is considered a promising crop for many regions in Colombia, requiring further research on new varieties and technologies. This study aimed to evaluate the effect of two organic amendments on two cashew varieties under nursery conditions in Puerto Carreño, Vichada department. A factorial experiment (3 organic amendment treatments x 2 varieties) with 4 replications was conducted. The treatments for the first factor were: chicken manure (30%), bovine manure (30%), and no amendment. The varieties used were Yucao and Mapiria. Emergence, survival, and morphometric variables such as stem length, stem diameter, and number of leaves were evaluated, as well as disease incidence and severity. Results showed that seedling emergence and survival were more influenced by the addition of organic amendments than by varieties. Stem length of cashew seedlings was influenced by the addition of bovine and chicken manure and their interaction with the two varieties until week 7, while stem diameter was influenced until the end of the nursery cycle. Neither variety nor treatment influenced the number of leaves. Anthracnose was primarily influenced by the variety factor, with Mapiria being more susceptible to both disease incidence and severity. Overall, both organic amendments had a significant effect on the development of cashew seedlings in both varieties studied.

Keywords: bovine manure; chicken manure; diameter; diseases; leaf number; longitude.

RESUMEN

El cultivo de marañón (*Anacardium occidentale* L.) se considera un cultivo promisorio para muchas regiones de Colombia, por lo que requiere más investigación sobre nuevas variedades y tecnologías. El objetivo del trabajo fue evaluar el efecto de dos enmiendas en dos variedades de marañón en condiciones de vivero en el municipio de Puerto Carreño, departamento de Vichada. Se realizó un experimento bifactorial (3 tratamientos de enmiendas orgánicas x 2 variedades) con 4 repeticiones. Los tratamientos del primer factor fueron: gallinaza (30%), estiércol bovino (30%) y sin enmienda y las variedades Yucao y Mapiria. Se evaluaron la emergencia, supervivencia y variables morfométricas como longitud, diámetro del tallo, número de hojas, así como la incidencia y severidad de las enfermedades. Los resultados evidencian que la emergencia y supervivencia de las plántulas fueron más influenciadas por la adición de enmiendas orgánicas que por las variedades; la longitud del tallo de las plántulas de marañón fue influenciada por la adición de estiércol bovino y gallinaza y su interacción con las dos variedades hasta la semana 7, mientras que el diámetro del tallo fue influenciado hasta el final del ciclo de vivero. Respecto al número de hojas no influyó ni las variedades, ni por los tratamientos. La antracnosis fue más influenciada por el factor variedad, siendo la variedad Mapiria la más afectada por la enfermedad tanto en incidencia como en severidad. En general, las dos enmiendas orgánicas tuvieron efecto significativo sobre el desarrollo de las plántulas de marañón en las dos variedades estudiadas.

Palabras clave: estiércol bovino; gallinaza; diámetro; enfermedades; número de hojas; longitud.

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a tropical shrub native to northeastern Brazil. It has been cultivated extensively in Central and South America, as well as Africa. The plant's primary products are the cashew nut, derived from the seed, and the cashew apple, a fleshy pseudofruit. The cashew apple, consumed fresh or processed, is rich in nutrients and possesses desirable sensory qualities, making it a valuable source of food and a potential ingredient for various products (SAG, 2005; Mothé et al., 2017). As a perennial species well-suited to tropical climates, cashew has emerged as a promising agricultural option for regions with low rainfall, offering a potential adaptation strategy to climate change (SAG, 2005). It is a resilient crop capable of thriving in challenging environments, including soils with low fertility, salinity, and irregular rainfall (Bezerra et al., 2007). The primary consumers of cashew nuts are the United States, India, and the European Union, with significant demand from countries such as the Netherlands, Germany, France, and the United Kingdom. India and Brazil historically have been the leading producers of cashews, followed by other notable growers, including Vietnam, Tanzania, and Indonesia (Coto, 2003; Bloomberg, 2016; Dendena & Corsi, 2014).

Cashew (*Anacardium occidentale* L.) was introduced to Colombia in the 1960s, but its development has been relatively slow despite efforts by institutions such as the Colombian Agricultural Institute (ICA) and the Colombian Corporation for Agricultural Research (CORPOICA) (Méndez, 2017). These organizations have identified significant potential for cashew cultivation in the country's semi-arid regions. Recent research has yielded promising results, including the development of three cashew genotypes: Corpoica Mapiria Ao1, Corpoica Yopare Ao2, and Corpoica Yucao Ao3. These genotypes exhibit favorable levels of productivity and resistance to anthracnose, making them suitable for validation in the Colombian Orinoquia region (Arango et al., 2018). Additionally, recommendations have been established for the production of grafted cashew plants, enhancing the efficiency and quality of cultivation (Arango, 2020). In recent years, several initiatives have been undertaken to promote the cultivation and export of cashew nuts in Colombia. One notable project is located in Puerto Carreño, Vichada, where efforts are focused on productive transformation and capacity building within the cashew value chain (Méndez, 2017).

The nursery stage plays a critical role in the successful establishment and long-term health of cashew (*Anacardium occidentale* L.) plants (SAG, 2005). While recommendations exist for producing grafted seedlings (Arango, 2020), many farmers continue to rely on traditional nursery practices. Despite the cashew plant's resilience, improvements in nursery technology can enhance seedling quality and survival rates. Furthermore, there is a need for continued research and development to support the cultivation of cashews in Colombia, particularly about innovative agricultural practices and technologies (Orduz-Rodriguez & Rodríguez-Polanco, 2022).

While numerous studies have investigated the impact of organic fertilization on cashew (*Anacardium occidentale* L.) seedlings globally, including in Salvador (Salazar González, 2008), Nigeria (Awodun et al., 2015), Benin (Tokore Orou Mere et al., 2022), and Tanzania (Valerian Mbasa et al., 2023), limited research has been conducted on the effects of organic manure in Colombian cashew nurseries. To address this knowledge gap, this study aimed to compare the influence of two substrates on the emergence, morphometric characteristics, and phytosanitary status of cashew seedlings of the Mapiria and Yucao varieties in the municipality of Puerto Carreño, Vichada, Colombia.

MATERIALS AND METHODS

The research was conducted from January to June 2021 at “Apiarios La Cristalina,” located in Caño Negro, Dagua village, 45 km from Puerto Carreño, Vichada. Cashew seeds were obtained from fruits of the best quality and size, selected from elite fields (defined by high yield, disease resistance, and nut quality) of the “La Primavera” farm in Vichada.

An experiment was conducted under nursery conditions using a completely randomized design (CRD) with two factors: fertilization with organic amendments and two varieties. The CRD was a 3 x 2 x 4 factorial design, with three fertilization treatments (30% chicken manure, 30% soil, and no amendment), two varieties (Mapiria and Yucao), and four repetitions.

The experiment had 480 bags of 5 kg each, 80 for each treatment, and 20 for each repetition, which were randomly located and constituted the experimental unit.

The substrates with the treatments that were used were the following (Table 1):

Table 1. Substrates, amendments, and varieties used in the treatments

Treatments	Soil (%)	Sand (%)	Factor amendment (%)	Factor variety
1.	50	20	Chicken manure 30	Mapiria
2.	50	20	Chicken manure 30	Yucao
3.	50	20	Bovine manure 30	Mapiria
4.	50	20	Bovine manure 30	Yucao
5.	80	20	Not amendment 0	Mapiria
6.	80	20	Not amendment 0	Yucao

The substrates were prepared using a nearby black soil from the Caño Negro region, mixed with river sand. Chicken and bovine manure, aged for over 30 days, were added in the proportions specified for each treatment

The seeds were sown while still attached to the false fruit. Additionally, a 1 cm-high layer of sand was added to each bag as a preventive measure to reduce the humidity of the substrate, which could prevent the attack of soil pathogens that affect the area.

Seeds, still attached to the false fruit, were sown into the substrates. A 1 cm layer of sand was added to each bag to reduce substrate humidity and prevent soil pathogen attacks. Manual irrigation with a hose was conducted daily, with the frequency adjusted based on local rainfall.

A traditional phytosanitary management approach was employed, involving the application of fungicides to control diseases. The amount of irrigation and shade management in the nursery was adjusted to regulate soil humidity and mitigate high temperatures.

System of variables:

% of Emergency and % of Survival

% of Emergence = (Plants emerged / Total bags planted) * 100” Equation 1
These data were taken during the first 3 weeks from sowing.

The percentage of survival of the seedlings was also evaluated with the following formula:

% of Survival= (Surviving plants (day 55) / Total bags planted) * 100” Equation 2

To assess the effects of substrates and varieties on seedling growth, 20 seedlings per experimental unit (a single bag) were evaluated weekly. The following morphometric variables were measured:

Stem length: Measured from ground level to the point where the last pair of leaves emerged from the stem (in centimeters).

Stem diameter: Measured 1 cm from the base of the stem (in millimeters using a Vernier Caliper).

Number of leaves: Counted weekly.

Phytopathological variables

In the same experiment described above with six treatments, the phytopathological variables of incidence and severity of the diseases were evaluated as follows:

Incidence of the diseases: a record of the diseases was kept taking the number of affected plants and calculating as follows:

% Incidence = “Number of plants affected” / “Number of plants evaluated” “x100” (Equation 3) (Agrios, 2005).

The records began when the first symptoms of the diseases appeared on the plants.

Disease severity (for foliar diseases only).

The involvement of diseased leaf tissue was evaluated through the severity of the disease over time, using a six-grade scale (0=without symptoms, and 5 = >75% of affected foliar area) (Ciba-Geigy, 1981).

The severity per repetition was estimated with the formula described below:

“Severity (%) = “ (∑axb))/kxN “x100” Equation 4 (Townsend & Heuberger) (Geygi, 1981), where:

a = symptom severity classes (0, 1, 2, 3, 4, and 5).
b = number of plants of each class.
k = maximum grade of the scale = 5.
N = number of plants per experimental unit = 10

An analysis of variance of one factor (treatments) was performed with the emergence variables, survival, the four morphometric measurements, and the two phytosanitary variables (incidence and severity), for which the assumption of normality was verified with the Shapiro-Wilk test. The data in percentages were transformed into 2ArcSin √%/100 to achieve normality. The means were verified by Tukey’s test with a 5% probability of error. The statistical package SPSS v21 was used.

RESULTS AND DISCUSSION

The ANOVA analysis revealed a significant influence of the manure amendment factor on emergence and survival (Table 2). However, neither the variety nor the interaction between variety and manure had a significant effect. Seedlings treated with chicken manure exhibited statistically higher emergence and survival rates ($p<0.05$) compared to those treated with bovine manure or the control group.

Table 2. Results of the statistical analysis of the percentage of emergence and survival in the different treatments

	F Value	
Treatments	**Emergency (%) Week 3**	**Survival (%) Week 5**
Amendments	26.38 **	26.38 **
Varieties	0.88 ns	0.88 ns
Int. Amendments x Variety	1.05 ns	1.05 ns
Factor Amendments	Emergency (%)	Survival (%)
Chicken manure	98.12 a	98.12 a
Bovine manure	91.87 b	91.87 b
No Amendments	82.50 c	82.50 c
MSD	5.52666	5.52666
Factor Variety		
Mapiria	91.66 a	91.66 a
Yucao	90.00 a	90.00 a
MSD	3.71	3.71
VC %	4.77	4.77

Ns: No difference for p<0.05, **: Difference for p<0.01. Means with unequal letters in the columns differ for p≤0.05 for each factor by Tukey's test.

These results demonstrate the superiority of substrates with organic amendments over the control treatments. Both chicken manure (Montenegro et al., 2017) and bovine manure (Arellano et al., 2015) are excellent sources of organic matter with a rapid rate of mineralization, leading to the release of essential nutrients for seedling growth.

The ANOVA analysis revealed significant influences of manure amendments, varieties, and their interaction on morphometric variables at various time points from week 7 to week 9. Stem length was significantly influenced by amendments in weeks 7, 8, and 9, by varieties in weeks 5 and 7, and by the amendment-variety interaction in week 7. Stem diameter was significantly influenced by both amendments and varieties separately, as well as their interaction, in weeks 5, 7, and 9. The number of plant leaves was significantly influenced (P<0.05) by amendments and the amendment-variety interaction in weeks 5 and 7.

Table 3 presents the comparison of means for stem length and stem diameter between the manure treatments. For stem length, seedlings treated with bovine manure exhibited significantly higher growth (P<0.05) than those treated with chicken manure or the control in weeks 5 and 7. In week 9, both chicken manure and bovine manure treatments resulted in significantly longer stems compared to the control. Regarding the Mapiria variety, seedlings showed significantly longer stems (P<0.05) than the Yucao variety in weeks 5 and 7, but no difference was observed in week 9.

Table 3. Results of the analysis of comparison of means of the length and diameter of the stem of the plants for the isolated amendment and variety factors

Factor/Treatment		**Stem length (cm) in different moments**	
Amendments	Week 5	Week 7	Week 9
Chicken manure	9.13 b	14.40 b	21.23 a
Bovine manure	11.78 a	17.99 a	24.32 a
No Amendments	6.80 c	11.47 c	17.33 b
MSD (5%)*	0.76	1.07	3.54
		Stem length (cm) in different moments	
Varieties	Week 5	Week 7	Week 9
Mapiria	9.77 a	15.31 a	19.77 a
Yucao	8.71 b	13.93 b	22.15 a
MSD (5%)*	0.51	0.72	2.37
Factor/Treatment		**Stem diameter (cm)**	
Amendments	Week 5	Week 7	Week 9
Chicken manure	0.40 a	0.43 a	0.49 b
Bovine manure	0.40 a	0.43 a	0.53 a
No Amendments	0.31 b	0.35 b	0.46 c
MSD (5%)*	0.010	0.016	0.028
		Stem diameter (cm)	
Varieties	Week 5	Week 7	Week 9
Mapiria	0.38a	0.41 a	0.51 a
Yucao	0.35 b	0.39 b	0.48 b
MSD (5%)*	0.007	0.011	0.019

*Means with unequal letters in the columns differ for p≤0.05 by Tukey's test for each variable.

For stem diameter, seedlings treated with organic amendments (chicken or bovine manure) exhibited significantly higher values ($P<0.05$) than the control in weeks 5 and 7. In week 9, both manure treatments resulted in significantly thicker stems compared to the control. The Mapiria variety consistently demonstrated thicker stems ($P<0.05$) in weeks 5,7, and 9 (Table 3).

Table 4 presents the interactions between amendments and varieties for stem length and stem diameter. At week 5, the bovine manure treatments with both Mapiria and Yucao varieties exhibited the greatest stem length, significantly outperforming the chicken manure treatments and the control groups for each variety. Within the manure treatments, Mapiria with bovine manure had longer stems than Yucao with bovine manure, and Mapiria without amendments also had longer stems than Yucao without amendments. Similar results were observed at week 7, with the chicken manure treatments demonstrating the longest stem length. While there were no significant differences between Mapiria and Yucao interactions with amendments at week 7, both varieties outperformed their respective control groups.

Table 4. Results of the comparison analysis of plant stem length mean for the interaction of amendments and variety factors at different weeks of seedling age.

	Factor/Treatment	**Stem length (cm)**			
	Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
Week 5	Chicken manure	9.19 bA	9.0839 bA		
	Bovine manure	12.37 aA	11.19 aB	0.88	6.45
	No Amendments	7.76 cA	5.85 cB		
	MSD (5%)*	1.07			
Week 7	Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
	Chicken manure	14.46 bA	14.34 bA		
	Bovine manure	18.59 aA	17.39 aA	1.25	5.77
	No Amendments	12.88 cA	10.05 cB		
	MSD (5%)*	1.52			
	Treatments	**Stem diameter (cm)**			
	Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
	Chicken manure	0.39 aA	0.41 aA		
Week 5	Bovine manure	0.40 aA	0.40 aA	0.012	
	No Amendments	0.36 bA	0.27 bB		
	MSD (5%)*	0.014			
	Treatments	**Stem diameter (cm)**			
	Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
	Chicken manure	0.42 bB	0.49 aA		
Week 7	Bovine manure	0.44 aA	0.48 aB	0.019	
	No Amendments	0.39 cA	0.32 bB		
	MSD (5%)*	0.023			
	Treatments	**Stem diameter (cm)**			
	Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
	Chicken manure	0.50 bA	0.49 abA		
Week 9	Bovine manure	0.56 aA	0.50 aB	0.033	
	No Amendments	0.47 bA	0.45 bA		
	MSD (5%)*	0.040			

* Capital letters compare the varieties in the rows and lower-case letters compare the treatments with amendments in the columns at each time by Tukey's test (P≤0.05). MSD: Minimum Significant Difference.

Table 4 presents the interactions between amendments and varieties for stem diameter. At week 5, the bovine manure and chicken manure treatments with both Mapiria and Yucao varieties significantly outperformed the control groups for each variety. Within the manure treatments, there were no significant differences between Mapiria with bovine manure and chicken manure or between Yucao with bovine manure and chicken manure. However, Mapiria without fertilizer had a thicker stem than Yucao without fertilizer. In week 7, Mapiria with bovine manure demonstrated a significantly thicker stem than Mapiria with chicken manure or without fertilizer, while Yucao with bovine manure and chicken manure did not differ. The stem diameter of Mapiria with chicken manure and without fertilizer was significantly thicker than Yucao with chicken manure and without fertilizer, respectively. However, Yucao with chicken manure had a thicker stem than Mapiria with chicken manure. At week 9, Mapiria with bovine manure (0.56 cm) again exhibited the thickest stem, significantly surpassing Mapiria with chicken manure, without fertilizer, and Yucao with bovine manure (0.50 cm).

The observed differences in stem length between the varieties can likely be attributed to their genetic constitution and the known accelerated growth of cashew seedlings (Coto, 2003). At the end of the 12-week nursery cycle, all seedlings in the organic fertilization treatments exceeded the recommended height of 19 cm for transplanting (Galdámez, 2004). This demonstrates the adaptability of the cashew crop to the conditions of the Vichada area.

Stem diameter is a crucial quality variable and indicator of plant vigor, closely linked to subsequent productivity (Salazar González, 2008). Seedlings treated with organic fertilizers consistently outperformed the control group for both Mapiria and Yucao varieties in weeks 3 and 5. However, in week 9, the chicken manure treatments with both varieties did not surpass the control. The threshold value of 0.5 cm, commonly used for forest and fruit species (Rueda Sánchez et al., 2012), was not reached by Yucao with chicken manure or either variety without organic fertilizer. While these results highlight the relative advantages of chicken manure, previous research by Salazar González (2008) found that chicken manure did not increase the diameter of plants from a local cashew variety.

For the number of leaves per plant, seedlings treated with chicken manure exhibited significantly higher values ($P<0.05$) than those treated with bovine manure or the control at week 5. However, at week 7, both bovine manure and bovine manure treatments resulted in higher leaf counts compared to the control. By week 9, there were no significant differences between treatments, with all seedlings exceeding 14 cm in height. (Table 5).

Table 5. Results of the analysis of comparison of means of the number of leaves per seedling for the interaction of the amendments and the varieties factors at weeks 5 and 7 of seedling age.

		Isolated factors			
Time	**Amendment Factor**	Leaves/seedling		MSD (5%)*	VC (%)
	Chicken manure	8.37 a			
Week 5	Bovine manure	8.013 b		0.34	3,39
	No Amendments	7.41 c			
	Amendment Factor	Leaves/seedling		MSD (5%)*	
Week 7	Chicken manure	12.26 a			
	Bovine manure	12.10 a		0.39	3,39
	No Amendments	10.53 b			
		Interaction factors			
	Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
	Chicken manure	8.41 aA	8.32 aA		
Week 5	Bovine manure	7.43 bB	8.59 aA	0.48	3,39
	No Amendments	7.64 bA	7.18 bB		
	DMS (5%)*	0.3987			
	Amendments	11.97 aA	12.56 aA		
Week 7	Chicken manure	11.70 aB	12.50 aA	0.83	3.97
	Bovine manure	11.38 aA	9.68 bB		
	MSD (5%)*	0.68			

Capital letters compare the varieties in the rows and lower-case letters compare the treatments with amendments in the columns by Tukey's test ($P \leq 0.05$). MSD: Minimum Significant Difference.

Table 5 presents the interactions between amendments and varieties for leaf number. At week 5, Mapiria with chicken manure and Yucao with both amendments exhibited the highest leaf numbers. For Yucao, any organic fertilizer treatment resulted in more leaves than the control, while Mapiria with chicken manure had significantly more leaves ($P<0.05$) than with bovine manure or no amendment. At week 7, both Mapiria and Yucao with chicken or bovine manure had significantly more leaves ($P<0.05$) than the control groups.

In the final week, all seedlings had an adequate number of leaves, exceeding the recommended 14 photosynthetically active leaves for successful field survival (Corpoica & Asohofrucol, 2013). These results demonstrate the vigor of both Mapiria and Yucao varieties under the unique edaphoclimatic conditions of Vichada, regardless of fertilization. This contrasts with a study in El Salvador, where, at the same age (63 days), only one of the 12 fertilized treatments reached 13 leaves, and the control had only 8.66 leaves (Salazar González, 2008).

The positive results observed with chicken and bovine manure concerning seedling emergence, survival, and development can be attributed to their fertilizing properties, which improve soil physical quality and fertility. Chicken manure is relatively concentrated and fast-acting, providing organic matter and essential nutrients such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B) (Montenegro et al., 2017). Bovine manure is characterized by its high organic matter content (5.39%) and richness in macro-elements (nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K)) and micro-elements (sodium (Na), molybdenum (Mo), iron (Fe), zinc (Zn), copper (Cu), boron (B)), which also contribute significantly to seedling growth (Arellano et al., 2015).

Organic amendments significantly influenced emergence, survival, and morphometric variables in cashew seedlings grown in a nursery. These findings align with Arango's (2020) assertion that substrate composition is crucial during the nursery stage, particularly for grafted seedlings. Arango recommended using 40% chicken manure in the substrate for this technology. Our results are consistent with previous studies conducted in various African regions demonstrating the benefits of organic fertilization on cashew seedlings (Awodun et al., 2015; Nduka et al., 2019; Tokore Orou Mere et al., 2022; Valerian Mbasa et al., 2023).

Anthracnose, caused by Colletotrichum gloeosporioides Penz, was the only disease observed during the experiment. As noted by Coto (2003), it is a common and harmful disease in cashew cultivation. Notably, damping-off, a concern for the technicians at "Apiarios La Cristalina," did not appear.

The absence of [disease name] could be attributed to low inoculum pressure, as this was a new nursery location. Additionally, the preventive measure of adding a 1cm high layer of sand to all the bags may have contributed to disease control. To confirm these findings, further research should be conducted in the region.

Anthracnose was observed for the first time in the Mapiria variety in week 5, but by week 6 it was already present in Yucao. With the passage of time, a trend was observed towards a higher incidence of anthracnose in Mapiria than in Yucao, regardless of the substrate, reaching values of 52.5% and 30% respectively, at the end of the nursery stage.

ANOVA revealed significant effects of varieties and amendments on anthracnose incidence and an interaction between these factors on severity in some weeks. Incidence was significantly influenced (P<05) by fertilizers in week 7 and by varieties in weeks 6, 7, and 8. Severity was significantly influenced by fertilizers in week 7, by varieties in week 9, and by the interaction of varieties and two factors in week 8.

Anthracnose incidence in cashew seedlings showed a significant statistical difference for amendments factors treatments only in week 7. Seedlings in the control group exhibited a lower incidence compared to those treated with chicken and bovine manure. However, varieties had a more pronounced effect. In weeks 7, 8, and 9, when the Mapiria variety consistently had a higher incidence (P<05) than Yucao (Table 6).

Table 6. Results of the analysis of comparison of means of the incidence of anthracnose for the factors amendments and varieties.

	Week 6	Week 7	Week 8	Week 9
Amendments	Incidence (%) (Arc sen √%/100)			
Chicken manure	11.0 (0.67 a)	19.0 (0.88 a)	24.0 (1.02 a)	44.0 (1.48 a)
Bovine manure	6.0 (0.49 a)	15.0 (0.80 a)	21.0 (0.95 a)	45.0 (1.46 a)
No Amendments	6.0 (0.49 a)	6.0 (0.49 b)	20.0 (0.94 a)	41.0 (1.38 a)
MSD (5%)*	0.27	0.17	0.14	0.26
Varieties	Incidence (%) (Arc sen √%/100)			
Mapiria	9.0 (0.60 a)	15.0 (0.80 a)	28.0 (1.11 a)	51.0 (1.59 a)
Yucao	6.2 (0.50 a)	10.0 (0.64 b)	17.0 (0.84 b)	36.0 (1.29 b)
MSD (5%)*	0.18	0.11	0.09	0.17
	Week 6	Week 7	Week 8	Week 9
Amendments	Severity (%) (Arc sen √%/100)			
Chicken manure	3.8 (0.39 a)	6.0 (0.51 a)	8.0 (0.56 a)	17.0 (0.85 a)
Bovine manure	2.4 (0.31 a)	4.6 (0.43 a)	7.0 (0.52 a)	15.0 (0.79 a)
No Amendments	2.3 (0.30 a)	2.3 (0.30 b)	6.0 (0.49 a)	13.0 (0.73 a)
MSD (5%)*	0.12	0.10	0.10	0.15
Varieties	Severity (%) (Arc sen √%/100)			
Mapiria	3.3(0. 36 a)	4.8 (0.44 a)	8.0 (0.55 a)	17.2 (0.86 a)
Yucao	2.4 (0.31 a)	3.7 (0.38 a)	6.0 (0.50 a)	13.0 (0.73 b)
MSD (5%)*	0.10	0.10	0.06	0.10

Means with unequal letters in the columns differ for p≤0.05 by Tukey's test. Source: Authors.

Anthracnose severity in cashew seedlings showed a significant statistical difference for amendment factor only in week 7. Seedlings in the control group exhibited lower severity compared to those treated with chicken and bovine manure. Comparing varieties, the Mapiria variety showed greater severity (P<05) than Yucao in week 9 (Table 6).

In week 8, Mapiria combined with chicken manure exhibited the highest anthracnose severity (11.0%), significantly differing from Mapiria without organic amendment and Yucao with chicken manure but not from Mapiria with bovine manure (Table 7).

Table 7. Results of the analysis of comparison of the severity of anthracnose for the interaction of amendments and variety factors at week 8 of seedling age.

	Severity (%) (Arc sen √%/100)			
Amendments	Mapiria	Yucao	SMD (5%)*	VC (%)
Chicken manure	11.0 (0.65 aA)	5.0 (0.47 aB)		
Bovine manure	7.0 (0.52 abA)	7.0 (0.53 aA)	0.11	15.05
No Amendments	6.0 (0.49 bA)	6.0 (0.49 aA)		
MSD (5%)*	0.14			

* Capital letters compare the varieties in the rows and lower-case letters compare the treatments with amendments in the columns by Tukey's test (P≤0.05). MSD: Minimum Significant Difference. Source: Authors.

The importance of this disease is evidenced by the fact that, despite the phytosanitary management carried out in the nursery, as some authors have pointed out (Coto, 2003; Jiménez *et al.,* 2014), one-third or more of the seedlings were diseased. In the case of Mapiria with chicken manure treatment, it exceeded 50%. The results, to a certain extent, coincide with those of Arango *et al.* (2018), who state that the three genotypes recommended for the Colombian (Orinoquia, Yoparo, Yucao, and Mapiria) are tolerant to anthracnose. However, they also point out that the percentage of attack by anthracnose at field conditions was 15.5% for Mapiria and 19.5% for Yucao.

High anthracnose severity in the nursery stage by week 9 poses a significant challenge for the phytosanitary management of cashew seedlings. This disease, which primarily affects new plant organs, including flowers, can severely reduce plant production (Coto, 2003; Jiménez et al., 2014). Nursery-stage infection suggests a high likelihood of severe anthracnose in the early plantation stages. Therefore, preventive measures are crucial to mitigate the disease's impact on crop productivity.

CONCLUSIONS

Initially, Mapiria and Yucao exhibited similar vigor. However, nursery conditions and organic amendments influenced emergence and survival. Bovine and chicken manure, as well as two varieties, affected stem length and diameter until week 7. Mapiria with bovine manure consistently yielded the best results for stem diameter. While leaf number was not influenced by varieties or treatments at the end of the nursery cycle, amendments and variety interactions influenced leaf number up to week 7. Anthracnose was primarily influenced by variety, with Mapiria being more susceptible to both incidence and severity.

Conflict of interest: The authors declare that they have no financial or personal interests that could have influenced the design, conduct, analysis, interpretation, or writing of this manuscript. All authors have contributed to the manuscript and reviewed its content, ensuring that no conflicts of interest compromised the validity of the results presented.

BIBLIOGRAPHIC REFERENCES

Agrios, G. (2005). *Plant Pathology*. 5th edition. Florida: Elsevier Academic Press. 922p.

Arango, L.V. (2020). *Recomendaciones para la producción de plantas injertadas de clones de marañón en tubete*. Bogotá Colombia: Corporación colombiana de investigación agropecuaria – AGROSAVIA. 56p.

Arango, L.V.; Clímaco, J,; Guevara, E.J; Navas A.A. (2018). *Corpoica Mapiria Ao1, Corpoica Yopare Ao2, Corpoica Yucao Ao3: Clones de marañón para la altillanura plana de la Orinoquía colombiana.* Colombia: Corporación colombiana de investigación agropecuaria - AGROSAVIA. 16p.

Arellano, S.; Osuna, E.S.; Martínez, M.A.; Reyes. L. (2015). Rendimiento de frijol fertilizado con estiércol bovino en condiciones de secano. *Rev. Fitotec. Mex.* 38(3): 313 – 318. https://doi.org/10.35196/rfm.2015.3.313.

Awodun, M.A.; Osundare O.T.; Oyelekan S.A.; Okonji C.J. (2015). Comparative effects of organic and inorganic soil amendments on the growth of cashew nut (*Anacardium occidentale* L.) seedlings. *Journal of Agricultural Biotechnology and Sustainable Development.* 7(4): 37-42. https://doi.org/10.5897/JABSD2015.0239

Bloomberg. (2016). Cashew prices are about to go nuts. https://www.bloomberg.com/professional/blog/cashew-prices-go-nuts/

Bezerra, M.A.; de Lacerda, C.F.; Gomes Filho, E.; de Abreu, C. E. B.; Prisco, J.T. (2007). Physiology of cashew plants grown under adverse conditions. *Brazilian Journal of Plant Physiology.* 19(4): 449–461. https://doi.org/10.1590/S1677-04202007000400012.

Ciba-Geigy, C. (1981). Manual de ensayos de campo en protección vegetal. 2da Edición. Basilea, Suiza: Werner Pûntener, División Agricultura. 205p.

Corpoica y Asohofrucol (Corporación Colombiana de Investigaciones Agropecuarias y Asociación Hortifrutícola de Colombia). (2013). Modelo tecnológico para el Cultivo de Mango en el Valle del Alto Magdalena en el departamento del Tolima. Ministerio de Agricultura. https://sioc.minagricultura.gov.co/DocumentosContexto/S1462-MANGO%20ASOHOFRUCOL%20ICA%20CORPOICA.pdf

Coto, O. (2003). Guía técnica del marañón. https://www.centa.gob.sv/2015/maranon/

Dendena, B.; Corsi, S. (2014). Cashew, from seed to market: A review. *Agronomy for Sustainable Development.* 34: 753–772. https://doi.org/10.1007/s13593-014-0240-7

Galdámez, A. (2004). Guía técnica del cultivo de marañón. IICA. Programa Nacional de Frutas de el Salvador. https://acortar.link/hoX2lW

Jiménez, E.; Sandino, V.; Gómez, J. (2014). *Insectos Asociados al Cultivo de Marañón en Nicaragua*. Managua: Universidad Nacional Agraria. 93p.

Nduka, B.A.; Ogunlade, M.O.; Adeniyi, D.O.; Oyewusi, I.K.; Ugioro, O.; Mohammed, I. (2019). The influence of organic manure and biochar on cashew seedling performance, soil properties and status. *Agricultural sciences*. 10(1): 110-120. 10.4236/as.2019.101009.

Méndez, C.M. (2017). Transformación productiva y fortalecimiento de capacidades: el caso del agro-negocio de marañón en Vichada, Colombia. https://repositorio.uniandes.edu.co/handle/1992/34269

Montenegro, S.P.; Gómez, S.; Barrera S.E. (2017). Efecto de la gallinaza sobre *Azotobacter* sp., *Azospirillum* sp. y hongos micorrízicos arbusculares en un cultivo de cebolla (*Allium stulosum*). *Entrammado.* 13 (2): 250-257. http://dx.doi.org/10.18041/entramado.2017v13n2.26232.

Mothé, C.G.; Oliveira, N.N.; Freitas, de Aqueline S.; Mothe, M.G. (2017). Cashew tree gum: A scientific and technological review. *International Journal of Environment, Agriculture and Biotechnology*. 2(2): 681–688. https://doi.org/10.22161/IJEAB/2.2.14

Orduz-Rodríguez J.O.; Rodríguez-Polanco E. (2022). El marañón (*Anacardium occidentale* L.) un cultivo con potencial productivo: desarrollo tecnológico y perspectivas en Colombia. *Agron. Mesoam*. 33(2): 47268. http://dx.doi.org/10.15517/am.v33i2.47268

Rueda Sánchez, A.; Benavides, J.D.; Prieto-Ruiz, J., Sáenz, J.T.; Orozco-Gutiérrez, G.; Molina, A. (2012). Calidad de planta producida en los viveros forestales de Jalisco. *Revista Mexicana de Ciencias Forestales*. 3(14): 69-82.

SAG. (2005). Guías tecnológicas de frutas y vegetales. El cultivo de marañón. http://www.dicta.gob.hn/files/2005,-El-cultivo-del-maranon,-G.pdf

Salazar González, N.J. (2008). *Desarrollo del portainjerto de marañón (Anacardium occidentale); utilizando diferentes fertilizantes foliares y al suelo*. https://oldri.ues.edu.sv/id/eprint/1676/

Tokore Orou Mere, S.B.J.; Batamoussi Hermann, M.; Djaha, A.J.B; Amanoudo, M.J.; Tassiki, A.; Akounnou, J.D.F. (2022). Reactions of cashew grafted seedlings to different formulas of mineral and organic fertilizers as bottom dressing in plantation. *International Journal of Biological and Chemical Sciences*. 16(1): 98-111. https://dx.doi.org/10.4314/ijbcs.v16i1.9

Valerian Mbasa, W.; Kapinga, F.A.; Nene, W.A.; Kidunda, B.R.; Kabanza, A.K.; Ngiha, K.N.; Lilai, S.A. (2023). Influence of cashew apple utilization on soil nutrient replenishment and performance of cashew seedlings. *Journal of Plant Nutrition*. 47(4): 595–614. https://doi.org/10.1080/01904167.2023.2280135