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SCIENTIFIC ARTICLE

Rooting of Stem Cuttings of *Hoya carnosa* in Different Types of Substrates

Enraizamiento de esquejes de tallo de *Hoya carnosa* en diferentes tipos de sustratos

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ABSTRACT

The Wax Plant (*Hoya carnosa*) is a hardy plant suited for both outdoor and indoor environments, and equally represents a profitable option for producers who commercialize this species. However, its propagation can be compromised by substrates unsuitable for rooting. The objective of this experiment was to identify the most adequate substrate for rooting stem cuttings of *H. carnosa*. The study was conducted in a nursery located in Cabañas Caacupé, from September to November 2022. A randomized complete block design was used, with 8 treatments and 4 replications. The treatments consisted of the following rooting substrates: Washed Sand, Coarse Sand, Compost+Coarse Sand, Vermicompost, Rice Husk, Phenolic Foam, Commercial Substrate, and Sphagnum Moss. The evaluated variables were rooting percentage, longest root length, number of roots, fresh mass of rooted cuttings, and survival percentage. An analysis of variance (ANOVA) and a mean comparison using Tukey's test at a 5% error probability were performed. Significant differences were found for the variables longest root length and number of roots. However, no significant differences were observed for rooting percentage, fresh mass of rooted cuttings, or survival percentage. Aerated organic substrates such as vermicompost, compost+coarse sand, and coarse sand favored the formation of vigorous roots, indicating that substrate quality has a greater influence on root development than on overall rooting percentage.

Keywords: ornamental plants, vegetative propagation

RESUMEN

La Flor de Nácar (*Hoya carnosa)* es una planta rústica de ambientes tanto de exterior como de interior, de igual manera, es una opción rentable para los productores que a comercializan esta especie. Sin embargo, su propagación puede ser comprometida por substratos no aptos para su enraizamiento. El objetivo de este experimento fue identificar el sustrato más adecuado para el enraizamiento de esquejes de *H. carnosa.* El trabajo se realizó en un vivero ubicado en la localidad de Cabañas Caacupé, en los meses de septiembre a noviembre del 2022. El diseño experimental utilizado fue de bloques completos al azar con 8 tratamientos y 4 repeticiones. Los tratamientos consistieron en los siguientes sustratos para enraizamiento: Arena Lavada, Arena Gorda, Mantillo+arena gorda, Humus de lombriz, Cascarilla de Arroz, Espuma fenólica, Sustrato Comercial y Musgo *Sphagnum*. Las variables evaluadas fueron porcentaje de enraizamiento, longitud de la raíz más larga, numero de raíz, masa fresca de esquejes enraizados y porcentaje de prendimiento. Se realizó un análisis de varianza ANAVA y una comparación de las medidas por la prueba de Tukey al 5% de probabilidad de error. Se encontró diferencias significativas en las variables longitud de la raíz más larga y número de raíces. No obstante, no se observaron diferencias significativas para el porcentaje de enraizamiento, masa fresca de los esquejes enraizados ni para el porcentaje de prendimiento. Los sustratos orgánicos aireados como humus de lombriz, mantillo+arena gorda y arena gorda favorecieron la formación de raíces vigorosas, indicando que la calidad del sustrato influye más en el desarrollo radicular que en el porcentaje total de enraizamiento.

Palabras clave: plantas ornamentales, propagación vegetativa

INTRODUCTION

The Wax Plant or Porcelain Flower (*Hoya carnosa*) is a climbing plant popularized worldwide as an ornamental plant due to the uniqueness and beauty of its flowers, as well as the morphological diversity of its leaves. It is particularly attractive for the waxy appearance of its star-shaped flowers and its succulent, glossy, or variegated leaves, frequently coated with a waxy cuticle (Alam et al., 2023).

Given its characteristics and outstanding ornamental qualities, together with the growing demand in the indoor plant market, interest in its commercial-scale production has driven the search for more efficient propagation methods.

Propagation occurs both by seeds and by cuttings. However, commercial cultivation from seeds does not constitute an efficient strategy to meet the demand for the genus *Hoya*, due to the low or null germination of seeds, which is why vegetative propagation represents the main multiplication method (Rodda and Simonsson, 2022, cited in Alam et al., 2023). In this context, vegetative propagation through stem cuttings is the predominant method, since, although it may present some difficulty, it is feasible under appropriate conditions (Roberts and Robinson, 1999). In practice, during spring, apical stem segments with two or three nodes are selected (Puccio, 2018), which are placed in water or in a suitable substrate to induce rooting, prior to transplanting to the final site. This propagation method has been widely recognized for its contribution to obtaining more uniform plants of better quality in the production of *Hoya carnosa*.

Producers have a wide variety of substrates available to promote plant rooting; however, knowledge of which is most efficient for the propagation of *H. carnosa* remains limited. This lack of information hinders the selection of a growing medium that optimizes root development while remaining economically accessible.

The relevance of this research lies in the need to determine the most favorable substrate for rooting stem cuttings of *H. carnosa*, considering both its biological effectiveness and economic viability. In this way, the study aims to generate practical recommendations that contribute to improving the propagation techniques used by producers in the region. Within this context, the objective of the study is to identify the most suitable substrate for rooting stem cuttings of *H. carnosa*.

MATERIALS AND METHODS

This research was framed within an experimental approach and was carried out on a productive farm located in Compañía Cabañas, in the city of Caacupé, Cordillera Department, Paraguay, at geographic coordinates 25°22’30.5” South latitude and 57°11’34.6” West longitude. The trial was conducted between September and November 2022.

The propagative plant material consisted of 10 mother plants of *H. carnosa*, three years of age, obtained from a homogeneous lot at a commercial nursery in Cabañas Caacupé. Plants were selected based on their optimal physiological condition and the absence of visible symptoms of diseases or nutritional deficiencies. They were maintained in the vegetative phase under partial shade conditions using a 70% shade net. To ensure the availability of young and vigorous shoots for the experiment, the mother plants were pruned at the end of the previous season (March 2022).

The experiment was conducted using eight treatments, including a control, consisting of different types of substrates for rooting cuttings. Each treatment was replicated four times, as presented in Table 1. The experimental design used was a Randomized Complete Block Design (RCBD). A total of 32 experimental units were arranged, each consisting of nine stem cuttings of *H. carnosa* planted in plastic trays with 50 ml volume cells, involving the use of 288 stem cuttings throughout the trial.

The selection of substrates used in the research was based primarily on availability and cost criteria, taking into account the productive reality of local growers. Priority was given to economically accessible materials that are easy to obtain in the regional market and do not represent a significant investment for producers, thereby ensuring the feasibility and potential adoption of the results. This approach allowed the selection of substrates that, in addition to being suitable for rooting, could be implemented without difficulty under real production conditions.

These substrates were subjected to a heat treatment through the application of hot water, with the aim of reducing the microbial load and eliminating possible pathogenic agents, thereby ensuring their disinfection prior to staking (Ahmed, Rahman, Islam, Ullah and Sarker, 2020).

Stem cuttings of *H. carnosa* of approximately 5 cm in length, with two nodes, were used, with the apex removed (last 1–2 cm), as this terminal portion tends to be excessively succulent and prone to wilting (Mesén, 1998). Each cutting retained a pair of leaves. The cuttings were made at a bevel cut, approximately 1 cm below the buds, with the aim of promoting a greater rooting surface and reducing the risk of rot.

Table 1. Treatments for rooting stem cuttings of Hoya carnosa. Caacupé, Paraguay, 2022.

Treatments	Rooting Substrates
T1	Washed Sand
T2	Coarse Sand
T3	Compost+Coarse Sand*
T4	Vermicompost
T5	Rice Husk
T6	Phenolic Foam
T7	Commercial Substrate
T8	Sphagnum Moss

Obs: Treatment T3 (Compost+Coarse Sand) was considered in a 1:1 ratio as the control treatment, as it is the most commonly used by producers.

The preparation of the cuttings, their disinfection, immersion in the commercial rooting solution, and subsequent establishment in plastic trays with cells were carried out under shade conditions in order to minimize water stress. During the cutting process, the cuttings were kept in containers with water to prevent dehydration. To induce rooting, the cuttings were immersed in a commercial rooting solution containing natural phytohormones, mainly auxins, cytokinins, and gibberellins, at a dose of 20 mL per 20 L of water, for a period of one hour, following the manufacturer's recommendations.

The plants were maintained in a micro-tunnel approximately 0.80 m in height, designed to allow adequate air circulation and maintain optimal relative humidity levels, essential factors for promoting rooting and reducing water stress in the cuttings. Subsequently, the micro-tunnel was opened every 15 days for supplementary irrigation and then closed again to preserve the internal humidity and temperature conditions. During these intervals, manual weed control was also carried out to prevent nutrient competition and maintain cutting health.

The evaluation of variables was carried out 45 days after planting the cuttings, as established by Penayo (2019). However, the survival variable was recorded 22 days after transplanting, a period considered adequate to verify the successful establishment of the cuttings. Prior to the beginning of the evaluations, the cuttings were carefully removed from the pots and subjected to a washing process with water to completely remove the substrates. The evaluated variables were:

1. **Rooting Percentage (%RP):** Calculated considering all cuttings in each experimental unit, using the formula: %RP = (number of rooted cuttings / total number of planted cuttings) × 100.

2. **Longest Root Length (LRL):** Measured with a digital caliper from the base of the cutting to the tip of the root. Data were recorded in centimeters.

3. **Number of Roots (NR):** A count was made of the roots developed by each cutting. Data were recorded in units.

4. **Fresh Mass of Rooted Cuttings (FMRC):** The fresh mass of the rooted cuttings was determined using an electronic balance. Data were recorded in grams.

5. **Survival Percentage (%SP):** Obtained by dividing the number of established cuttings by the total number of cuttings with roots, multiplied by 100.

For the analysis of quantitative variables, an Analysis of Variance (ANOVA) was applied. In cases where significant differences were detected, means were compared using Tukey's test at a 5% error probability. All statistical analyses were performed using Infostat software, version 2020 (Di Rienzo et al., 2020).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences in the variables root length (RL) and number of roots (NR), while no differences were detected in rooting percentage (%RP), fresh mass of rooted cuttings (FMRC), or survival percentage (%SP). This pattern suggests that, although the substrates used did not notably affect the initial capacity for root emission, they did influence the morphophysiological quality of the root system, expressed in root length and number of roots.

The absence of significant differences in %RP can be explained by the fact that *Hoya carnosa* is a species with high rhizogenic capacity, which allows it to emit adventitious roots across a wide range of physicochemical substrate conditions. This behavior is consistent with findings reported by Carvalho and Gosek (2008), who observed high rooting percentages in *Nandina domestica* regardless of the medium, although with variations in root vigor. Similarly, Mabizela, Slabbert, and Bester (2017) found in *Cyclopia subternata* that substrate type has a greater influence on root growth and development than on the mere occurrence of rooting.

In this study, vermicompost (T4) produced the highest rooting percentage (100%), followed by coarse sand (T2) and compost+coarse sand (T3) (97.25%). This can be attributed to the adequate aeration, moisture retention capacity, and presence of bioactive compounds in vermicompost (Xu and Mou, 2016), which promote the differentiation of adventitious roots. These results are consistent with those of Torales (2022), who reported 100% rooting in *Kalanchoe blossfeldiana* in substrates with coarse sand and compost, and with Montiel (2023), who obtained 90% rooting in *Hibiscus rosa-sinensis* using washed sand. In contrast, the lower percentage in phenolic foam (75.25%) could be attributed to its limited water retention and low nutrient availability, conditions that reduce the mitotic activity of meristematic tissues at the cut zone (Park, Yoon, Eui and Kim, 2021).

Regarding root length, vermicompost (T4: 6.89 cm), compost+coarse sand (T3: 6.75 cm), and Sphagnum moss (T8: 6.23 cm) showed the highest values. The similarity among these treatments suggests that substrates with adequate aeration and balanced organic content stimulate sustained root growth, possibly due to an optimal balance between oxygenation and moisture in the rhizosphere. These results contrast with those reported by Montiel (2019) and Alfonso (2022), who found greater root length in sandy and commercial substrates, respectively, which could be attributed to species-specific differences in oxygenation and medium texture requirements. They also differ from the findings of Penayo (2019) in *Rhododendron* spp., where a peat–vermiculite substrate produced the longest roots. These results suggest that *H. carnosa* responds favorably to substrates that combine good aeration with moderate moisture retention, regardless of their organic or inorganic origin, a condition favorable for the development of its adventitious root system.

Regarding the number of roots, the compost+coarse sand (T3: 7 roots/cutting) and coarse sand (T2: 7 roots/cutting) substrates showed the highest values and did not differ

Table 2. Rooting percentage (%RP), Longest Root Length (LRL), Number of Roots (NR), Fresh Mass of Cuttings (FMC), and Survival Percentage (%SP) of Hoya carnosa stem cuttings. Caacupé, Paraguay, 2022.

Treatments	RP (%)	LRL (cm)	NR	FMC (g)	SP (%)
T1	94,5 *ns	5,28 BC	5 AB	2,37 *ns	100 *ns
T2	97,25	5,79 ABC	7ª	2,9	100
T3*	97,25	6,75 AB	7ª	2,5	100
T4	100	6,89 A	6B	2,54	100
T5	83,25	5,26 BC	4B	2,15	100
T6	75,25	3,4 D	4B	2,19	100
T7	94,5	4,65 CD	5AB	2,38	100
T8	94,5	6,23 AB	5AB	2,5	100
cv (%)	12,90	11,60	14,77	13,65	-

Obs: T1=Washed Sand; T2=Coarse Sand; T3=Compost+Coarse Sand (Control); T4=Vermicompost; T5=Rice Husk; T6=Phenolic Foam; T7=Commercial Substrate; T8=Sphagnum Moss; cv=coefficient of variation. *ns=not significant.

statistically from each other, while vermicompost (T4: 6 roots/cutting) showed a lower value with a significant difference compared to the former. These results are explained by the combination of adequate porosity and moderate organic matter content, which improves both oxygenation and the availability of nutrients and beneficial microorganisms for rhizogenic induction (Gehlot, Tripathi, Arya and Arya, 2015).

The physical properties of substrates, such as porosity and moisture retention, vary according to the proportion of materials and particle size (Gutiérrez, Hernández Escobar, Ortíz-Solorio, Anicua-Sánchez and Hernández Lara, 2011). Furthermore, the combination of particle shapes and sizes, along with pore type and distribution, determines the available water content and consequently directly influences root growth (Gayosso-Rodríguez, Gutiérrez, Estrada Botello and Sánchez-Hernández, 2021).

Coarse sand, by improving the physical structure of the medium, facilitates the expansion of fine roots, while vermicompost provides natural auxins and humic acids that stimulate the formation of lateral roots. These results are consistent with those reported by Alfonso (2022) for *Begonia rex*, where the combination of compost and coarse sand was the most effective, although they differ from Penayo (2019), who reported a lower number of roots in coarse sand for *Rhododendron* spp. These discrepancies may be due to anatomical differences between species and to the pH or chemical composition of the substrates used.

Regarding fresh root mass, although no significant differences were detected among treatments, the highest value corresponded to coarse sand (T2: 2.9 g). This suggests that, although biomass does not differ statistically, coarse sand allows vigorous root development, possibly due to its excellent drainage and low compaction, which prevent hypoxia and promote cell elongation (Fatemeh and Zaynab, 2015). These results differ from those of Núñez (2022), who found greater fresh mass in Sphagnum moss for *Clusia rosea*, which could be related to the high water retention capacity of that substrate and to differences in root tissue type between tropical and succulent species such as *H. carnosa*.

Finally, the survival percentage (100%) observed in all transplanted cuttings confirms that prior rooting guarantees the successful establishment of plants, regardless of substrate type. This behavior has also been reported by González (2022) in *Chrysanthemum* spp. and by Núñez (2022) in *Clusia rosea*, who demonstrated that cuttings with functional roots maintain high post-transplant survival due to the rapid resumption of water and nutrient absorption.

CONCLUSIONS

The rooting of *Hoya carnosa* directly depends on the physical and biological conditions of the substrate, which determine the morphophysiological quality of the root system rather than the overall rooting percentage. The results confirm that substrate composition and structure influence the expression of the species' rhizogenic potential, partially validating the hypothesis that significant differences exist in rooting quality according to the propagation medium used, specifically in the variables LRL and NR, although not in %RP or %SP.

In this context, well-aerated organic substrates, such as vermicompost, compost combined with coarse sand, and coarse sand alone, provide a favorable environment that balances moisture, oxygenation, and nutrient availability — essential conditions for the formation and growth of vigorous adventitious roots. Therefore, these substrates are considered the most suitable for the vegetative propagation of *Hoya carnosa* under controlled conditions.

The study demonstrates that substrate selection should not focus solely on maximizing rooting percentage, but rather on optimizing the structural quality of the root system, as this determines plant survival and subsequent growth after transplanting. Consequently, it is reaffirmed that efficient propagation of *Hoya carnosa* requires substrates with high porosity, water stability, and moderate organic input — factors that must be considered in sustainable ornamental production protocols.

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