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Dasometric behavior of genetic families of the threatened forest species *Juglans neotropica* Diels, collected in the province of Tungurahua, Ecuador.

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Summary

Juglans neotropic is a forest species native to the Andes, of great socioeconomic importance for its fine wood and high commercial value, its fruits are used in confectionery, its leaves in medicine, it is a source of juglone (ichthyotoxic and fungistatic molecule) and dyes or dyes. At the moment it is an endangered species due to the overexploitation of its wood, which has a negative impact on its natural regeneration and genetic erosion. The dasometric characteristics of 156 J . *neotropica trees* from mothers of superior characteristics, collected in the province of Tungurahua, were investigated. All individuals were obtained from open-pollinated seed. Planting was carried out in the real frame system of 4 m x 4 m, in a randomized incomplete block design with 19 replications, with one tree per family per repetition (single tree plot). Conventional statistical analysis detected no significant differences. However, the techniques of multivariate analysis of main coordinates and the HJ-Biplot, generated 3 groups of trees identified as superior, intermediate and surveillance. Trees of the J18, J22, J13, J20, J14, J37, J9 and TOAFP1 families stood out, which should be considered in the selection process of parent trees in forest genetic improvement programs of the species.

Key words: Dasometric variables, Families, genetic variation, *Juglans neptropica*, HJ-Biplot, main coordinates,

Introduction

Toro & Roldan (2018) and Ramos et al (2020) state that, in fossil and anatomical studies of wood, they have determined the genus *Enghelardia*, within the family Juglandacea, and intuit as the evolutionary origin of the rest of its progeny, composed of *Alfaroa, Pterocarya, Carya and Juglans*.

Azas (2016) and Valverde (2016) reveal that in the Asian continent the *genus Juglans* has been reported for 56 million years, from where other species diversified through the Bering Strait to the American continent. The rest of the American walnuts were known 23 million years ago, where similar traits have been found, although with taxonomic differences in their flowers and wood (more heterocellular rays, larger vessels and pores as one moves from north to south). Among these species are *Juglans australis* (Argentina), *J. neotropica* (Ecuador, Colombia, Peru) and *J. boliviana* (Bolivia).

On the other hand, Nieto & Rodríguez (2010) state that *J. neotropica* is a forest species native to the Andes and is distributed in several formations of the Lower Montane Forest. In Ecuador it is known as tocte or walnut, it is distributed in the inter-Andean alley and towards the eastern and western mountain ranges between 1600 and 2800 m.a.s.l.

Several researchers, including Díaz & Rivera (2007), Gómez & Toro (2007), Ortega (2007), Chusquillo (2014) and Azas (2016), state that *J. neotropica* is a species of great socioeconomic importance because it is considered a species of fine wood of high commercial value, desired in the market, its fruits are used for confectionery. Its leaves are recognized due to the medicinal properties they possess; Therefore, it is a species that has been used to recover soils degraded by mining, cattle ranching or other types of erosion, such as for enrichment of secondary forests, ornamental in large urban areas; as a species of shade in pastures and high-altitude coffee, protector of water sources and habitat and food for wildlife, as a source of minstrone (ichthyotoxic and fungistatic molecule) and as a source of dyes or dyes.

52% of its populations have been overexploited by timber, without any technical management, which has affected their natural regeneration (Gómez et al., 2013), and for the moment it is a species that has been classified as endangered in the Andean zone (Romero, 2018; Gallagher, 2018; Ministry of Environment and Sustainable Development, 2020; GBIF Secretariat, 2021). On the other hand, the available literature on the genetic diversity of *J. neotropica* in the range of the species is very limited, and it has been observed that nurserymen require long periods of time in nursery to produce plants with characteristics suitable for permanent planting.

The research carried out by Toro and Roldán (2018) on *J. neotropica* report issues related to evolutionary history, botanical description, ecology, uses and make a proposal for propagation and silvicultural management and indicate certain conservation perspectives in favor of the recovery of their populations and to be an alternative for sustainable use in the Andean areas due to its multiple uses in businesses or green markets and also for its Resilient characteristics in the restoration of degraded soils in the face of climate change adaptation.

On the other hand, the work carried out with *J. pyriformis* (Maning, 1957; Rzedowski, 1978; Narave 1983; Niembro et al., 2004; Benítez et al., 2004; Luna-Vega et al., 2006; Martínez et al., 2009) address general aspects of its taxonomy, distribution, phenology, production, biogeography and the potential use of its seed as a biofuel. In Europe, the species *J. regia* and *J. nigra* have been widely studied, both for their economic importance and for the value of their wood and fruits (Balci et al., 2001; Aleta et al., 2003; Fady et al., 2003; Colarič et al., 2006; Pollegioni et al., 2006; Oğuz et al., 2008).

There is limited quantitative information about their growth, development and yield in plantations (Toro & Roldan, 2018). The success of a forest plantation is based on the increase of its dasometric variables such as height, diameter at breast height, basal area and timber volume that determines its growth in a given period of time (Klepac, 1983). The management of forest plantations from the silvicultural point of view is important to promote tree growth and should be based on dasometric measurements of the species that consider increases in diameter, height and production in timber volume. Silvicultural treatments, such as thinning, seek to improve the structure of the stand and, most importantly, increase the useful volume at final cutting (Smith et al., 1997).

On the other hand, despite its economic importance, there is insipient information regarding the genetic diversity of *J. neotropica* populations, which in the future will enable conservation and improve forest production (Ramos, et al 2020). The genetic diversity of populations serves to maintain a reservoir of response conditions to the environment that allows the adaptation and survival of species (Piñeiro, and Karp cited in Ramos 2020).

Therefore, it is necessary to evaluate the dasometric characteristics of *Junglans neotropica* trees from mothers collected in the province of Tungurahua, which are part of a genetic trial planted at the Tunshi Experimental Station of the Polytechnic School of Chimborazo (ESPOCH) using multivariate techniques.

Methodology

The present research was carried out in a genetic assay of *J. neotropica* installed at the Tunshi Experimental Station, of the ESPOCH, located in the parish of Licto, canton Riobamba, province of Chimborazo at a latitude of 01°30´S, longitude of 78°40´W 586 and altitude of 2820 m.a.s.l., in the Central Sierra of the Republic of Ecuador. the study site corresponds to the Espinosa-Lower Montane Steppe Life Zone (eEMB) (Holdridge 1989; Vera et al., 2023).

A total of 156 trees were identified from families collected in Tungurahua province, which grow in the J. *neotropica* genetic assay installed in April 2018. To this end, information recorded in the collection log and database available in the project "Research Network on Conservation, Domestication and Genetic Improvement of *Juglans neotropica* Diels. in the Ecuadorian Highlands for commercial use and the restoration of degraded ecosystems" executed by the Faculty of Natural Resources (FRN) of ESPOCH. All individuals were obtained from open-pollinated seed. Planting was carried out in the real frame system of 4 m x 4 m, in a randomized incomplete block design with 19 replications, with one tree per family per repetition as an experimental unit (single tree plot).

The research corresponds to the quasi-experimental type for the evaluation of the dasometric characteristics of individuals of genetic families (progenies) collected from selected mother trees of *J. neotropica* whose passport data are indicated in Table 1.

Cuyuja (Napo)1. Families, Number of Individuals, and Seed Collection Sites *J. neotropica* of selected mothers

Families	No. Trees	Collection Site
J8	8	Quillan 2
J9	16	Pinllo
J13	15	Pillaro 1
J14	14	Ambato 1
J15	5	Ambato 4
J16	9	Patate 3
J17	2	Patate 4
J18	7	Ambato 6
J19	7	Ambato 9
J20	7	Pinllo
J22	11	Totoras
J23	13	Pillarlo 3
J24	Families	No. Trees
Collection Site	J8	8
Keel 2	J9	16
Pinllo	J13	15
Pillaro 1	J14	14
Ambato 1	J15	5
Ambato 4	J16	9
Patate 3	J17	2
Patate 4	J18	7

Source: Fierro (2023)

Variables evaluated

In the evaluation of the behavior of *J. neotropica* families from the province of Tungurahua, the following dasometric growth variables were surveyed by individual and family/progeny:

Total plant height (cm) - A variable that was taken with the help of a telescopic ruler graduated in cm, recording from the ground level to the terminal bud of the tree.

Diameter at the base of the plant or neck of the plant (DAB/DAC). - It was done by registering a horizontal mark on each tree, with paint, at 3 cm from ground level, where the diameter was taken with the help of an electronic forcipule, on a scale in mm.

Diameter at chest height (DAP). - It was done by recording a horizontal mark on each tree, with paint, at 1.3 m from ground level, where the diameter was taken with the help of a diametric tape on a scale in cm.

Clean shaft height (cm) - variable that was taken with the help of a telescopic ruler graduated in cm, recording from ground level to the insertion of the first branch.

Health.- The most important health problem was identified and recorded using a documentary measurement instrument, using a dichotomous variable presence (1) and absence (0).

Log.- The Mean Annual Increment (AMI) was estimated for the diameter at the base of the stem (DAB), total height (ht), basal area and square diameter was estimated using the dasometric growth variables.

Statistical analysis

With the information recorded, an Excel database was constructed, in which the families of the trees that had complete information on all the variables of interest for this study were considered, resulting in a sample of n=112 trees. Respective formulas were applied to estimate the mean annual increase in OBD, mean annual increase in height, basal area per hectare, for which a group of quantitative response variables and categorical variables are available, and from an integrative approach and greater discrimination of the data, multivariate analysis was used, and in particular the Principal Coordinate Analysis (Gower, 1966) and HJ-Biplot (Galindo, 1985).

Principal Coordinates is a technique that is also known as metric multidimensional scaling or classical multidimensional scaling, and aims at the summarized representation of the similarities between individuals in a low-dimensional space in which the Euclidean distances between the points estimate the original dissimilarities, widely used for the treatment of multivariate data with quantitative and categorical variables (Gower, On the other hand, Biplot analysis is a procedure for the simultaneous graphical representation of the rows and columns of a matrix, which allows summarizing the information of a matrix of rank r in a space of dimension q, less than r. The Biplot that absorbs as much information as possible, in terms of variability, from a matrix X, of rank r, is the one corresponding to the matrix X[q] of rank q, which constitutes the approximation to the low rank of X, which is obtained from the decomposition into singular values of X (Eckart and Young 1936) such as:

$$X_{[q]} = U_{(q)} D_{(q)\lambda} V_{(q)}^{T}$$

where, U(q) is the matrix whose columns contain the *q first eigenvectors of* XXT , D(q)λ *is the diagonal matrix with the q first singular values of X, and V*(q) *is the matrix containing the* q first eigenvectors of *XTX*. This expression also corresponds to the decomposition of $X_{[q]}$ into singular values. There are two classic options to achieve better quality representation, either columns (GH) or rows (JK).

Galindo (1985, 1986) proposes *taking* $A = U_{(q)} D_{(q)\lambda}$ *and* $B = D_{(q)\lambda} V_{(q)}^{T}$. The Biplot thus constructed was named HJ-Biplot by its author, respecting the logic of the names proposed by Gabriel 1971. Its main feature is that both rows and columns reach the highest quality of representation. In this case, it is obvious that the internal product of the vector markers will not reproduce the data of the starting matrix, even if the q dimensions are retained. However, this is not a problem, since the goal is generally not to reproduce the original data, but to obtain a simultaneous approximation of the rows and columns of X in which both are well represented.

Multivariate main coordinate analysis was used for mixed data and HJ-Biplot for quantitative data. The analysis was generally performed in R Statistical Software (R. Core Team, 2021), for descriptive analysis and analysis of variance of a single criterion.

Results and discussion

The dasometric evaluation was carried out on individuals from a 4.7-year-old stand of *J. neotropica*, from progeny collected from selected mother trees in the province of Tungurahua. The statistical analysis performed for the variable diameter at chest height (DAP at 1.3 m from the ground) showed that there were no statistically significant differences between the progeny evaluated (p=0.206). The trees had an average DAP of 5.83 cm and a coefficient of variation of 21.14 %. The J20 family had the best average (7.65 cm), while the J16 family had the lowest average (5.17 cm) (Table 2).

The analysis of variance performed identified that there were no statistically significant differences (p=0.161) in the mean annual increase (AMI) of the diameter at neck height of the trees evaluated at 4.7 years. The trees had an average DAC AMI of 20.5 mm and a coefficient of variation of 18.89 %. The J20 family had the best average with 26.79±5.4 mm , in contrast the J16 family showed the lowest average with 17.47±1.22 mm (Table 2).

0.69±0.2092

Ambato 6	**J19**	**7**	**Ambato 9**	**J20**	**7**	**Pinllo**	**J22^{-1})**	**11**
Cattails	J23	13	Catch It 3	J24	13	Ambato 3	J37	14

Tungurahua 6	SB-LL-05	5	Baeza (Napo)	J7	1	Tungurahua	J39	1
Guaranda 5	J21	1	Ambato 05	P3	1	Ambato 08	J1192	1
Catch It 6	TOAF PL	5	Cuyuja (Napo)	340.40±42.11	65.63±9.50	300.68±62.96	1.78±0.55	0.60±0.09
J15	3	5.53±1.72	20.12±6.44	295.23±56.79	56.02±10.69	207.43±48.92	1.60±0.90	0.55±0.17
J16	6	5.17±0.98	17.47±1.22	270.50±36.59	52.75±8.56	270.50±36.59	1.35±0.49	0.52±0.10
J18	Genetic family	n	DAP (cm)	IMA DAB (mm)	Plant height (cm)	IMA Height (cm)	Clean shaft (cm)	Basal area (m2
Square diameter (cm)	J8	5	5.86±1.09	19.21±2.64	312.20±57.18	60.40±12.78	Sec. 234.32±20.84	1.74±0.62
0.59±0.11	J9	12	5.88±1.38	20.99±3.70	320.68±78.29	61.97±16.03	Sec. 252.28±77.25	1.79±0.76
0.59±0.14	J13	13	5.98±1.39	20.77±4.39 PM	337.55±54.63	66.37±11.83	274.28±64.14	1.85±0.
0.60±0.14	J14	13	5.97±0.88	20.84±2.98	340.40±42.11	65.63±9.50 AM	300.68±62.96	1.78±0.55
0.60±0.09	J15	3	5.53±1.72	20.12±6.44	295.23±56.79	56.02±10.69	Sec. 207.43±48.92	1.60±0.90
0.55±0.17	J16	6	5.17±0.98	17.47±1.22	Phone: 270.50±36.59	52.75±8.56	Phone: 270.50±36.59	1.35±0.49
0.52±0.10	J18	5	7.36±1.85	23.91±5.74	375.44±63.97	74.39±12.13	Night±57.5624.45	2.79±1.32

Note: The table shows: the number of individuals per family (n), the mean values and standard deviation of DAP, Mean annual increase in diameter at the base of the plant (IMA DAB), Plant height, Mean annual increase in height, clean stem, basal area per hectare and quadratic diameter of genetic families of *J. neotrópica*.

In the same line of analysis, it was identified that there is insufficient evidence to demonstrate that there is a difference between the averages of plant height (p=0.175) and clean stem height (p=0.138) of the progeny of *J. neotropica* studied. The trees had an average height of 322.25 cm and a coefficient of variation of 19.31 %; as well as, an average clean shaft height of 257.5 cm, and a coefficient of variation of 25.36%, where the J20 family experienced the best average in total height with 450.50±20.51 cm, unlike the J16 family that presented the lowest average in total height 270.50±36.59 cm; In contrast, for the variable height of the clean shaft, the J37 family experienced the best average (253.71±65.09 cm) and the TOAFP1 family presented the lowest average (183.95±39.39 cm) (Table 2). The behavior of the mean annual increase (AMI) in height of the families of *J. neotropica* evaluated did not show statistically significant differences (p=0.161). The trees had an average height IMA of 62.66 cm and a coefficient of variation of 21.10%, with the J20 family having the best average (89.89±2.56 cm), in contrast to the J16 family with the lowest average (52.75±8.56 cm) (Tables 2, 3 and 4).

The variables basal area and square diameter evaluated at 4.7 years showed the same trend, the analyses of variance carried out showed that among the families evaluated from the Tungurahua origin there are no statistically significant differences in basal area (p=0.109) and square diameter (p=0.204). The trees had an average basal area of 1.74 m2 $^{ha-1}$, and a coefficient of variation of 43.12 %, of which the J20 family experienced the best average (2.88±0.48 m2 $^{ha-1}$) and the J16 family had the lowest average (1.35±0.49 m2 $^{ha-1}$ (Tables 2, 3 and 4). In the same sense, the average square diameter of the progeny was 0.58 cm and a coefficient of variation of 21.12 %. The J20 family experienced the best average with 0.77±0.06 cm, in contrast the J16 family presented the lowest average 0.52±0.10 cm. Finally, certain trees of the progeny of *J. neotropica* in study presented holes in the stem, a symptom that was observed both from the basal part and in the terminal part (Figure 1), this problem causes the tree to stop its growth. The stem dies and as a means of survival the plant tends to sprout from the bottom of the existing damage. Individuals who presented these characteristics have been characterized as severe damage that corresponded to 27.56% (43 trees out of 156) (Figure 1a) and that did not enter the analysis of dasometric growth variables; However, trees were identified with a mild problem, only in the terminal part of 27.56% (43 of 156 trees) (Figure 1b) and there were 70 trees (44.87%) that did not present symptoms of the health problem (Figure 1c).

a. undamaged J. neotropica

b. J19*J. neotropica* con daño leve

c. 5*J. neotropica* sin daño

Figure 1. Health problem image of individuals from genetic families of *Juglans neotropica* Diels

The summary of the behaviors obtained in this research is shown in Table 2 and Figure 1a, 1b and 1c, where it is possible to observe certain interesting trends that show the progeny in the variables studied, which intuit the presence of individuals with superior characteristics that probably the analysis does not allow to identify as such.

Measures of central tendency and dispersion were calculated for the dasometric variables, where high values for the coefficients of variation were observed, which suggests that the trees belonging to the different families of Tungurahua had dissimilar responses (Table 3).

43.12

5.30±0.54	**18.05±2.92**	**Sec. 296.22±44.84**	**57.74±9.59**	**Sec. 236.22±80.80**	**1.39±0.28**	**0.53±0.05**	**J20**	**2**

7.65±0.64	26.79±5.04	450.50±20.51	89.89±2.56	202,20±42.00	2.88±0.48	0.77±0.06	J22	10
5.75±1.27	20.92±5.09	331.97±94.14	65.19±19.72	292.33±72.48	1.69±0.79	0.58±0.13	J23	10
5.51±0.98	20.90±2.02 PM	Sec. 298.16±39.68	55.83±8.97	Sec. 217.10±54.57	1.53±0.52	0.55±0.10	J24	12
5.67±0.99	20.39±3.74	314.19±47.75	60.90±10.01	Sec. 254.82±67.39	1.62±0.56	0.57±0.10	J37	12
5.44±1.27	19.14±3.89	307.30±59.37	59.94±12.58	Sec. 252.71±65.09	1.53±0.71	0.54±0.13	TOAFP1	2
6.90±1.98^{-1})	21.89±2.07	349.00±91.36	70.43±20.04	183.95±39.39	2.43±1.34	0.69±0.20	1.43	43.12

In the analysis of variance for dasometric variables, no statistically significant differences were identified, indicating that their behavior is similar (Table 4).

0.204

Dasometric variables	**J. neotropic**	**J. neotropic**	**undamaged J. neotropica**	**F value**	**Pr(>F)**
Altura Total	10	Dasometric variables	stocking	D.E	min
Max	rank	skew	Kurtosis	CV	IMA DAC (mm)
20.50	3.87	12.48	32.90	20.42	0.62
0.35	18.89	DAP (cm)	5.83	1.23	3.00

When analyzing the basal area $^{ha-1}$ of the *Jungle* families (Figure 2), it can be observed that the J18, J20, TOAFP1 families stand out; however, this behavior could not be detected in the analysis of variance.

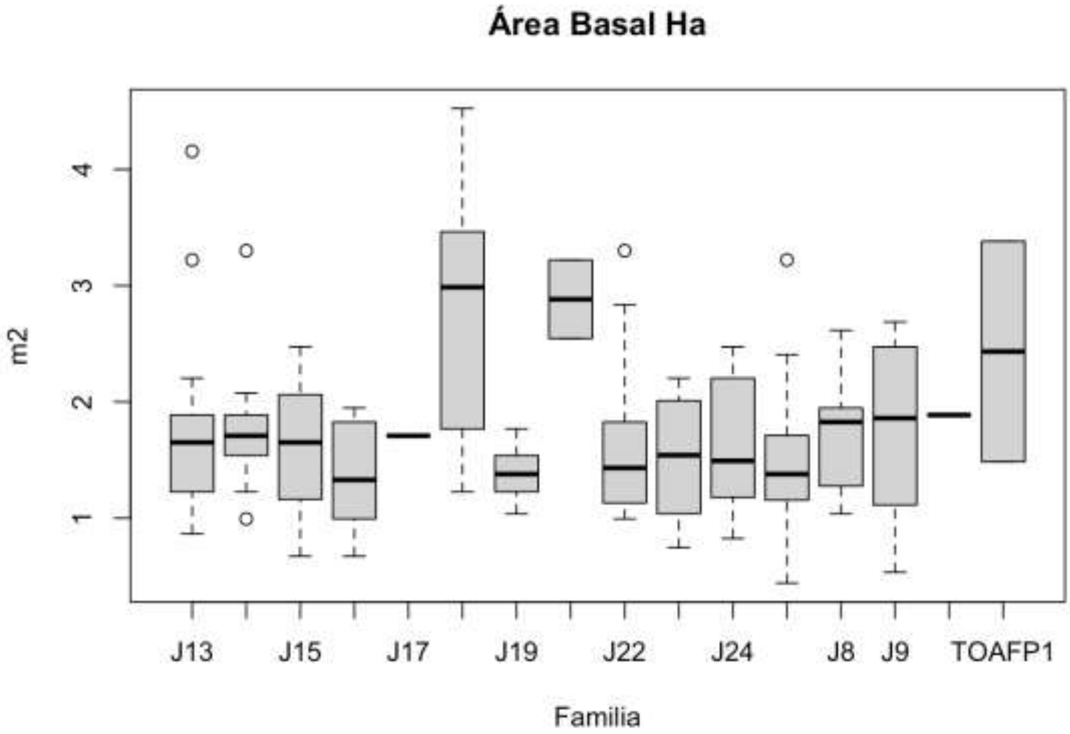

Figure 2. Diagram of boxes and whiskers for basal area (m2 ha-1) of jungle families *collected in the province of Tungurahua.*

Principal coordinate analysis, being a multivariate technique suitable for the treatment of mixed data (quantitative and categorical), explained 59.8% of the total variance, corresponding to 46.7% on the first axis and 13.1% on the second axis (Figure 3). For its determination, the variables clean stem and basal area per tree were not considered because they presented inconsistent values.

This analysis allowed us to observe 3 well-defined groups of the *Jungle* families of Tungurahua origin. It is interesting to note that trees belonging to the same family share more than one group, which suggests that since *Jungle* is a cross-pollinated species, the genetic expression of its different parents causes these half-siblings to react differently in their interaction with the same environmental conditions.

Trees of families such as J13 (2 trees), J20 (2 trees), J14, J22, J18, J37 and TOAFP1 (Figure 3, Green cluster) have higher values in all dasonometric characteristics, suggesting that we are at the head of a group of higher trees, to which more attention should be paid in future forest genetic improvement plans.

On the other hand, there are trees of different families, which were grouped according to their degree of reaction to the health and quality of the log (Figure 3, Blue cluster), which are precisely the categorical variables of this study. From a genetic point of view, this response is important to highlight, since all the trees suffered attacks from the pest, they managed to survive and continued their growth, although slowly, probably demonstrating a certain degree of resilience.

Trees of families with good log quality and medium values in dasometric characteristics (Figure 3, Red cluster) could be classified as intermediate, and would become the first replacements for the higher trees identified in this research.

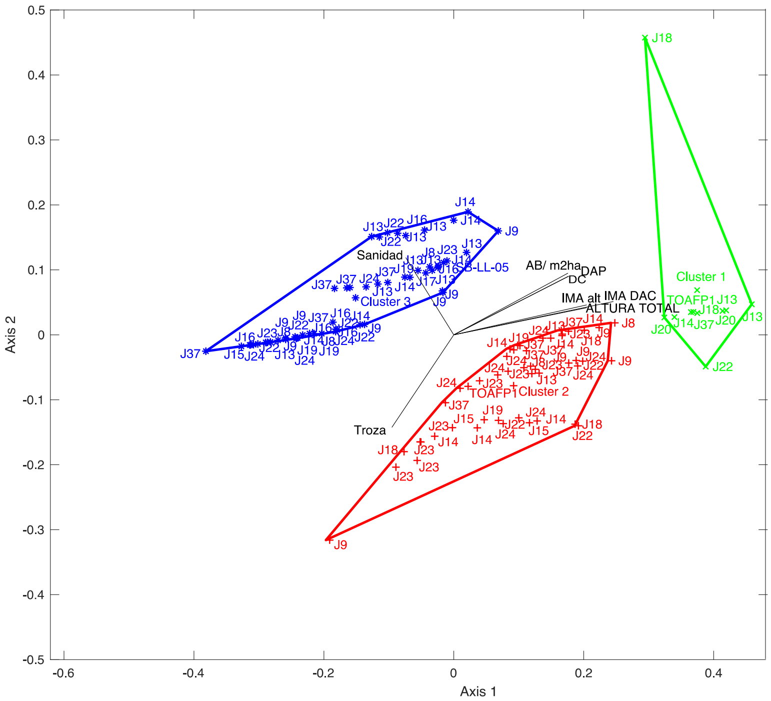

Figure 3. Grouping of individuals from the families of *Juglans* of the province of Tungurahua.

Tables 5, 6 and 7 present the most representative characteristics of this type of analysis, such as: the coordinates of the means, the amount of representation of each of the clusters and the quality of representation of each of the first three axes. It was evident that with the first two axes (cumulative) a high quality of representation was achieved of the three identified family groupings (> 91.0). Cluster 1 (green) and Cluster 3 (blue) were better represented in the analysis, with the first axis, reaching a representation quality greater than 86.0.

0.015125

	6.60	0.52	0.25
21.14	IMA height (cm)	62.66	13.22
33.81	108.09	74.28	0.37
0.40	21.10	Overall height (m)	322.25

0.86273

	192.00	531.00	339.00
0.37	0.20	19.31	Clean shaft (m)
257.5	65.31	146.90	414.10

267.20	0.23	-0.87	25.36

99.2709

	1.74	0.75	0.44
4.52	4.08	1.12	1.43
43.12	52.8129	91.1414	94.1029
Dasometric variables	G.L.	SC	CM

In order to know the behavior of the trees of the different families in terms of quantitative variables, the multivariate HJ-Biplot technique was applied in order to simultaneously observe both the trees or individuals, as well as the dasometric variables that are responsible for their grouping. For its determination, the variables clean stem and basal area per tree were excluded.

The HJ-Biplot analysis was able to extract 94.3% of the total variance, with 86.4% corresponding to the first axis and 7.9% to the second axis (Figure 4). With this procedure, the J18 family has 3 representatives, followed by the J13 and J22 families with 2 representatives and the J14, J37, J9 and TOAFP1 families with only one representative and correspond to the upper trees (Figure 4, Green cluster).

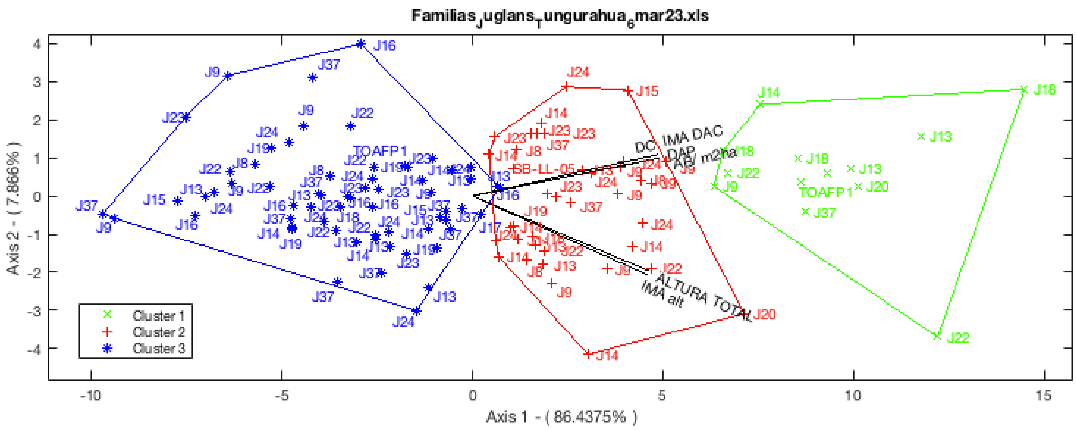

Figure 4. HJ-Biplot for the grouping of individuals from the families of *Juglans* in the province of Tungurahua

Discussion

The dasometric characteristics of the progeny evaluated, and particularly of the species *J. neotropica*, have been little investigated. The coefficients of variation show a high variation between the individuals of the progeny in the variables studied, similar data were reported by Acosta et al (2011) in a study of dasometric characterization of *Juglans pyriformis* Liebm in Mexico.

The Diameter at chest height (DBH) of the present research (5.83 cm) is similar to the average reported by Cueva (2018) (6.00 cm) for *J. neotropica*. This trend is probably due to the fact that the genetic management carried out during the trial of both the present research and Cueva (2018) were very similar in management and care of the plantation. Loewe, et al (2021) in a study carried out in *J. regia* indicates that they found very small diameters given their age, which has also been reported in other studies such as that of Zanuttini *et al.* (2006), where 7-year-old walnut logs had diameters between 8 and 10 cm.

The average mean annual increase (AMI) in diameter at the height of the neck at the base of the tree in this research (20.50 mm) is higher than the average AMI of DAC reported by Ortega (2007) and Boada & Guamán (2005), being averages of 17.2 and 16.7 mm, respectively. Yamamoto and Barra (2003); Inga and del Valle (2017) reported that the diameter growth rate varies from 6 mm/year to 28 mm/year.

The mean annual increase (AMI) in height of the present research (62.66 cm) is higher than the average height MI reported by Ortega (2005), (55 cm), Boada (2005) (51 cm) and Montenegro and Pozo (1993) (18 cm), this trend is probably due to the fact that the individuals evaluated come from selected mothers, that is, from trees with superior morphological characteristics. In contrast to the plants in the authors' essays above, they come from seed from unknown sources. However, several researchers (Barreto & Herrera, 1990); Ecuadorian Institute of Forestry and Natural Areas [Inefan] et al., 1997; Yamamoto and Barra, 2003; Molina et al., 2003; Ospina et al., 2003; Masías, 2007; Díaz and Rivera, 2007; Ortega, 2007; Reynel and Marcelo, 2010; Palomeque, 2012; Gómez et al., 2013), cited in Toro et al (2018) state that growth rates in height are between 14 cm/year and 200 cm/year (value calculated with already reproductive individuals, close to eight years), being higher in areas where the species grows naturally under agroforestry systems and in areas with soils degraded by mining or intensive agriculture with silvicultural management.

With the conventional descriptive statistical analysis, the intrinsic numerical differences of the dasometric variables, experienced by the individuals of the different families of *Jungles* collected in the province of Tungurahua were not observed, so it is assumed that in general terms the families of *Juglans* behaved in a similar way.

However, when we use multivariate analysis techniques such as principal coordinate analysis, when the data are mixed, and HJ-Biplot when the data are quantitative, it is possible to distinguish 3 clearly differentiated groups, with Group 1 having the highest values. It should be noted that trees of the J18 family that excelled in the descriptive analysis also did so in the multivariate analysis, hence it can be inferred that the trees belonging to the J18, J22, J13, J14, J37, J9 and TOAFP1 families, have representatives cataloged as superior trees that should be taken into account in future forest genetic improvement works.

Conclusions

Conventional statistical analyses indicate that the averages of the dasometric variables studied from individuals of *J. neotropica* progenies collected from higher mother trees in the province of Tungurahua, studied at 4.7 years, showed similar behaviors in all the quantitative variables evaluated. The analysis of the main coordinates discriminated the individuals into three groups with their respective dasometric and health variables responsible for their grouping, which allows the establishment of policies to be considered in subsequent forest genetic improvement programs, considering the trees as superior, intermediate and surveillance identified in this research.

The most important health problem identified in the progeny individuals from the province of Tungurahua, evaluated in the genetic assay, probably corresponds to the Curculionidae family, presenting 27.56% (43 trees) of individuals with a severe problem that affected growth in height and DAP, 27.56% presented a slight damage and 44.87% (70 trees) did not present this problem. This tendency may probably be related to their genetic variability.

The trees of the J18, J13, J20, TOAFP1, J22, J37, J9 and J14 families of *J. neotropica* from the province of Tungurahua, as they excel in the dasometric variables evaluated, are the superior trees of this genetic study.

References

1. Acosta-Hernandez, Celia, Cecilia; Mauricio Luna-Rodríguez; Juan Carlos Noa-Carrazana; Jorge Galindo-Gonzalez; Santiago Mario Vázquez-Torres; Zoylo Morales-Romero; Lourdes Georgina Iglesias-Andreu. (2011). Morphological and dasometric characterization of the threatened species *Juglans pyriformis* Liebm. Chapingo Journal Forest and Environmental Sciences Series 17(1): 59-67, 2011. doi: 10.5154/r.rchscfa.2010.03.015 http:// www.chapingo.mx./revistas
2. Aleta, N.; Ninot, A.; Voltas, J. (2003). Characterization of the agroforestry behavior of twelve walnut (*Juglans* sp) genotypes in two locations in Catalonia. Agricultural Research. Forest Resources System. 12(1): 39-50.
3. Azas, R. D. (2016). Evaluation of the effect of pregermination treatments on walnut seeds (*Juglans neotropica* Diels) in the Pumin enclosure in the province of Bolívar. [Bachelor's thesis, University of the Armed Forces, Santo Domingo de los Tsáchilas].
4. Balci, I.; Balta, F.; Kazankaya, A.; Sen, S. M. (2001). Promising native walnut genotypes (*Juglans regia* L.) of the east black sea region of Turkey. Journal American Pomological Society 55(4): 204-208.
5. Boada, C.; Guamán, F. (2005). Study of the attack of *Gretchena garai* Miller in *Juglans neotropica* Diels (Walnut) in single plantation and associated with four forest species in two sites, Province of Imbabura. Bachelor's thesis as a prerequisite to obtain the title of Forestry Engineer. Universidad Técnica del Norte. Ibarra-Ecuador Page 38-48.
6. Benitez, B. G.; Pulido-Salas, T. P.; Equihua-Zamora, M. (2004). Multipurpose trees native to Veracruz for reforestation, restoration, and planting. Institute of Ecology A.C., SIGOLFO, CONAFOR. Xalapa, Veracruz, Mexico. 288 p.
7. Colarič, M. F.; Stampar, M. H.; Solar, A. (2006). Sensory evaluation of different walnut cultivars (*Juglans regia* L.). Acta Agriculturae Slovenica 87: 403-413.
8. Cave, 2018. Estimation of the biological cutting shift for *Neotropic Juglans* Diels through dendrochronological methods in two Andean forest ecosystems of the province of Loja Available from: https://www.researchgate.net/publication/333644514_Estimacion_del_turno_biologico_de_corta_para_Juglans_neotropica_Diels_a_traves_de_metodos_dendrocro

nologicos_en_dos_ecosistemas_forestales_andinos_de_la_provincia_de_Loja?channel=doi&linkId=5cf914564585157d1595e9b9&showFulltext=true#fullTextFileContent [accessed Jan 22, 2024].

9. Diaz, M. C., & Rivera, A. D. (2007). Evaluation of the initial behavior of forest species planted in different stages of succession at the "San Francisco" Zamora Chinchipe Research Station. [Bachelor's thesis, Universidad Nacional de Loja].
10. Fady, B.; Ducci, F.; Aleta, N.; Becquey, J.; Díaz-Vázquez, R.; Fernández-Llópez, F.; Jay-Allemand, C.; Lefe'vre, F.; Ninot, A.; Panetsos, K.; Paris, P.; Pisanelli, A.; Rumpf, H. (2003). Walnut demonstrates strong genetic variability for adaptive and wood quality traits in a network of juvenile field tests across Europe. Kluwer Academic Publishers. New Forest 25: 211–225.
11. Fierro, A. (2023). Dasometric characterization of families of *Junglans neotropica* Diels collected in the province of Tungurahua. Bachelor's thesis as a prerequisite to obtain the title of Forestry Engineer. Chimborazo Polytechnic High School. Riobamba-Ecuador.
12. Galindo, M. P. (1985). Contributions to the simultaneous representation of multidimensional data. Valencia, Spain. 250 p. Doctoral thesis. University of Salamanca. Department of Statistics.
13. ________. 1986. An alternative of simultaneous representation: HJ-Biplot. In: Qüestiió (Quaderns D'estadística i Investigación Operativa). Vol. 10, no. 1; p. 13-23.
14. Gallagher, G. (2018). The IUCN Red List of Threatened Species. IUCN Red List of Threatened Species. https://www.iucnredlist.org/e
15. GBIF Secretariat. (2021). GBIF Backbone Taxonomy. Checklist dataset. https://doi.org/10.15468/39omei accessed via GBIF.org.
16. Gómez, M. L., Toro, J. L., & Piedrahita, E. (2013). Propagation and conservation of native tree species. Medellín, Colombia: Corporación Autónoma Regional del Centro de Antioquia-CORANTIOQUIA.
17. Gower, J. (1966). Some distance properties of latent roots and vector methods used in multivariate analysis. Biometrika, 53: 325-338.
18. Inga, J. G., & del Valle, J. I. (2017). Log-relative growth: A new dendrochronological approach to study diameter growth in *Cedrela odorata* and *Juglans neotropica*, Central Forest, Peru. Dendrochronologia, 44, 117-129. doi: 10.1016/j.dendro.2017.03.009.
19. Klepac, D. 1983. Growth and increase of trees and forest stands. 2nd ed. Universidad Autónoma Chapingo. Chapingo, Mexico. 365 p.
20. Luna-Vega, I.; Alcántara-Ayala, O.; Contreras-Medina, R.; Ponce-Vargas, A. (2006). Biogeography, current knowledge and conservation of threatened vascular plants characteristic of Mexican temperate forests. Biodiversity and Conservation, 15: 3773–3799. DOI 10.1007/s10531-005-5401-1
21. Loewe, Veronica; Bozo, Alejandro; Jaime, Nicolás. (2021). Evaluation of use and proposed classification of Common walnut waste wood (*Juglans regia*). Science & Forest Research Vol. 27 No. 1. April 2021. https://www.infor.cl/index.php/?option=com_infor&view=cifor
22. Manning, W. E. (1957). The genus *Juglans* in Mexico and Central America. Journal of Arnold Arboretum 38: 121-150.

23. Martínez-Pérez, D.; Partida-Sedas, J. G.; Pérez-Portilla, E. (2009). Plant species for biofuels in diversified agricultural systems in Veracruz, Mexico. Revista Brasileira de Agroecología, (4): 2 3438-4342
24. Ministry of Environment and Sustainable Development. (2020). List of threatened wild species of the continental and marine-coastal biological diversity of Colombia - Resolution 1912 of 2017 issued by the Ministry of Environment and Sustainable Development. v2.5. Ministry of Environment and Sustainable Development. Dataset/Checklist. https://doi.org/10.15472/5an5tz
25. Montenegro, M. Pozo, E. (1993). Integrated Control of the Walnut Borer (*Gretchena* sp) of Walnut *(Juglans neotropica* Diels). Thesis, Universidad Técnica del Norte Ibarra – Ecuador. Page 38-45
26. Narave, F. H. 1983. Juglandaceae. Fascicle 31. INIREB. Xalapa, Veracruz. Flora of Veracruz. 30 p
27. Niembro-Rocas, A.; Morato, I.; Cuevas-Sánchez, J. A. (2004). Catalogue of fruits and seeds of trees and shrubs of current and potential value for forestry development in Veracruz and Puebla. Instituto de Ecología, A.C. Final Report of the CONACYT-CONAFOR-2002-CO1-5741 project. Xalapa, Veracruz. Mexico. 928 p
28. Nieto, V. M., & Rodríguez, J. (2010). Juglandaceae (Walnut family) *Jugans andina* Triana y Cortés, *Juglans colombiensis Dode* , *Juglans honorei* Dode Black cedar, walnut cedar, walnut, bogota walnut. Bogotá, Colombia: Corporación Nacional de Investigación de Forestal.
29. Oğuz, H. I.; Doğan, A.; Gün, A.; Kazankaya, A.; Muradoğlu, F. (2008). Determination of Fruit Characteristics of Some Turk-ish Walnut (*Juglans regia* L.) Cultivars Grown in Bozdoğan District (Aydin). Journal of Applied Biological Sciences 2(2): 89-91.
30. Ortega, H. (2007). Study of Gretchena garai Miller attack on walnut (*Juglans neotropica* Diels) in single plantation and associated with four forest species at two sites. [Bachelor's thesis, Universidad Técnica del Norte, Ibarra, Ecuador].
31. Pollegioni, P.; Bartoli, S.; Malvolti, M. E.; Mapelli, S.; Berta-ni, A.; Cannata, F. (2006). Identification of the Italian ecotype of *Juglans regia* L. by means of molecolari, morphological and biochimici markers. Forest@ 3(4): 598-60.
32. R. A. Ramos Veintimilla, O. Murillo Gamboa, and L. A. Gallo, (2020). Potential for genetic improvement in *Juglans neotropica* diels, at 10 months of age in Tunshi, Chimborazo" in VI International Congress of Science, Technology, Entrepreneurship and Innovation 2019, KnE Engineering, pages 562--575. DOI 10.18502/keg.v5i2.6278
33. R. Core Team. (2021). A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.
34. Smith, D.M., B.C. Larson, M.J. Kelty, and P.M. Ashton. 1997. The practice of silviculture: applied forest ecology. 9th ed. John Wiley and Sons. New York. 537 p.
35. Toro, E., & Roldán, I. C. (2018). State of the art, propagation and conservation of *Neotropic Juglans* Diels., in Andean areas. Madera bosques vol.24 no.1 Xalapa abr. http://dx.doi.org/10.21829/myb.2018.2411560
36. Valverde, A. (2016). Study and analysis of the Tocte nut (*Juglans neotrópica*) and its application in pastry. [Bachelor's thesis, University of Guayaquil, Guayaquil].
37. Vera-Vélez Roy, Jorge Grijalva-Olmedo, Raúl Ramos-Veintimilla, Franklin Sigcha-Morales, Ricardo Limongi-Andrade. (2024). Response of three fast-

growing timber species to different bioclimates in Ecuador. Tropical and Subtropical Agroecosystems Vol 27, No 1 (2024).
38. Yamamoto, J. P., & Barra, M. (2003). Native forest species with potential for reforestation in the province of Oxapampa and technical data sheets of the highest priority species. Oxapampa, Peru. Pronature.
39. Zanuttini, R.; Cremonini, C.; Brunetti, M., & Berti, S. (2006). Caratterizzazione del tondame di noce e ciliegio. *Sherwood* 120:7-13.

Conflict of Interest

The authors declare that there is no conflict of interest in relation to the submitted article.