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GROWTH AND GENETIC PARAMETERS OF PROGENIES OF *Cordia trichotoma* IN THE JUVENILE PHASE

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ABSTRACT - Increasing the productive potential of native species is a challenge for forest genetic improvement. Progeny tests are efficient tools to determine the reproductive capacity of individuals and to assist with the selection of superior genotypes. *Cordia trichotoma* (Vell.) Arrab. ex Steud, is a native species of commercial interest due to its high potential for sawn wood. The performance of seedling production from different progenies was the objective of this work. Seeds were collected from 34 matrices selected phenotypically and georeferenced in the region of Lavras - MG. The experiment was conducted in a completely randomized design with 4 replications of 12 plants. Germination after 70 days of sowing, survival and height at 170 days after germination were evaluated. Height and genetic parameters were estimated according to mixed REML / BLUP models using the Selegen software model 82. Progeny 104 (70.8%) was superior in germination and progenies 86 (35.42%), 92 (35.42%) and 111 (43.75%) had the highest survival rates. Height shows high values for the individual additive genetic variation coefficient (49.18%) and genotypic variation coefficient between progenies (24.59%) and moderate values of heritability in the restricted individual sense (0.45) and heritability within progenies (0.38). Due to high values for the coefficient of genotypic variation and moderate values of heritability, there is a potential for height improvements. Progenies 104 stand out in the germination and the progenies 86, 92 and 111 in the seedlings survival). Regarding height, progeny 95 is the only one that stands out negatively.
Keywords: louro pardo, genetic improvement, seedling production.

CRESCIMENTO E PARÂMETROS GENÉTICOS DE PROGÊNIES DE Cordia trichotoma EM FASE JUVENIL

RESUMO - Aumentar o potencial produtivo de espécies nativas é um desafio para o melhoramento genético florestal. Testes de progênies são eficientes ferramentas para determinar a capacidade reprodutiva dos indivíduos e auxiliar na seleção de genótipos superiores. A *Cordia trichotoma* (Vell.) Arrab. ex Steud, é uma espécie nativa de interesse comercial, devido ao seu alto potencial para madeira serrada. O desempenho da produção de mudas de diferentes progênies foi o objetivo deste trabalho. Foram coletadas sementes de 34 matrizes selecionadas fenotipicamente e georreferenciadas na região de Lavras -MG. O experimento foi conduzido em delineamento inteiramente casualizado com 4 repetições de 12 plantas. Foram avaliados a germinação após 70 dias da semeadura, a sobrevivência e a altura aos 170 dias após a germinação. A altura e os parâmetros genéticos foram estimados segundo modelos mistos REML/BLUP, pelo *software* Selegen modelo 82. A progênie 104 (70,8%) foi superior na germinação e as progênies 86 (35,42%), 92 (35,42%) e 111 (43,75%) apresentaram as maiores sobrevivências. A altura apresenta altos valores para o coeficiente de variação genética aditiva individual (49,18%) e coeficiente de variação genotípica entre progênies (24,59%) e moderados valores de herdabilidade no sentido restrito individual (0,45) e herdabilidade dentro de progênies (0,38). Devido aos altos valores para o coeficiente de variação genotípica e moderados valores de herdabilidade, existe um potencial de melhoramento para a altura. Destacam-se as progênies 104 na germinação e as progênies 86, 92 e 111 quanto à sobrevivência das mudas. Para a altura, a progênie 95 é a única a se destacar negativamente.
Palavras-chave: louro pardo, melhoramento genético, produção de mudas.

INTRODUCTION

According to Bernardo (2020), genetic improvement is the genetic alteration of plants to benefit humans. However, we can note a different pace between agricultural and forestry breeding advances. The advances on agricultural species are noteworthy and based on programs which are over a hundred years old. However, the progress in forestry genetic improvements is mainly on eucalyptus and pine programs and the vast majority of tree species are still unimproved or under the domestication phase. Therefore, forest genetic improvement aims, above all, to increase the productive potential of native species.

One of the native species with high potential for sawn wood is *Cordia trichotoma* (Vell.) Arrab. ex Steud,

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known as louro-pardo. This species naturally occurs in the domains of Atlantic Forest and Savannah (Cerrado), especially in the south and southeast regions of Brazil (LORENZI, 2002). Its wood, much appreciated in the furniture manufacturing, has a brown-yellow color in the sapwood and a little darker in the heart, relatively dense (0.65 g cm^{-3} to 0.78 g cm^{-3}), hard and with good resistance, but susceptive to decay when exposed to moisture (LORENZI, 2002; CARVALHO, 2003).

An improvement program presents a scheme of gradual steps, namely: species tests, provenance tests, progeny tests, and clonal tests, culminating in commercial plantations (KAGEYAMA; VENCOVSKY, 1983). The species and provenance test aims to indicate which species are the most potential for production and which subpopulations (provenance) have the most desirable characteristics. The progeny test, on the other hand, is one of the most efficient tools of genetic improvement to be able to determine the reproductive potential of individuals, assisting the selection of superior genotypes.

Due to the slow growth rate of some tree species, forestry breeding programs combine different tests to reduce costs and increase efficiency. Therefore, important information, such as the assessment of provenance, is combined with progeny tests, maximizing possible responses and accelerating the results of the breeding program. In this context, this work aimed to evaluate *C. trichotoma* progenies regarding the growth of seedlings in a nursery and their genetic parameters.

MATERIAL AND METHODS

The experiment occurred in a forest nursery in Lavras, Minas Gerais, Brazil. The climate is classified as Cwa according to the Köppen classification, with an average annual temperature of 19.3ºC. The average temperature in the hottest and coldest months are 22.1ºC and 15.8ºC, respectively, and annual rainfall of 1530 mm with moderate water deficit from June to August (ALVAREZ et al., 2013).

The seeds of *C. trichotoma* were collected in June 2019 on 35 mother trees selected phenotypically and georeferenced nearby Lavras - MG. Progenies were coded as following: 2, 19, 30, 36, 41, 45, 45C3, 46, 47, 50, 71, 74, 76, 78, 86, 90, 91, 92, 93, 94, 95, 96, 97, 99, 100, 101, 102, 103, 104, 105, 107, 108, 109, 110, 111. Seed processing was carried out by drying the fruit in full sun, with subsequent corolla removal. Progenies 2 to 86 were previously processed and stored in the cold room.

The seedlings production was in the full sun using tubes of 110 cm³ with a substrate composed of 30% carbonized rice husk, 30% manure and, 40% coconut fiber, with automated irrigations taking place four times a day for five minutes. Each progeny was manually sown in 48 plastic tubes. Cover fertilization uses mono ammonium phosphate (MAP) in the proportion of 10 grams per liter on the 142nd day after sowing.

The germination evaluation occurred by counting the number of sprouts that emerged after 70 days of sowing. Seedling’s survival evaluated on the 170th day after sowing used the number of sown containers as a reference. The heights were measured using the graduated ruler and that was so from the stem base to its apical bud. To evaluate germination and survival, a completely randomized design was used with four replications of 12 plants each. After examining all the assumptions of the analysis of variance (ANOVA), it ran at a 5% probability of error. The Scott-Knott means cluster test was performed at 5% significance when identified a significant difference, both analyzes assisted by the software Sisvar (FERREIRA, 2011).

To compare the heights and order progenies, the experiment featured as a half-sibling progenies test with one plant per plot. The mixed model approach adopted model 82 of the Selegem REML/BLUP software, which uses as a statistical model of Equation 1 (RESENDE, 2007):

$$y = Xu + Za + e \qquad \text{(Equation 1)}$$

Where:
y = vector of data,
u = scalar referring to the mean (considered as a fixed effect),
a = vector of the additive genetic effects (considered as a random effect),
e = vector of the residues (considered as a random effect) and
X and Z = incidence matrices of pointed effects.

Genetic analysis consists of: the phenotypic variance, additive genetic variance, residual variance, heritability in the restricted sense at the individual level, heritability parameters at progeny level, coefficients of individual additive genetic variation, coefficients of additive genetic variation at the progeny level, and residual variation coefficient. According to the genotypic value, the progenies were ordered and it was also calculated the accuracy and confidence interval values for each genotype. A comparison among progenies was performed by overlapping the estimated confidence values of the genotypic by the methodology of Resende (2007).

RESULTS AND DISCUSSION

The analysis of variance was able to detect a significant difference both for germination at 70 days and for survival at 170 days (Table 1). None of the progenies reached 100% germination; the average was 24.6%, and the maximum observed was 70.8% in progeny 104, superior to the others by the Scott-Knott test (Table 2). The average survival was 13.92%, the maximum observed for progeny 111 (43.75%) progeny 86 (35.42%) and progeny 92 (35.42%) (Table 2).

Germination of *C. trichotoma* is not uniform and does not have high frequencies, as seen by most progenies with germination below 50% (Table 2). This phenomenon can be linked to two main hypotheses, the low storage capacity and the time window for seed collecting.

The loss of viability through storage can be verified by the fact that, out of the seeds of 15 progenies, previously stored in a cold chamber, only three germinated, namely the progenies 86 (41.70%), 19 (2.1%), and 50 (2.08%). Similar behavior was observed by Maffra (2019) who saw that the storage for 120 days resulted in an average of 1.56% of emergence, with storage responsible for the drastic reduction of seedling emergence.

TABLE 1 - Analysis of variance for germination at 70 days after sowing and survival at 170 days after germination of *Cordia trichotoma* seedlings.

Variation sources	DF	Median Square	
		Germination	Survival
Progenie	18	1930.29*	793.03*
Error	57	12.64	45.36
Overall average		24.6%	13.92%
Coefficient of variation (%)		14.5	48.37

*Significant by F test, at the level of 5% probability of error, DF = degrees of freedom.

TABLE 2 - Germination at 70 days and survival at 170 days after germination of *Cordia trichotoma* seedlings.

Progenies	Germination (%)	Survival (%)
	70th day	170th day
104	70.80 A*	18.75 C
111	56.25 B	43.75 A
90	50.00 C	29.17 B
100	50.00 C	29.17 B
86	41.70 D	35.42 A
92	41.70 D	35.42 A
95	35.40 E	20.83 C
97	31.50 E	6.25 D
93	22.90 F	8.30 D
108	18.80 F	4.17 D
91	12.50 G	6.25 D
96	8.33 H	4.17 D
99	8.33 H	10.42 D
110	8.33 H	6.25 D
102	2.13 I	2.08 D
19	2.10 I	0.00 D
109	2.10 I	2.08 D
50	2.08 I	2.08 D
107	2.08 I	0.00 D

*Means followed by the same letter in the column do not differ, according to the Scott Knott test, at a 5% probability of error.

Germination of *C. trichotoma* is naturally irregular, ranging from 14% to 80% (MENDONÇA et al., 2001; FELLIPE et al., 2012). Although *C. trichotoma* seed has tolerance to desiccation and cold (SALOMÃO et al., 2003), it does not retain the germination rate when stored. Even when sown immediately after collection, the average germination is 75% (LIMA et al., 2008). When seeds are stored in a cold room for three months, germination drops to less than 50%, and it drops to below 25% when stored for 15 months (LIMA et al., 2008). Another factor is the common practice of sowing the diaspore (seed, dispersion structures, and petals). The structures besides the seed may increase pathogens' presence which may reduce the emergence and vigor of the seeds. However, even with treatments and the removal of the structures, the germination of *C. trichotoma* did not exceed 70% of germination (BERGHETTI et al., 2015).

The right moment to collect seeds also influences the germination rate. Studies by Machado et al. (2015), in Maringá, observed that the brown-colored diaspores collected in the period from April to July with persistent and senescent perianth do not germinate, in contrast, the diaspores collected from September to October with brown color germinate.

A phenotypic variance of seedlings' height at 170 days was 27.07, consisting of additive genetic variance (12.43) and residual variance (14.64). The heritability parameters in the strict sense at the individual level were 0.45 and within progenies were 0.38. Both estimated heritabilities were considered moderate (0.15 to 0.50), according to Pupin et al. (2017), which demonstrates a reasonable genetic control of the trait. Heritability in the strict sense is a helpful parameter, as it is part of the additive proportion of the genetic variance that is passed on to the descendant generation (BORÉM; MIRANDA, 2009). Zanatto et al. (2020) point out that the greater reliability of the selection of superior progenies is directly linked to high heritabilities. Both estimated heritabilities indicate a moderate capacity to explore the height of *C. trichotoma* seedlings in breeding programs for the species, both in strategies for selecting superior individuals and selecting families.

The individual additive genetic variation coefficient quantifies the magnitude of the genetic variation available for selection and, therefore, high values are desirable (PIMENTEL et al., 2014), the same consideration can be conveyed for the coefficient of genotypic variation between progenies, in which measures genetic variation between families. The residual variation coefficients, individual additive genetic variation coefficient, and genotypic variation coefficient between progenies are 68.28%, 49.18%, and 24.59%, respectively, considered high according to Pupin et al. (2017). Chinelato et al. (2014) found an additive genetic variation coefficient value of 6.75% for diameter at breast height and 3.47% for the height of progenies of *Schizolobium parahyba* and, Pinto et al. (2013) reports individual genotypic coefficients below 10% for the height and diameter of the trunk of *Carica papaya*, considering them low. According to Silva et al. (2018) the higher the coefficients of genetic and genotypic variation, the greater are the exploration potentials and gains from selection within breeding programs.

When analyzing the effect of treatments, taking them as Chinelato et al. (2014), an additive genetic variation coefficient value of 6.75% for diameter at breast height and 3.47% for the height of progenies of *Schizolobium parahyba* and, Pinto et al. (2013) reports individual genotypic coefficients below 10% for the height and diameter of the trunk of *Carica papaya*, considering them low. According to Silva et al. (2018), the higher the coefficients of genetic and genotypic variation, the greater are the exploration potentials and gains from selection within breeding programs.

The comparison and classification among progenies (Table 3) take into account the decomposition of the phenotypic mean into genotypic value, in addition to estimating the additive component within the genotypic value. Most progenies do not differ by the statistics used, only progeny 95 stood out as inferior to the others when comparing the confidence interval. The progenies were ordered according to the value of the additive effect.

TABLE 3 - Classification of progenies according to height at 170 days after germination of *Cordia trichotoma* seedlings in Lavras, Minas Gerais State, Brazil.

Order	Genotype	Genotypic value	Additive effect	Accuracy	Confidence interval		Average heights
					Lower limit	Upper limit	
1	90	10.28	6.24	0.76	8.06	12.51	12.00
2	92	8.75	3.17	0.79	6.62	10.88	9.47
3	50	7.61	0.88	0.34	4.35	10.86	11.00
4	111	7.57	0.80	0.81	5.53	9.60	7.71
5	109	7.49	0.65	0.34	4.24	10.74	10.00
6	108	7.34	0.34	0.45	4.25	10.43	8.00
7	99	7.34	0.34	0.61	4.60	10.08	7.60
8	97	7.31	0.28	0.52	4.35	10.26	7.67
9	102	7.15	-0.04	0.34	3.89	10.40	7.00
10	91	6.93	-0.47	0.52	3.98	9.89	6.33
11	110	6.84	-0.65	0.52	3.89	9.79	6.00
12	86	6.77	-0.79	0.79	4.64	8.90	6.59
13	96	6.72	-0.89	0.45	3.63	9.81	5.00
14	104	6.18	-1.97	0.70	3.73	8.63	5.33
15	100	6.09	-2.15	0.76	3.86	8.32	5.50
16	93	5.91	-2.50	0.57	3.07	8.75	3.50
17	95	5.55	-3.24	0.72	3.15	7.95	4.30

Pimentel et al. (2014) highlight the selective accuracy as an identifier of the quality of the information and techniques used to predict genotypic values, the accuracy being associated with the precision of the selection. This measure refers to the correlation between predicted genetic values and the true genetic values of individuals. The greater the selective accuracy is in the evaluation of an individual, the greater the confidence in the evaluation and the predicted genetic value for the individual are. The selective accuracy within the experiment ranged from 0.34 to 0.81, the low accuracy within some progenies is due to the mortality present in that family.

Based on the comparison between progenies, the vast majority show morphological similarities in height, which resulted in difficulty in comparing them at such an early stage of development. The same challenge was found by Silva et al. (2018) in progenies of *Copernicia prunifera* ((Miller) H. E. Moore) in the nursery phase, at 90 days after germination. More discrepancies regarding growth factors and other variables should be strongly pronounced during the growth of *C. trichotoma* progeny tests on the field.

CONCLUSIONS

The progenies of *C. trichotoma* showed high values for the coefficient of genotypic variation and moderate values of heritability for the height of seedlings at 170 days, which shows potential for improvement for this trait.

Progenies 104 stand out for germination and progenies 86, 92, and 111 for seedlings survival. For height, progeny 95 is the only one that stands out negatively.

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