ABSTRACT – This paper is a part of a study of the genetic variation in open pollinated progenies of *Eucalyptus saligna* Smith produced from seeds collected from 169 mother-trees growing in the Seed Collection Area in the Forestry Park of Itatinga, State of São Paulo, Brazil. At the age of 17 months, a mechanical thinning was made with the main objective of obtaining the two spacings to be tested (3.0 x 1.0 m and 3.0 x 2.0 m, with 9 and 5 plants per plot, respectively), and for evaluating the spacing x genotype interaction. The two spacings resulted from the thinning operations were considered to be two different trials. The evaluation of the trials was conducted at the ages of 15, 26, and 32 months, for height growth, diameter growth, basal area, and cylindric volume. The results obtained at 32 months revealed considerable genetic variation for all growth characteristics studied, at all ages and spacing considered. The joint analysis for spacings showed genetic variation among progenies for all growth characteristics and stem form. The interaction between progenies and spacing showed very low F values for all characteristics. However, when the joint analysis was split, the results showed significant values at the 1% level for the progenies within the spacing, for all characteristics, except volume at the 3,0 x 1,0 m spacing. The F values obtained were more expressive for all characteristics in the wider spacing.

INTRODUCTION

In Brazil modern silviculture is based on intensive cultivation of populations of exotic species, mainly *Eucalyptus* and *Pinus*. The objective is to rationalize and organize production in the plantations so as to achieve and sustain maximum wood production and better quality derivative products at the lowest possible cost.

The more widely used *Eucalyptus* species in Brazil include: *E. granids* Hill ex Maiden, *E. saligna* Smith and *E. urophylla* S.T. Blake. The species have enormous potential when one considers both their adaptability to diverse conditions and their productive capacity.

*Eucalyptus saligna* has been little studied from a genetical point of view and because of this it was considered important to assess the genetic potential of the base population of Itatinga – São Paulo – which has produced nearly all the commercial seeds of
the species used in Brazil. A particular aspect of this research was the effect of spacing, which is regarded as one of the most important silviculture techniques.

Research in silviculture and tree improvement has traditionally been conducted separately. Given the progress made, however, in both specialties using sophisticated forestry techniques and multi-populations within improvement programs, it was considered important to integrate them. Practiced together, they can determine the best genotypes for particular systems of organization and for particular sites, thus increasing productivity.

The present paper deals with two complex and extensive issues: progenies and spacing. The interaction between them will be studied with the objective of quantifying the interaction, genotype X spacing for the progeny of *Eucalyptus saligna* Smith.

**LITERATURE REVIEW**

Spacing influences growth characteristics and, consequently, cultivation techniques, felling and volume production. The question of spacing itself will be determined by the site, the species, and possibly by the genetical quality of the reproductive material to be used. (SILVA, 1984).

BALLONI & SIMÕES (1980) commented that the selection of spacing in plantations in most forestry projects has depended upon the destined use of the wood, ignoring other ecological and or forestry factors of capital importance. DANIEL et alii (1982) highlighted that competition for light, humidity and nutrients were largely determined by the number of trunks per unit. The combined factors of environment and genetics ensure that the development of tree crowns is sufficiently intense, as to promote competition; in the coetaneous populations the competition is more intense among the tree crowns than among the roots.

GUIMARÃES (1965), for *Eucalyptus saligna* Smith, at the age of eight years, and BALLONI & SIMÕES (1980), for the same species at the age of 6 years, verified an increasing mortality tendency and noted that an increasing percentage of trees were overcome by closer spacing, when compared with similar plantations of *E. grandis* Hill ex Maiden. This clearly shows that the planting of *E. saligna* Smith in close spacings for conventional rotations of 6 or 7 years should be considered with care.

BALLONI & SIMÕES (1980) and KAGEYAMA (1986) underline the existence of numerous differences in respect of the influence of spacing over growth in height. They point out cases in which the average height increases with spacing, and others where the result is inverse; nevertheless, they also state that in very closed spacing the average height decreases in proportional to the greater number of trees which are overcome.

MESKIMEN & FRANKLIN (1987) verified the nonexistence of differences in the average height of *E. grandis* Hill ex maiden of 7 years and 3 months of age in relation to spacing, although diameter was directly influenced by a reduction in spacing. PEREIRA et alii (1982) found for the same species that the height of the population was influenced by the number of plants per hectare. COUTO (1977), when studying five different spacings for *E. urophylla* S.T. Blake up to the age of 7 years and 9 months, verified that the average height and diameter of the plantation rose in direct proportion to the increased spacing, BALLONI & SIMÕES (1980) noted a decreased tendency of average height of the *E. grandis* Hill ex Maiden trees, and the *E. saligna* Smith, in proportion to decreased spacing.

REZENDE et alii (1980), in experiment on spacing with *Eucalyptus grandis* Hill ex Maiden of Zimbabwe provenance, and *Eucalyptus saligna* Smith of Itatinga, concluded
that greatest volume growth was obtained with the least spacing; whilst in the case of *Eucalyptus saligna*. Smith spacing did affect volume and diameter growth, but not height. COELHO et alii (1970), in an experiment conducted on 4 species, 2 types of spacing and 4 cutting periods, found that spacing positively affected the growth of various species of trees; however, it did not affect the growth of *Eucalyptus saligna* Smith, *E. alba* Reinw, and *E. propinqua* Deane, in term of height.

GUIMARÃES (1960) for *Eucalyptus saligna* Smith, COUTO (1977) for *E. urophylla* S.T. Blake and MESKIMEN & FRANKLIN (1978) for *Eucalyptus grandis* Hill ex Maiden, for their part, verified that the average basal area and therefore, the average volume per hectare diminished with increased spacing. BALLONI & SIMÕES (1980) affirmed that the most dense populations produced more volume of wood than those of lesser density, but that larger spacing produced a greater number of trees with greater individual volume. The authors highlight that, even when those plantations with a larger number of trees have an overall larger volume production, the useful volume may not increase and a greater number of trees with trunks of a small diameter are produced.

Drastic changes have been brought about in the genetic structure and in the environment of forest plantations as a result of improved generations and intensive forest management techniques. Whilst plants are being cultivated, the environment may be modified through fertilization, irrigation, pruning, thinning, weeding, or by adopting different spacings, as well as through other cultivation techniques directly influencing soil and tree growth. Therefore, one should consider the possibility of the phenotype of trees being influenced positively or negatively by the environment and the interaction genotype X environment.

SHELBOURNE (1972) defined the interaction genotype X environment as the variation between genotypes and their response to different environment conditions. MATHESON (1978) concluded that the interaction genotype X environment was the combined action of genotypes and environments. Similarly, QUIJADA (1980) defined the interaction genotype X environment as the lack of uniformity in the response of two or more groups of plants in two or more environments.

Although, certain characteristics do not undergo major changes with respect to environmental variation those characteristics of greater economic interest generally do undergo substantial changes. This is shown by the fact that small variations in the environment are sufficient to provoke significant phenotype modifications, such as production, height and diameter, in certain cases of forest species.

Experiments with forest species, which consider the use of spacing as a factor of interaction with genotype, are rare, even though, as mentioned above, the effects of spacing influence the growth of forest species and the productivity of the population. Spacing also plays an important role in the technological and economic aspects of wood production.

Mathieu (1967), cited by MORGENSTERN (1982), studied the effect of two different spacings (0.3 x 0.3 and 1.0 x 1.0) in the offspring of *Pinus sylvestris* L.. He evaluated survival capacity, height and diameter growth, trunk form and branch development. Significant interactions were only noted in relation to capacity for survival.

CAMPBELL & WILSON (1973), citing Allard and Bradshaw (1964), demonstrated that the interactions genotype X spacing are problematical for those seeking improvements, as the interactions can disguise the true values of the genotypes. In such cases, the significance of these interactions depends on the size of these effects. Evans et alii (1966),
cited by CAMPBELL & WILSON (1973), suggested that statistically significant interactions could be a manifestation of:

a) the changes in the variances of genotypes with different spacings,

b) the changes in the variances between genotypes according to different spacings or,

c) a combination of changes in levels and variances.

CAMPBELL & WILSON (1973) worked with 30 full-sibs families of *Pseudotsuga menziesii* (Mirb) Franco and found interactions progeny X spacing for height characteristics and volume index.

FRIES (1984) studied the interaction genotype X spacing in *Pinus sylvestris* L. using small seedlings produced from seed and grafted clones with the aim of detecting the occurrence of competitive interactions between them. The author found interactions between spacing and the level of genetic variation, but, in the case of the interaction genotype x spacing no significant results were obtained.

MAMKOONG (1966), SHELBOURNE (1972), KAGEYAMA (1980), KANG (1980), NAMKOONG (1980) and TALBERT (1980) all highlighted the importance of genotype X environment interaction in forestry development, and pointed out that this also affects strategies for selecting programs. NAMKOONG et alii (1980), regarding improvements, showed that selection can favour widely adapted genotypes or genotypes which particularly well to specific environments.

According to MATHESON & RAYMOND (1984 b), the interaction genotype x environment is caused by a deviation in individual genotype values in a site, as a result of the additive effects of the genotypes and environments. The deviations are caused by changes in the behaviour of the genotypes among different sites, or by a variation in the expression of the behaviour of the genes controlling this particular characteristic.

To detect the interactions genotype X environment a great variety of statistical techniques have been developed. The aim is to establish which environments and which genotypes are largely responsible for the variance of the interaction, and the characterization of the latter in terms of their stability.

VENKOVSKY (1978) highlighted the importance of the phenomenon of the interaction of treatments with environments to achieve improved results. He emphasized, citing Allard (1971), that the size of the interaction largely depended on the individuals tested and also on the environmental conditions where the experiment takes place. The author goes on to say that it can be shown that the interaction is comprised of two elements: one owing to the difference in the genetic variability of the material within different environments, and the second, the lack of correlation between the effects of the same material in different environments. It is essential to note that the latter is the most important part of the interaction, as a low correlation can signify that material which proves to be superior in one environment may not be so in another. VENKOVSKY (1978) draws attention to the need to be aware that the interaction may still exist even when there is a high correlation between environments.

It is important to note that the genotypes can produce interaction both in the growth parameters and in the characteristics which define the quality of the wood. The properties of the wood which influence its quality can, on occasions, produce interactions which are more significant than those of the growth characteristics (ZOBEL & TALBERT, 1984).
According to KAGEYAMA (1980) and ZOBEL & TALBERT (1984), the tests of open and controlled pollinated progenies have been important in determining the reproductive values of selected trees. This allows one to estimate the genetic parameter, and thus enables the selection of new, superior individuals.

**MATERIALS AND METHODS**

a) Installation of the Progenies Test

The 169 open pollinated progenies tested were obtained from trees selected at random in the “seed collection area” of the *Eucalyptus saligna* Smith in the plantation of Itatinga, situated in the municipality of Itatinga, São Paulo, Brazil at a latitude of 23° 10’ S and 48° 40’ West of Greenwich, at an altitude of 857 meters. The regional climate according to Koppen is a CWa, with an average annual temperature of 21°C and rainfall of 1296 mm. The predominant types of soils in the region are latosols and podzols and the topography is gentle and undulated.

The experiment was established in the Guaruja Forest Park, property of the National Reforestation Company (CIRENA), belonging to the RIPASA group in the Avare municipality, São Paulo, Brazil. The experimental site was located at a latitude of 23° 11’ S and a longitude of 48° 47’ west of Greenwich, at an altitude of 660 m. The climate was CWA, according to Koppen, with an average temperature of 23.5°C, average annual rainfall of 1,300 mm.

The soil was prepared with a bedding plow and the seedlings were sown in the beds. When planting, 100 g per plant of 6-30-6 fertilizer formula were applied in furrows. Initially, spacings of 3.0 x 1.0 m were established: 3 m between rows and 1 m between plants within the same row. The plants were weeded five times during the first eighteen months, from times manually and once mechanically in order to eliminate the competition of the weeds with the *Eucalyptus* progenies.

The design used for the test was a lattice, with four replications 13 x 13, as established by COCHRAN & COX (1965). The experimental plots were laid out in rows and originally comprised of 20 plants, with each plots representing one progeny. The testing area was marked out by a boundary of two rows of a mixture of the same progenies used in the trial.

After seventeen months, one half of each plot within the replications were mechanically thinned. The aim was to facilitate the operation and avoid plots of different spacings from joining. The thinning enabled the establishment of two tested spacings within each of the plots: 3.0 m x 1.0 m and 3.0 x 2.0 m. As the plots were not thinned on a random basis due to operational difficulties and also to avoid one spacing affecting another, it was decided to analyze them separately, i.e., as two distinct experiments with reference to the two different spacings.

b) Evaluation of the tests and Statistical Analysis

The tests were examined in the field at the fifteen months before the thinning, and at 26 and 32 months. Height and normal diameter (dbh) were registered, the survival rate among the small plants was studied and at the final evaluation values for the trunk form of
the 42 best progenies in the four replicates were also registered. At the age of 17 months, wood samples were taken from those trees felled to evaluate basic density.

Schemes for analyzing in lattice and randomized complete-blocks design were employed, both for comparing treatment methods, as well as for estimating the components of the variance. The individual analyses of variance for mean survival, total height, normal diameter (dbh), basal area and volume were carried out on each of the adopted spacings on the basis of the schemes proposed by Cochran & Cox (1965).

The combined analysis of variance for spacing and age groups in 169 progenies were evaluated in accordance with Cochran & Cox (1965), using the values of the totals of the adjusted treatments obtained from the individual analysis in lattice. The error employed in these analyses was the mean error between the effective errors of the individual analysis under consideration.

The analysis of the covariance between pairs of trees of the same age for one defined characteristic and spacing, enabled the parameters that quantify the association between different age groups to be deduced, which is important for understanding the development of the tree in terms of age. The determination of the mean product (MP) on the basis of the analysis of variance was carried out using the method suggested by Kempthorne (1966) cited by Geraldi (1977). Likewise, the analysis of covariance was also applied to pairs of trees with the same growth characteristics for each spacing and age group.

The quantification of the relation between the sizes of the progenies in the two spacings tested was obtained using “Spearman’s coefficient of rank correlation” (rs) and its significance was inferred by the “t” test.

RESULTS AND DISCUSSION

a) The Growth of the Progenies:

The mean rates for survival and growth in height, diameter, basal areas and volume for the progenies of Eucalyptus saligna Smith are presented in Table 1.

Table 1 – General means for the characteristics in the two spacings and the three age groups studied.

<table>
<thead>
<tr>
<th>Spacing (m)</th>
<th>Age</th>
<th>3.0 x 1.0</th>
<th>3.0 x 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>6.98</td>
<td>10.18</td>
<td>10.71</td>
</tr>
<tr>
<td>Diameter(cm)</td>
<td>5.43</td>
<td>6.69</td>
<td>7.36</td>
</tr>
<tr>
<td>Volume (m$^3$/tree)</td>
<td>0.0180</td>
<td>0.406</td>
<td>0.0524</td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>97.8</td>
<td>96.71</td>
<td>96.01</td>
</tr>
</tbody>
</table>

The development of the characteristics of growth studied in the two spacings and age groups under consideration can be observed in Figure 1.

The data for the mean rate for survival from the trials showed high values for the majority of the tested progenies in the different age groups and spacings. In the smaller spacing besides natural mortality attributed to random factors, there was also additional
mortality due to the competition between the trees as the area available for growth was fully occupied. The results of the present work coincided with those obtained by other authors including GUIMARÃES (1965) for *E. saligna* Smith; BALLONI & SIMÕES (1980) for *E. saligna* Smith, in comparison with *E. grandis* Hill ex Maiden; COUTO (1977) for *E. urophylla* S.T. Blake. When the distance between the trees is small, all of these species generally tend to eliminate a number of individual trees due to more aggressive competition.
The progenies showed fairly vigorous height growth in both spacings although it was much more notable in the closer spacing. This response could be the result of the effects of the thinning conducted after seventeen months, which may have affected the mean height of the population. According to Johnston et alii, cited by COUTO (1977), the mean height is very sensitive to thinning or natural mortality, which on the whole tend to eliminate smaller trees. When considering the increases in growth during the last six months, it could be noted that the increase in height was greater in the widest spacing. This fact would suggest that the mean height could be more influenced by greater spacing as time goes on, which concurs with the results obtained by various authors showing that greater values in average height of the populations correspond to wider spacings.

KAGEYAMA (1986) noted heterogeneity among the response of the Eucalyptus species to spacing and highlighted a wide range of results, verifying the existence of a tendency for the classification of the species on the basis of their response to greater or lesser amounts of light. Thus, GUIMARÃES (1960) for Eucalyptus saligna Smith, COELHO et alii (1970) FOR E. grandis Hill ex Maiden, BALLONI & SIMÕES (1980) for Eucalyptus saligna Smith and E. grandis Hill ex Maiden, and SIMÕES and SPINA FRANÇA (1983) for E. saligna Smith, E. grandis Hill ex Maiden and E. urophylla S.T. Blake, verified the tendency of the species to increase in mean height in relation to greater spacing. COELHO et alii (1970) for E. saligna Smith, E. alba Reinw-u. and E. propinqua Deane ex maiden, MESKIMEN & FRANKLIN (1978) for E. grandis Hill ex Maiden and REZENDE et alii (1980) for E. saligna Smith and E. grandis Hill ex Maiden verified that there was no difference in the mean height of the trees in the spacings tested, although the authors indicated that the spacings did have a positive influence on growth in diameter. FISHWICK (1976) emphasized that in good quality sites spacing had little influence on the
average heights, although many investigations note small increases in height with wider spacings.

The growth in diameter followed the same tendency as the growth in height of the plants. The results obtained for this parameter coincided with those reported by various authors such as GUIMARÃES (1960), REZENDE et alii (1980), COELHO et alii (1970), SIMÕES & SPINA-FRANÇA (1983) which verified that wider spacing corresponded to greater mean diameters.

The mean individual volumes expressed as average values per hectare were calculated for the ages of 15, 26 and 32 months in the spacing of 3.0 x 1.0 m where they reached values of 59.89, 135.42 and 174.62 m$^3$ per hectare, respectively, and of 72.03 and 99.72 m$^3$ per hectare for the ages of 26 and 32 months, respectively in the spacing of 3.0 x 2.0 m.

The results obtained also confirmed, however, those reported by various authors including GUIMARÃES (1960), COUTO (1977), MESKIMEN & FRANKLIN (1978) and BALLONI & SIMÕES (1980), who proved that in closer spacings and, therefore, those with a greater number of trees per hectare, the increase in mean volume per hectare was greater than that produced in wider spacings.

TABLE 2 – Results of the analysis of the individual variance for the different characteristics and age groups in the two tested spacings in randomized complete-blocks and lattice designs.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Age Months</th>
<th>3.0 x 1.0 Spacing</th>
<th>3.0 x 2.0 m Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>CV (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Látice</td>
</tr>
<tr>
<td>Height (m)</td>
<td>15</td>
<td>6.98</td>
<td>6.53</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>10.18</td>
<td>7.77</td>
</tr>
<tr>
<td>Diameter (cm)</td>
<td>15</td>
<td>5.43</td>
<td>8.16</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>6.69</td>
<td>9.42</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>7.36</td>
<td>9.82</td>
</tr>
<tr>
<td>Volume (m$^3$/ per tree)</td>
<td>15</td>
<td>0.0179</td>
<td>17.77</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>0.0406</td>
<td>22.97</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>0.0523</td>
<td>23.09</td>
</tr>
<tr>
<td>Survival(%)</td>
<td>32</td>
<td>96.01</td>
<td>11.27</td>
</tr>
<tr>
<td>Trunk form (notes)</td>
<td></td>
<td>3.53</td>
<td>9.77</td>
</tr>
</tbody>
</table>

CVexpLátice, is the coefficient for experimental variation for the lattice; CVexpBAA, is the coefficient for experimental variation for the randomized complete-blocks; E lattice (%) is the efficiency of lattice in percentages; Fprog Lattice, is the value of F for the progenies from the lattice design using the effective error; FprogBAA is the value of F for the progenies from the randomized complete blocks sign; ns – not significant; * significant up to 5%, ** significant up to 1%.
b) Results of the analysis of individual variance

Table 2 shows the results of the individual analysis of variance for the characteristics evaluated including height, diameter and volume, in the three age groups studied and the two spacings tested.

The values for F, both for the analysis of variance in lattice as well as for randomized complete-blocks design, did not present any defined tendency of variation in relation to age or to spacing. The genetic variations detected by the individual analysis of variance showed a certain homogeneity between spacings and between ages within the spacings in the two designs contemplated. The form height of the trees showed greater values for F for the progenies, followed by diameter, basal area, volume and survival rate.

A tendency towards greater values for F in the lattice design was verified, when the designs in lattice and randomized complete-blocks were compared.

In the case of the rate of survival, however, the values for F were equal in both designs, given that these values were more expressive in the smallest spacing and could reflect greater mortality in this spacing.

The efficiency of the lattices for characteristics of growth were greater than 115% in all cases except for the height of plants in the spacing 3.0 x 2.0 m, where a value of 109% was obtained; for survival, efficiency rates in the lattices of 100% were obtained for both spacings. Therefore, it was considered, in accordance with SNYDER (1966) and MIRANDA FILHO (1978), that these values of the efficiency rates of the lattices fully justified the use of the referred to design for the analysis of the data for progeny trials of *Eucalyptus saligna* Smith progeny.

The different behaviour of the progenies in the two spacings could be interpreted as a differential expression of the genetic material in different spacings, which would be reflected in the interaction genotype X spacing, or could also be interpreted on the basis of the variation of experimental error between the two spacings.

Growth in height and diameter revealed the lowest values for the coefficients of variation in the analysis of variance, showing, therefore, greater experimental precision. Considering the totality of the coefficients of experimental variation off the analysis of variance, one can confirm that for all the characteristics studied statistical efficiency was high.

Given the value of F obtained, the individual analysis of variance for trunk form in the two tested spacings showed significant genetic variations of up to 1% for the progenies growing in the greater spacings; for the smaller spacing, no significant genetic variation was detected. This would suggest that wider spacing indicated the differences between means of progenies more easily.

c) Combined analyses of variance

The results of combined analyses of variances which include the two spacings, for the characteristics of height, diameter (dbh), basal area and volume for the ages 26 and 32 months age groups are presented in Table 3.

The results obtained showed very similar values for F, for the characteristics studied and for the 26 and 32 months groups. On the other hand, the effect of the spacings on the growth of the progenies produced important results for height and diameter at 26 months.
and for diameter and volume at 32 months. These results would suggest that the variation between progenies was affected by spacing which accords with MATHESON & RAYMOND (1984 a).

It could be considered that the variations between the two spacings for the growth of the progenies were not caused by climatical or edafic differences, given that both experiments were conducted in the same locality; although in the case of the soil there could have been micro-environmental variations in the plots, which affected the behaviour of the progenies. However, it is thought that the extreme proximity of the plots in the two spacings tested, and the existence of four replications in the progeny trials, minimized this effect. It was considered, therefore, that the differences in growth of the progenies were due to the differential effects of the genetical expression between progenies.

The interaction progenies X spacing showed, for all the characteristics and ages under evaluation, values which were hardly significant, and indeed all the values for F were less than one.

Table 3 – Results of the combined analysis of variance for the characteristics of growth and trunk form in the two spacings and for 26 and 32 months age groups.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Age (months)</th>
<th>General average</th>
<th>F prog.</th>
<th>F esp.</th>
<th>F prog. x esp</th>
<th>CVexp (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (m)</td>
<td>26</td>
<td>9.98</td>
<td>3.16**</td>
<td>2.51**</td>
<td>0.80ns</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>10.62</td>
<td>3.30**</td>
<td>0.42ns</td>
<td>0.72ns</td>
<td>15.10</td>
</tr>
<tr>
<td>Diameter (cm)</td>
<td>26</td>
<td>6.86</td>
<td>2.72**</td>
<td>2.98**</td>
<td>0.93ns</td>
<td>17.81</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>7.65</td>
<td>2.77**</td>
<td>7.85**</td>
<td>0.85ns</td>
<td>18.97</td>
</tr>
<tr>
<td>Basal area (m²/tree)</td>
<td>26</td>
<td>0.00394</td>
<td>2.39**</td>
<td>3.22**</td>
<td>0.90ns</td>
<td>30.93</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>0.00494</td>
<td>2.33**</td>
<td>8.59**</td>
<td>0.81ns</td>
<td>32.10</td>
</tr>
<tr>
<td>Volume (m³/tree)</td>
<td>26</td>
<td>0.0419</td>
<td>2.38**</td>
<td>0.63ns</td>
<td>0.78ns</td>
<td>40.47</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>0.0561</td>
<td>2.29**</td>
<td>3.39**</td>
<td>0.75ns</td>
<td>40.58</td>
</tr>
<tr>
<td>Tree form (notes)</td>
<td>32</td>
<td>3.59</td>
<td>3.55**</td>
<td>2.77**</td>
<td>0.77ns</td>
<td>10.22</td>
</tr>
</tbody>
</table>

Fprog = F of progenies; F esp = F of spacing; Fprog x esp = F of progenies x spacing; CV exp = Coefficient of experimental variation; ** = significant up to 1%; ns = not significant; basal area in m² per tree; volume in m³ per tree.
Given that only as a result of a more detailed analysis could the presence of the interaction genotype X spacing be detected with greater precision, the combined analysis of variance for the characteristics of growth in the tested spacings at the age of 32 months is broken down. The results obtained can be observed in Table 4.

The results indicate that when the progenies within the spacings, both that of 3.0 x 1.0 m and 3.0 x 2.0 m, are considered, the tendency of the values for F thus obtained are those that were always present for the characteristics evaluated: greater values in the case of those progenies within the wider spacing.

If one considers that the volume, a characteristic comprised of height and diameter, reflects more clearly the effect of the progenies within the spacing, one can confirm that the progenies react differently in the spacings 3.0 x 1.0 m and 3.0 x 2.0 m, which would characterize and interaction of a simple type, although this was not detected by the F test.

FIGURE 2 – Behaviour of a sample of progenies of Eucalyptus saligna Smith for the volume in the two tested spacings at the age of 32 months.
TABLE 4 – Results of the values for F for the breakdown of the effects of the progenies within the evaluated spacings.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Height</th>
<th>Diameter</th>
<th>Cylindrical Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progenies/spacing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3.0 x 1.0 m)</td>
<td>1.62**</td>
<td>2.4**</td>
<td>1.00ns</td>
</tr>
<tr>
<td>Progenies/spacing</td>
<td>2.4**</td>
<td>4.22**</td>
<td>2.02**</td>
</tr>
</tbody>
</table>

** significant up to 1%; ns – not significant

It is important to mention that the better progenies for the characteristics studied were not the same in the two spacings; however, there were some progenies which reacted in a similar form in the two spacings, occupying almost the same relative position, as can be observed in Figure 2.

By maintaining the averages for adjusted treatments for the different characteristics studied, the response of the progenies in the two tested spacings allowed one to differentiate three behaviour types of the progenies in relation to the spacing:

- progenies which developed better in the smallest spacing (3.0 x 1.0 m).
- progenies which developed equally in both spacings, occupying both the best as well as the worst positions, or even the intermediate positions in both spacings, and
- progenies which developed better in the widest spacing (3.0 x 2.0 m).

On analyzing Figure 2, one can verify the presence of simple and complex interactions. It is important to highlight that these interactions occurred both in those progenies considered to be the best in terms of volume production per tree, as well as in those estimated to be the worst in terms of production in the two spacings.

Although the greater part of the progenies did not demonstrate interactions, and the differences between them were not significant, the few progenies which presented interactions and good volume production in either or the spacings should be taken advantage of in selection for an improvement program.

The quantification of the relation between the means for the progenies in the two tested spacings at the age of 32 months, using the “Spearman coefficient of rank correlation” (rs), can be observed in Table 5.

TABLE 5 – Spearman’s coefficient of rank correlation between the two spacings, at the level of averages for the plots, for the characteristics of height, diameter, volume and tree type, at the age of months.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Spearman’s Coefficient of Correlation (rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0.62**</td>
</tr>
<tr>
<td>Diameter (DAP)</td>
<td>0.50**</td>
</tr>
<tr>
<td>Cylindrical Volume</td>
<td>0.52**</td>
</tr>
<tr>
<td>Trunk Form</td>
<td>0.37*</td>
</tr>
</tbody>
</table>

** significant up to 1% using the “t” test
significant up to 5% using the “t” test; using only the best 42 progenies in terms of volume production in the spacing of 3.0 x 2.0 m.

The results obtained show positive correlations between the two spacings, and displayed significant values for all the characteristics studied. Nevertheless, it can be observed that the values for rs are not expressive and do not coincide with the relative positions of the progenies in the two spacings which, according to VENCOVSKY (1978), is caused by the lack of correlation between the material of one environment and of another.

CONCLUSIONS

The results obtained in this study give rise to the following conclusions:

The growth and survival of the plants in the two experiments were considered to be good, confirming the potential of the species for these conditions. The growth in the spacing 3.0 x 2.0 m was greater than that obtained in the spacing 3.0 x 1.0 m for all the characteristics.

At the level of individual analysis significant genetic variations between progenies were highlighted for all the growth characteristics studied, for all the age groups and spacings evaluated. The genetic variations detected showed a certain homogeneity between spacings and between age groups within the spacings.

For the survival value of the plants, only genetic variations in the smallest spacing were verified; for trunk form these variations only existed in the wider spacing. In the smaller spacing the variations between progenies in terms of survival increased and, furthermore, concealed the difference for trunk form.

The two designs used in the present study, lattice and complete-blocks, were equally efficient for evaluating the progeny trials, when considering the values for F obtained.

The combined analysis of variance which include the two spacings revealed genetic variations between progenies for all the characteristics and age groups considered. The effect of the spacing increased significantly from the age group of 26 to that of 32 months for all the characteristics, excluding height.

The interaction progenies X spacing was show to be not significant for all the characteristics and age groups studied.

The break down of the interaction progenies X spacing showed greater expression for variation between progenies within the spacing 3.0 x 2.0 m, than in the smaller spacing, mainly for volume. This would suggest the presence of an interaction progenies x spacing.

The Spearman coefficient of rank correlation, when applied to the averages of the progenies between the two spacings, did not coincide with the relative positions of the progenies within the two spacings and were more accentuated for trunk form, reinforcing the possibility of the existence of some type of interaction. This greatly influences the selection of the best progenies for the two spacings, when the progenies do not coincide.

On analyzing the differential growth of the progenies in relation to spacing, it was possible to define three types of behaviour of the progenies: progenies which develop better in the closer spacings and in the 3.0 x 2.0 m, and progenies which develop equally in both spacings.
REFERENCES


