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Translated from the original in spanish **Original article**

Morphological characterization of six genes of Jatropha curcas **L. (Euphorbiaceae) in the Andalusian**

Caracterización morfológica de seis genotipos de Jatropha curcas L. (Euphorbiaceae) en la granja Andil

Caracterização morfológica de seis genótipos de ***Jatropha curcas*** *L. (****Euphorbiaceae****) na fazenda Andil*

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ABSTRACT

The species *Jatropha curcas* L. is distinguished by its rapid growth and adaptability to degraded and dry soils. This research, conducted at the Andil experimental farm of the Southern State University of Manabí, aimed to gather information on the morphological characteristics of six selected genotypes, including four hybrids and two clones of *Jatropha curcas*. A total of 576 plants were planted in 24 subplots, with four plots assigned to each genotype. Over a period of 23 months, variables such as height, stem diameter, and number of branches were measured on eight selected plants per subplot. Descriptive statistics were calculated, and interpolation was performed for periods not studied. The hybrid JAT 001100 stood out with an average height of 197,72 cm and a range of 199,44 cm, followed by JAT 001103 with 193,9 cm. Stem diameter showed no significant differences, ranging between 7 cm and 6,5 cm. Hybrids JAT 001100, JAT 001103, and JAT 001165 exhibited a higher number of branches (average of 8 to 8,1). Overall, commercial hybrids outperformed local clones in growth and development. These findings contribute to the understanding of *Jatropha curcas* and may be useful for genotype selection in genetic improvement programs.

Keywords: Adaptability, growth, species, genotype, morphology.

RESUMEN

La especie *Jatropha curcas* L. se destaca por su rápido crecimiento y su adaptabilidad a suelos degradados y secos. Esta investigación, realizada en la granja experimental Andil de la Universidad Estatal del Sur de Manabí, tuvo como objetivo recopilar información sobre las características morfológicas de seis genotipos seleccionados, incluyendo cuatro híbridos y dos clones de *Jatropha curcas*. Se plantaron 576 plantas en 24 subparcelas, asignando cuatro parcelas a cada genotipo. Durante 23 meses, se midieron variables como altura, diámetro del tallo y número de ramas en ocho plantas seleccionadas por subparcela. Se calcularon estadísticos descriptivos y se realizó una interpolación para períodos no estudiados. El híbrido JAT 001100 destacó con una altura promedio de 197,72 cm y un rango de 199,44 cm, seguido por el JAT 001103 con 193,9 cm. El diámetro del tallo no mostró diferencias

significativas, oscilando entre 7 cm y 6,5 cm. Los híbridos JAT 001100, JAT 001103 y JAT 001165 presentaron un mayor número de ramas (promedio de 8 a 8,1). En general, los híbridos comerciales superaron a los clones locales en crecimiento y desarrollo. Estos hallazgos contribuyen al conocimiento de *Jatropha curcas* y pueden ser útiles para la selección de genotipos en programas de mejoramiento genético.

Palabras clave: adaptabilidad, crecimiento, especie, genotipo, morfología.

RESUMO

The species *Jatropha curcas* L. stands out for its rapid growth and adaptability to degraded and dry soils. This research, carried out in Andil Experimental Farm of the State University of Southern Manabí, aimed to collect information about the morphological characteristics of six genotypes selected, including four hybrids and two clones of *Jatropha curcas* . 576 plants were planted in 24 subplots, assigning four plots to each genotype. During 23 months, variables such as height, stem diameter and number of branches were measured in eight selected plants per subplot. Statistics were calculated descriptive and interpolation was performed for periods not studied. The JAT 001100 hybrid stood out with an average height of 197.72 cm and reach of 199.44 cm, followed by JAT 001103 with 193.9 cm. The diameter of the stem no presented significant differences, ranging between 7 cm and 6.5 cm. The hybrids JAT 001100, JAT 001103 and JAT 001165 presented greater number of branches (average of 8 to 8.1). In general, commercial hybrids outperformed local clones in growth and development. Those finds contribute to the knowledge of Jatropha curcas and can be useful for the selection of genotypes in genetic improvement programs.

keywords: adaptability, growth, species, genotype, morphology.

INTRODUCTION

The Euphorbiaceae family includes *Jatropha curcas* L., described by Jaspal *et al.* (2023), as a perennial, drought-resistant and extremely adaptable plant, it grows 3 to 6 meters high, with heart-shaped green leaves, smooth and gray bark, and latex; produces seeds containing inedible oil; It is a tropical plant, it can be grown as a commercial crop or on farms in areas with variable rainfall levels, ranging from low to high. The plants can be grown as a crop or as a border hedge to keep grazing animals away from crops and minimize soil erosion. It is a versatile tree species suitable for agroforestry and other reforestation programs. Its potential for various uses has been explored.

An agronomic characterization allows us to know the constitution and functioning of the morphological components of the *Jatropha curcas* species. This procedure describes, among other aspects, the morphological characteristics that distinguish one material from another within the same species. In recent years, this interest has already provided some findings regarding the physiological, genetic, agronomic, agroecological and production characteristics of this species (García *et al*. 2023).

To address this problem, an exhaustive review of the available scientific literature on the topic was used. Various investigations on the cultivation of *Jatropha curcas*, in different regions of the world (Aguilar *et al*. (2015; Avila *et al*. 2018), have provided information on aspects such as plant height (Virgens *et al*. 2017; Herrera *et al*. 2017); the diameter at the base of the stem (Landeros, 2017; Wencomo *et al*. 2020) and the number of branches (Noda 2020).

In this same order of ideas, Mendoza *et al*. (2015) investigated the adaptability of *Jatropha curcas*, in specific climatic conditions, namely: temperature: 26.3°C, annual precipitation: 527 mm, altitude: 47.4 meters above sea level, relative humidity: 83% and heliophany: 1.159,30 h/light year and found that foreign varieties demonstrated greater tolerance to drought and better root development compared to local clones.

The morphological description of different varieties of *Jatropha curcas* in specific local contexts, such as on the Andil farm, is crucial to understand the adaptation of these genotypes to particular climate and soil conditions, which is key to optimizing their growth potential. in height, stem diameter and number of branches. For example, the Andil farm is located in an area with a dry tropical climate, characterized by an average temperature of 24ºC, an average annual rainfall of 1,000 mm, an average relative humidity of 80%, a flat topography and soils with a clay loam texture (National Institute of Meteorology and Hydrology [INAMHI], 2015). This detailed understanding of the environment is essential to develop effective cultivation strategies that maximize the relationship of morphological characteristics with the efficient development of the *Jatropha curcas* in different edaphoclimatic conditions.

The objective of this research was to generate information on the morphological characteristics of four foreign commercial hybrids and two local clones of *Jatropha curcas* (Euphorbiaceae) on the Andil farm. Likewise, results related to morphological parameters are presented, such as the height of the plants, diameter at the base of the stem and the number of branches.

In this sense, scientific knowledge is generated about the agronomic behavior of different foreign commercial hybrids and local clones of *Jatropha curcas*, as a contribution to the development of genetic improvement strategies and promoting the sustainable cultivation of this species in the region. Through the evaluation of key variables, useful information is provided to farmers and decision makers in the agricultural, forestry and energy fields, thus promoting progress towards a more sustainable and environmentally friendly energy matrix.

MATERIALS AND METHODS

Location of the study area

The trial was established on October 25, 2020, on the premises of the Andil experimental farm of the State University of the South of Manabí; located in the Jipijapa canton, province of Manabí, Ecuador. In this sense, factors such as access to water for irrigation, as well as accessibility to the area, were taken into account. Once these indicators were defined, it was decided to work in the area with the following geographical coordinates UTMX: 548135 Y: 9850736, with the help of a GPS Maps 62sc.

Methodology

Characteristics of the genotypes studied at the Andil farm

This research is non-experimental, which is a research approach in which information is observed and collected without deliberately manipulating variables. Instead of controlling the variables, the researcher seeks to observe and analyze how they behave in their natural environment, which is why an evaluation of the morphological characteristics of six genotypes of *Jatropha curcas was constituted,* namely: four introduced commercial hybrids and two controls or local clones from the germplasm bank of the National Institute of Agricultural Research (INIAP), of the Experimental Station (EE) of Portoviejo (Table 1).

Table 1. - *Genotypes (include four hybrids and two clones) of Jatropha curcas studied*

Genotypes
Hybrid JAT 001100
Hybrid JAT 001103
Hybrid JAT 001164
Hybrid JAT 001165
Material CP 041-promising
Material CP 052-promising

Statistic analysis

In this research, a population consisting of six genotypes was analyzed, made up of four foreign hybrids and two local varieties or clones of *Jatropha curcas*, 24 subplots were planted, considering four for each meaning, the sample was intentional of eight plants taking into account the effect of edge; Statistics such as height, diameter at the base of the stem and number of branches were measured for 23 months from December 2020 to December 2022, exonerating the months of November 2021 and October 2022 from measurement, as of which a database was generated between the three statistics measured over time of 4,416 values.

The variables were classified as discrete and continuous, with clear differences between them. For example, the number of branches is a discrete variable, while the height and diameter of the stem are continuous variables. A descriptive statistical design was adopted, as no statistical inferences were made. For quantitative variables, linear measurements in centimeters and the count of the number of branches over time were recorded. A stadimetric ruler was used to measure the height and a caliper to measure the diameter at the base of the stem.

Monthly, for each treatment, position and dispersion statistics were calculated, such as the mean, the standard deviation, the median, the maximum, the minimum and the range. This allowed each treatment to be evaluated from a descriptive perspective. In addition, graphical representations of the statistics were made, which facilitated the correction of parallax errors through linear segmental interpolation. All statistical analyzes were carried out with the Infostat package (INFOSTAT, 2008) complemented by Microsoft Office Excel.

Numerical analysis

As described in the statistical analysis above, there were two months in which no measurements were recorded. To obtain more complete and precise information, numerical interpolation techniques were applied to estimate the average values corresponding to those months. Segmental interpolation, specifically the natural cubic spline, was used to obtain a

robust estimate of the mean values of the statistics under study. This analysis was performed using GeoGebra software.

The purpose of applying this interpolation technique was to calculate the values of the variables of interest during the months without measurements, thus guaranteeing the continuity and coherence of the data throughout the study period. Although it is not a study of growth dynamics, this interpolation is crucial to provide a complete data set that allows a more precise and detailed evaluation of the trends and patterns in the behavior of the variables studied.

The cubic spline (k=3) is the most used spline, since its calculations are not excessively complex and it achieves a very good fit to the tabulated points.

This polynomial S is defined over a partition of an interval of the form $[t_0, t_n]$, remaining as follows: $[t_0, t_1]$, $[t_1, t_2]$,… ,$[t_{n-1}, t_n]$. Let S_i be the cubic polynomial that represents S in the interval $[t_i, t_{i+1}]$, (Equation 1) therefore:

$$S(x) = \begin{cases} S_0(x) & x \in [t_0, t_1] \\ S_1(x) & x \in [t_1, t_2] \\ \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \\ S_{n-1}(x) & x \in [t_{n-1}, t_n] \end{cases} \quad [1]$$

The polynomials S_{i-1} and S_i interpolate the same value at point t_i, (Equation 2) fulfilling that:

$$S_{i-1}(t_i) = y = S_i(t_i) \qquad (i = 1,2, \dots, n-1)[2]$$

S is continuous throughout $[t_0, t_n]$. and S^{ι} and S^{μ} are continuous, a condition that is met in the cubic spline, so it is possible to find the analytical expression for it (Equation 3):

$$S_i(x) = \frac{z_i}{6h_i}(t_{i+1} - x)^3 + \frac{z_{i+1}}{6h_i}(x - t_i)^3 + \left(\frac{y_{i+1}}{h_i} + \frac{z_{i+1}h_1}{6}\right)(x - t_i) + \left(\frac{y_i}{h_i} - \frac{z_i h_1}{6}\right)(t_{i+1} - x)[3]$$

This equation with i= 1, 2,3,… ,n-1, generates a system of n-1 linear equations with *n+1* variables $z_0, z_1, \dots, z_n$. We can choose z_0 and z_1 conveniently and solve the system of equations.

RESULTS AND DISCUSSION

In this research it was decided to prioritize morphological variables such as plant height, stem diameter and number of branches. The selection of these variables was influenced by the growth stage of the plants, considering that during the first two years of cultivation on the Andil farm it was not possible to accumulate the minimum amount of 1 kg of seeds in each treatment. This amount is necessary for the analysis of seed and oil yield to be feasible and relevant. Therefore, focusing the study on morphological characteristics allows obtaining relevant and consistent data on the development and adaptation of *Jatropha curcas*, providing a solid basis for future research aimed at productive performance once the plants reach a more mature stage and productive.

In this context, it is considered that the data obtained on the height, diameter and number of branches of *Jatropha curcas* provide valuable information about its adaptability to adverse conditions, such as water stress, dry climates and soils with low fertility, conditions that They are similar to the edaphoclimatic characteristics of the southern region of Manabí, which is one of the regions where the best hybrids and varieties are intended to expand with emphasis on the variable height, diameter and number of branches.

According to the results presented in Table 2, it is highlighted that Hybrid JAT 001100 showed an average height of 197.72 cm, a diameter of 6.9 cm and a total of eight branches. Furthermore, it is observed that the standard deviation is homogeneous, since a similar behavior is evident in the variables of height, diameter and number of branches.

Table 2. - *Morphological evaluation of six genotypes of Jatropha curcas*

Hybrid JAT 001100						
Variables	**Half**	**Deviation Standard**	**Median**	**Maximum**	**Minimum**	**Range**
Height	197.72	49.03	211.12	239.66	40.22	199.44
Diameter	6.9	1.75	7.12	9.76	2.02	7.74
Number-branches	8	6.1	5	twenty	0	twenty
Hybrid JAT 001103						
Variables	**Half**	**Deviation Standard**	**Median**	**Maximum**	**Minimum**	**Range**
Height	188.3	48.8	202	230.2	35.4	194.8
Diameter	7	2	7.4	10.1	1.8	8.3
Number-branches	7.5	5.8	5	18	0	18
Hybrid JAT 001164						
Variables	**Half**	**Standard deviation**	**Median**	**Maximum**	**Minimum**	**Range**
Height	193.9	45.7	208	235.1	46.5	188.6
Diameter	7	1.9	7.3	10.1	2.1	8
Number-branches	8.1	6.1	6	19	0	19
Hybrid JAT 001165						
Variables	**Half**	**Standard deviation**	**Median**	**Maximum**	**Minimum**	**Range**
Height	179.2	47.1	195	219	34.8	184.2
Diameter	6.9	1.9	7.2	10.1	1.9	8.2
Number-branches	8	5.9	6	22	1	twenty-one
Material CP 041-promising						
Variables	**Half**	**Standard deviation**	**Median**	**Maximum**	**Minimum**	**Range**
Height	162.8	47.7	166.3	229.2	31.1	198.1
Diameter	6.5	1.9	6.9	9.9	1.8	8.1
Number-branches	7.2	5.4	7	17	0	17
Material CP 052-promising						
Variables	**Half**	**Standard deviation**	**Median**	**Maximum**	**Minimum**	**Range**
Height	159.6	Four. Five	165	225.3	31.9	193.4
Diameter	6.8	1.8	6.9	9.5	2	7.5
Number-branches	5.4	4.7	4.1	14	0	14

When analyzing the results of the measurements of Hybrid JAT 001103, which are detailed in Table 2, an average height of 188.3 cm, a diameter of 7 cm and an approximate number of 7.5 branches can be observed. It is relevant It should be noted that both the position and the dispersion of the study variables show uniform values, which indicates consistency in the results obtained.

Regarding to the Hybrid JAT 001164 (Table 2), the data reveal an average height of 193.9 cm, a diameter of 7 cm and an approximate number of branches of 8.1. The results also show mean, standard deviation, median, maximum, minimum, and range values. It is important to mention that these first genotypes showed consistent patterns in the variables of height, diameter and number of branches.

In relation to the data produced by the measurements of Hybrid JAT 001165, a significant difference is evident in the statistics, such as the mean, standard deviation, median, maximum, minimum and range, compared to the first three genotypes (Table 2) in the variables of height, diameters and numbers of branches. These results indicate a marked disparity with respect to the patterns found in the previous genotypes (Hybrid JAT 001100, Hybrid JAT 001103 and Hybrid JAT 001164).

In the case of Material CP 041-promisoria, which is detailed in Table 2, a clear difference is observed in the values of the statistics, such as the mean, standard deviation, median, maximum, minimum and range, compared to the first three genotypes in relation to the variables of height, diameters and numbers of branches. However, it is important to highlight that it presents similarities with the JAT 001165 Hybrid in terms of these statistics. These findings point out a notable variation in relation to the first three genotypes, but also reveal certain similarities with the hybrid JAT 001165.

The results obtained in this research reveal that the statistical results of the CP 052-promising Material (Table 2), exhibit a marked disparity in the values of the statistics, such as the mean, standard deviation, median, maximum, minimum and range, in comparison. with the hybrids Hybrid JAT 001100, Hybrid JAT 001103 and Hybrid JAT 001164, referring to the variables of height, diameters and numbers of branches. However, a similarity is

observed with the JAT 001165 Hybrid and the CP 041-promising Material, in terms of said statistics.

Analysis of linear segmental interpolation applied during the first two years of the Jatropha curcas plantation in the experimental farm

In Figure 1, relative to the average height in all genotypes, it can be seen that in the first six months, there is a sharp increase in the average height, that later in a similar way in all cases the growth even in the last two months that seems to tend towards a sharp increase again.

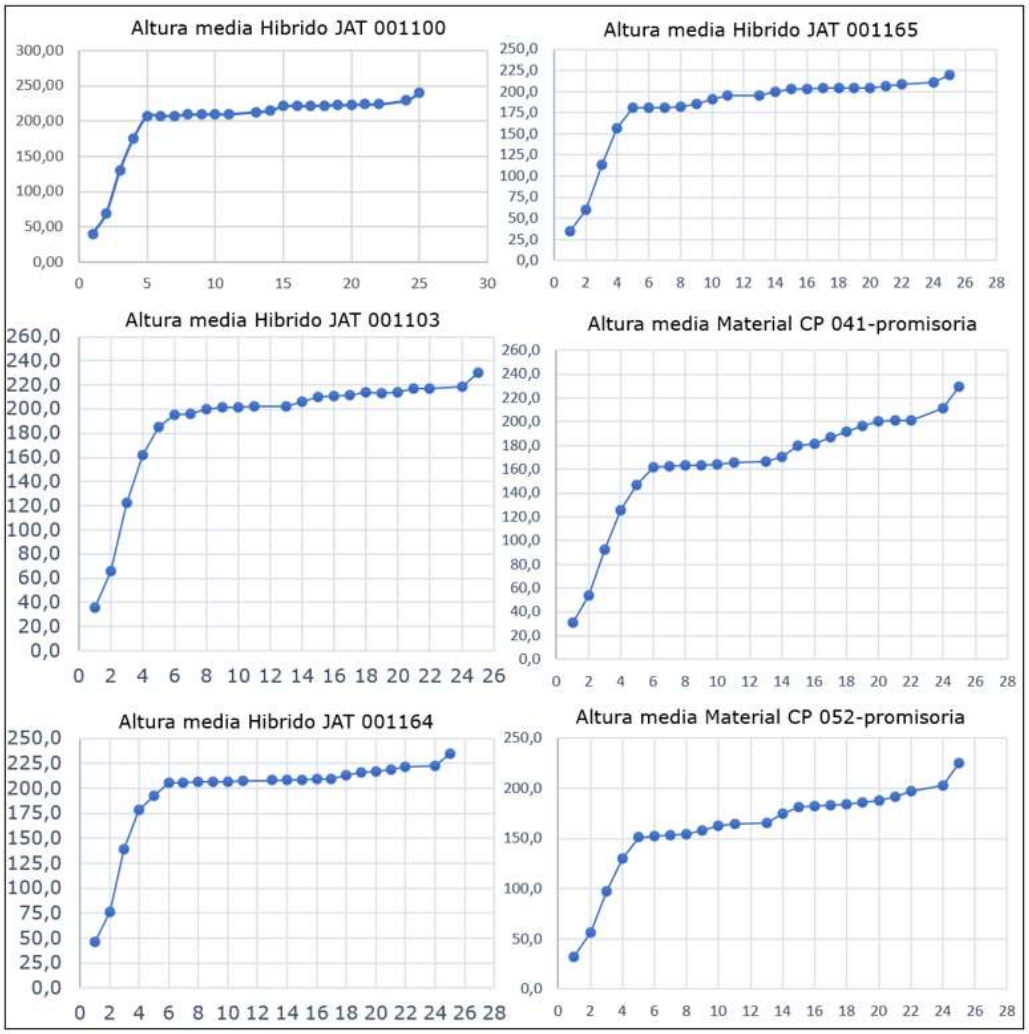

Figure 1. - Average height recorded by interpolation in the six genotypes studied

The analysis of linear segmental interpolation carried out with the data from the measurements carried out during the first two years of the plantation of four hybrids and clones of the *Jatropha curcas* on the Andil farm (Table 3). In this sense, it is highlighted that as the months passed, a differential increase in diameters was observed, with different levels of acceleration.

The results obtained from the measurements of Hybrid JAT 001100 show a significant average height, diameter and number of branches. These results can be compared with the findings of Araiza *et al*. (2016), who studied three wild populations of *Jatropha curcas* in Sinaloa, Mexico. Although the contexts of the studies are different, the comparison can provide insight into the morphological variability of the species under different environmental conditions. In Andil `s research, the homogeneity in the standard deviation suggests a consistency in the growth of Hybrid JAT 001100. This contrasts with the variations observed by Araiza *et al*. (2016) on the morphological characteristics of plants from different sites, indicating the influence of environmental factors on the growth of *Jatropha curcas*.

The agronomic behavior of the four foreign commercial hybrids and two local clones of *Jatropha curcas*, analyzed in terms of the plant height statistics during the first six months, showed a rapid increase in the average height in all materials, followed by a variability significant in the standard deviation. In all cases, a dampening of growth was observed in the following months, although in the last two months there seemed to be a sharp increase again. This pattern of adaptive development is consistent with the findings of the research of Intriago and Santana (2023), who found significant influences of the genotypes evaluated on the plant height variable in the periods of 90, 180 and 270 days after transplantation.

Additionally, García *et al.* (2023), carried out a similar study and also observed a trend of dampened growth followed by a rebound in the last evaluation period. These findings reinforce the consistency of the study results on the Andil farm and support the notion that the growth pattern observed in this research is part of the common behavior of the species.

Furthermore, future studies could address aspects such as the response of these materials to different climatic and edaphic conditions, as suggested by Intriago and Santana (2023). These studies would allow us to obtain a more complete picture and provide key information to optimize specific agricultural management practices for each genotype (García *et al*. 2023).

Table 3. *Average monthly diameter achieved during the first 25 months of plantation*

#	D medium	Months	Year
1	2.02	December	2020
2	3.07	January	2021
3	4.09	February	2021
4	5.32	March	2021
5	6.18	April	2021
6	6.55	May	2021
7	6.68	June	2021
8	6.89	July	2021
9	6.93	August	2021
10	6.95	September	2021
11	6.98	October	2021
13	7.12	December	2021
14	7.12	January	2022
15	7.27	February	2022
16	7.6	March	2022
17	7.77	April	2022
18	8.00	May	2022
19	8.05	June	2022
20	8.11	July	2022
21	8.37	August	2022
22	8.39	September	2022
24	8.69	November	2022
25	9.76	December	2022

Note. *#: Sampled month number, D-mean: mean diameter.*

The interpolation analysis reveals that the four hybrids show an absence of measurements in months 12 and 23, corresponding to November and October, respectively. Although no data were recorded in those months, it is estimated that the approximate mean diameter was 7.1 cm in month 12 and 8.4 cm in month 23. These values were obtained using a natural cubic spline segmental interpolation function (Figure 2).

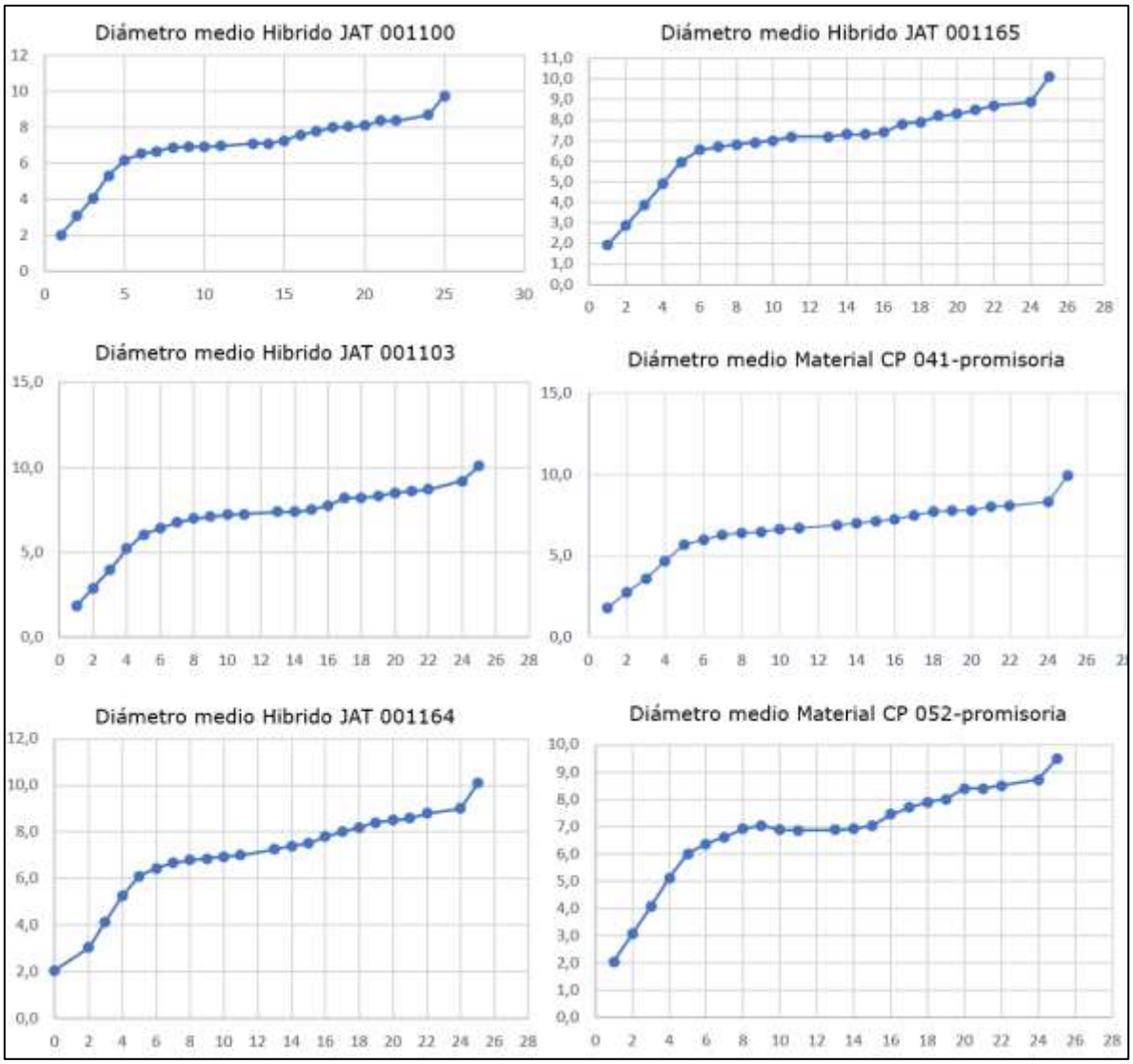

Figure 2. - *Average diameter recorded by interpolation in the six genotypes studied in Andil*

The average diameter has the same behavior in the first six months of measurements, the average grows quite quickly, subsequently stabilizing more and growing less abruptly, apparently resuming a larger average in diameter difference in the last two three months.

In Figure 3 the curves generated with the results of the average number of branches per month in each meaning are presented.

Stem diameter

Stem diameter is an important parameter to evaluate the growth and development of *Jatropha curcas*. According to the results of this study, it was observed that the behavior of this variable showed a similar trend during the first six months of measurements. The mean standard deviation of height increased rapidly at this stage, then stabilized and grew less rapidly. However, in the last three months, an increase in the mean height difference was observed.

These values coincide with previous research, namely Díaz *et al* . (2018) found that under field conditions there were no significant differences in the diameter of the *Jatropha* stems, during the first six months of evaluation. This similarity suggests the existence of a common growth pattern in stem diameter in the species.

Importantly, discrepancies between studies can be attributed to variations in culture conditions, genotypes evaluated, and measurement methods used. In this regard, more research is required to fully understand the behavior of the stem diameter in *Jatropha curcas* and its relationship with the growth and development of the plant.

In general, stem diameter is a key indicator in the structural development and vigor of the plant. As mentioned by González *et al.* (2020), a larger stem diameter is associated with greater water and nutrient transport, which may influence the productivity of *Jatropha curcas*. Therefore, adequate monitoring and management of stem diameter are essential elements in the agronomic management of this species.

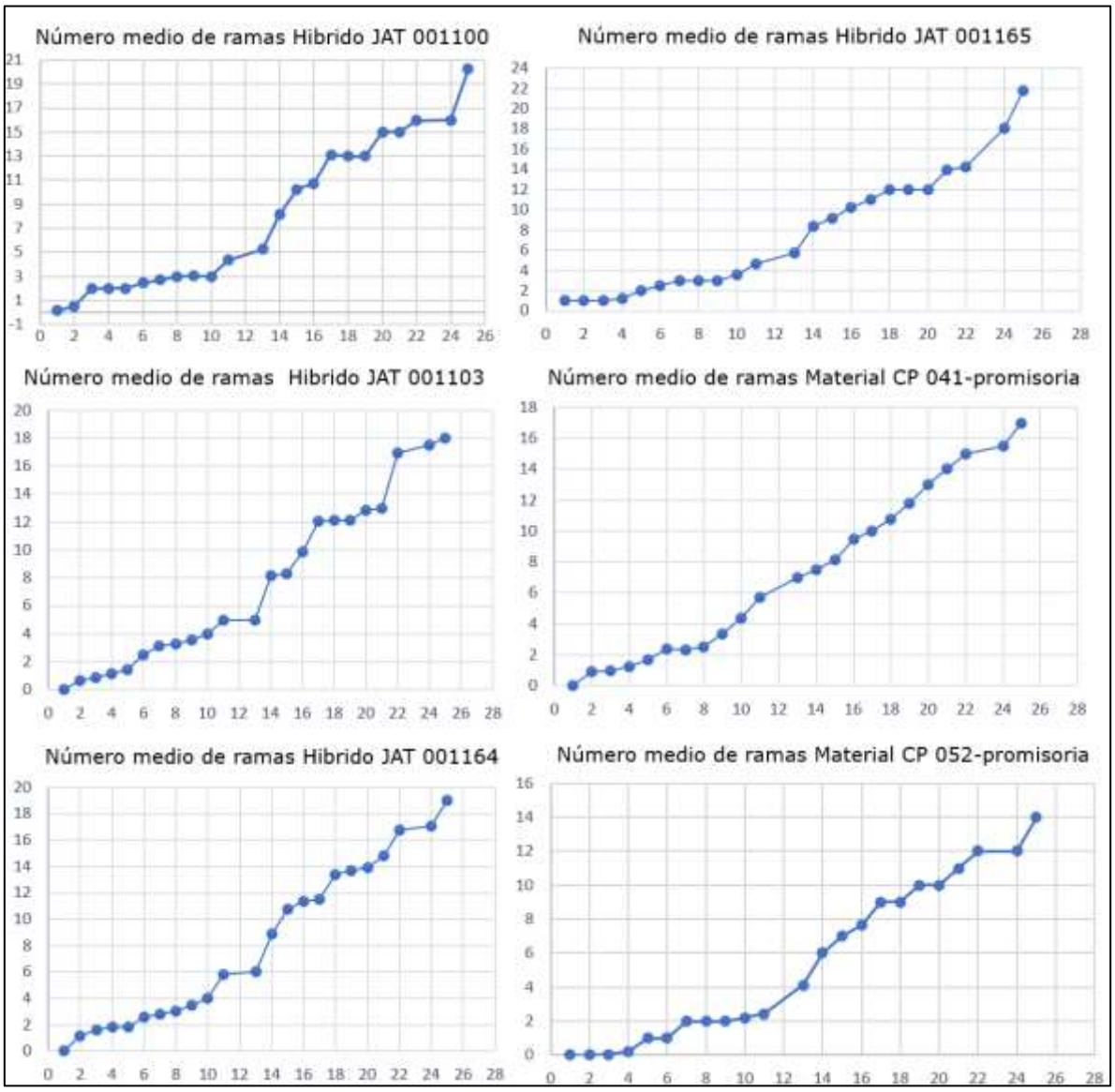

Figure 3. - *Average number of branches recorded by interpolation in the six genotypes studied in Andil*

The case of the average number of branches, in the graphs relating to the JAT 001165 Hybrid materials and CP 052-promising material in the first four months remains constant, in the JAT 001165 Hybrid , one branch on average and in the CP 052 meaning -promising , no branch on average, in the rest a growing increase can be observed in all the months measured without registering a sudden growth, the graphs in the case of the branches show little difference, however it is interesting to note that in the hybrids JAT 001100 and JAT

001165, in the last month, the highest average number of branches was recorded, with 20 and 22 branches on average, respectively and it is also observed that in the first month measured only the hybrid JAT 001165, registered one branch On average, no branches were observed in the rest of the genotypes investigated.

During the analysis of the number of branches, different patterns were observed in the different genotypes evaluated. The materials JAT 001100, JAT 001103, JAT 001164 and CP 041-promisoria showed abrupt growth in the first four months, but there was no development of branches in the last two months analyzed. On the other hand, the JAT 001165 and CP 052-promisoria genotypes did not experience growth in the number of branches during the first four months, but presented the greatest average increase in the last two months. It is interesting to note that in the JAT 001100 and JAT 001165 genotypes, the highest average number of branches were recorded in the last month, with 20 and 22 branches, respectively. Furthermore, in the first month of measurement, only JAT 001165 showed an average of one branch, while the other materials did not present branches in that period, which coincides with Intriago and Santana (2023).

The results of the number of branches in Andil also indicate that it was not significantly influenced by the genotypes evaluated at the intervals of 90, 180 and 270 days. These findings are consistent with research conducted by Intriago and Santana (2023), who found a lack of significant influence of genotypes on the number of branches of *Jatropha curcas* . It should be noted that the JAT-001165 hybrid showed greater representativeness in terms of number of branches in the Andil farm trial.

The materials JAT 001100, JAT 001103 and JAT 001164 showed consistent patterns in the variables of height, diameter and number of branches. This consistency is reflected in the uniform values of mean, standard deviation, median, maximum, minimum and range, which indicates stability in the growth and development of these hybrids.

The genotypes JAT 001165, CP 041-promisoria and CP 052-promisoria, presented a marked disparity in the statistical values compared to the first three hybrids (JAT 001100, JAT 001103 and JAT 001164), however, they showed similarities between themselves. suggesting a

variation in the growth and development of these materials compared to the initial hybrids. When comparing these results with the study by Ocampo and Garay (2009), who evaluated 15 clonal hybrids of *Jatropha curcas* in Paraguay, it is observed that, as in the Andil farm study, there are significant differences in the height of the plants and the number of branches among the evaluated materials. However, no significant differences were observed in other morphological characteristics, suggesting that certain characteristics of *Jatropha curcas* may be more susceptible to genetic and environmental variability. The results of this study have important implications for the selection and improvement of *Jatropha curcas* .

The variability observed in different genotypes indicates that certain hybrids and clones may be more suitable for specific conditions or to achieve particular objectives, such as greater height or number of branches. The selection of materials with desirable characteristics can be crucial for the success of breeding and improvement programs for this species.

The JAT 001103 and JAT 001164 genotypes showed consistent patterns in terms of height, diameter and number of branches. The uniformity in the dispersion of the variables indicates stability in the growth and development of these hybrids. These results are important to understand the genetic variability and responses of different hybrids under similar growing conditions. On the other hand, the materials JAT 001165, CP 041-promisoria and CP 052-promisoria, presented significant differences compared to the first three hybrids, but show similarities between themselves. These differences may be due to genetic variations or different responses to environmental and growing conditions. When comparing these results with the study by García *et al.* (2023), who evaluated morphological and productive characteristics of non-toxic accessions of *Jatropha curcas* in Veracruz, a wide morphological variation is observed in the accessions studied. This study also found significant differences between accessions, reflecting genetic diversity and improvement potential in *Jatropha curcas.*

During the period of the first two years of plantation, the JAT 001100 hybrid showed the best morphological development. It is important to note that no measurements were made in the months of November 2021 and October 2022. However, using the natural cubic spline function, it was possible to perform an interpolation and obtain a statistical approximation for those periods. This statistical approach largely coincides with the findings of the study carried out by Díaz *et al.* (2018), who stated that one year after its establishment, significant differences were observed in favor of the added compost treatment in the periods of 20 and 26 months.

Regarding the average height by genotype, it was observed that the JAT 001100 hybrid reached the highest average height, with a value of 197.72 cm. Furthermore, a standard deviation of 49.03 cm and a variation range of 199.44 cm were recorded. These results indicate that the JAT 001100 hybrid exhibited genotypic growth different from the findings reported in the research of Machado (2011), Guerrero *et al.* (2011) and Mejía *et al.* (2011). These previous studies showed different results in terms of plant height growth in similar genotypes. Therefore, the results obtained at the Andil farm suggest the existence of genetic variability and possible environmental factors that influence the growth and development of *Jatropha curcas* hybrids.

During the months of February to March, a significant increase in stem diameter was observed, with values that varied from 4.09 to 5.32 in 2021, at approximately 118 days. It was found that the four hybrids and two clones evaluated presented practically similar standard deviation and range of variation. However, these results differ from the reports of Aguirre (2019) in his study on other perennial crops, where it is stated that mycorrhizal symbiosis achieves greater induction in plant development after 90 days of sowing, which favors a more accelerated growth, aspects that highlight the importance of considering the specific characteristics of each species and genotype when analyzing the effects of environmental factors and symbiosis on the growth of *Jatropha curcas*.

The means obtained for the number of branches ranged between 8 and 8.1, with a similar standard deviation in the three cases. The CP 052-promisoria Material obtained the lowest result, with only 5.4 branches, which coincides with the results of Machado (2011), Guerrero *et al.* (2011) and Mejía *et al.* (2011). These studies indicate that the variation in the number of branches is minimal and there are no significant differences between treatments.

CONCLUSIONS

The differences observed in height, diameter and number of branches between the genotypes are expected and provide valuable information about their agronomic behavior under specific growing conditions. Homogeneity in certain hybrids suggests stability and uniformity in their performance, while variability in others indicates that they may be less predictable and require more specific agronomic management.

The use of descriptive techniques allows for a precise understanding of how different genotypes respond to the environmental conditions of the Andil farm, which is crucial for future genetic improvement strategies and cultivation practices. The identification of genotypes with consistent and desirable characteristics can guide the selection and development of more productive and adaptable materials for the sustainable production of *Jatropha curcas*.

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