

Predicted Genetic Gains Adjusted for Inbreeding
for an Eucalyptus grandis Seed Orchard

K. V. Reddy, D. L. Rockwood, C.W. Comer
and G. F. Meskimen-

Abstract.--One-half of a genetic base population (GPOP77) of Eucalyptus grandis Hill ex Maiden containing 529 families representing four generations of selection was harvested in August 1978. Family and individual tree heritabilities for 64-month coppice height, diameter at breast height (DBH) and volume were 0.65, 0.65 and 0.59, and 0.31, 0.32 and 0.27, . respectively. Predicted gains were adjusted for inbreeding due to mating of related individuals as well as for natural selfing. The predicted genetic gains through different selection strategies ranged from 41% to 90%. Impressive gains were also predicted for clonal propagation of selected individuals.

Additional keywords: heritability, coppice, inbreeding, selfing.

In southern Florida Eucalyptus grandis has been the focus of intensive genetic improvement (Franklin 1978). It is recommended on the palmetto prairie (low fertility) and acid flatwoods (Geary et al. 1983). Trees planted in southwest Florida constitute a landrace developed through three generations of selection and progeny testing. Each generation of selection enhances the landrace's adaptation to local conditions (Meskimen 1983).

In south Florida, substantial genetic gain for juvenile height and volume growth at 2.5 years of age was found in 33 E. grandis progenies tested (Rockwood and Meskimen 1981).

Graduate Research Assistant, Associate Professor, Assistant Research Scientist and Adjunct Assistant Professor, respectively, Department of Forestry, University of Florida, Gainesville, FL. Research reported here is supported by Oak Ridge National Laboratory under subcontract no. 19X-09050C and a cooperative program between the Institute of Food and Agricultural Sciences of the University of Florida and the Gas Research Institute, entitled "Methane from Biomass and Waste". The USDA For. Serv., Southeastern Forest Experimental Station, installed and maintained the experimental materials through September, 1984.

In Florida the current *E. grandis* base population consists of 529 families (Geary et al. 1983). These families were all derived from 228 original introductions, mainly from Australia and South Africa, that went through up to four generations of selection. Consequently, some of the 529 families in the current base population were related due to common ancestry leading to a certain degree of inbreeding.

In a tree improvement program, care should be taken to avoid the deleterious effects of inbreeding. These effects may be of greater importance in eucalypts than has previously been considered. The most significant consequence of inbreeding depression is the reduction of the mean phenotypic value manifested by characters connected with reproductive capacity, physiological efficiency and general vigor of the offspring. Selfing, the most severe form of inbreeding has been shown to adversely affect most characteristics in *E. grandis* (Van Wyk 1981). Estimation of inbreeding consequences is of practical importance in continuing development of *E. grandis* seed orchards in southern Florida. This paper reports the effect of inbreeding due to mating of relatives as well as to natural selfing on predicted gains from a 50-family seed orchard.

MATERIALS AND METHODS

The *E. grandis* genetic base population (GPOP77), located at LaBelle, Florida, was planted on July 1977 and includes 529 open-pollinated families representing four generations of selection (Table 1). Each family was represented 60 times in a completely randomized single-tree plot design on 17.3 hectares. Spacing was 1.8 m between trees on paired beds spaced 2.3 m within pairs and 3.5 m between pairs, for a density of 1,916 trees per hectare. The southern half of the plantation was harvested in August, 1978. Coppice height and DBH at 264 months were used to calculate the volume according to the formula DH , where H and D are height and DBH, respectively. Genetic gains were predicted for different selection strategies for both individual and combined selection, using selection intensities obtained from tables provided by Namkoong and Snyder (1969).

The effect of inbreeding on predicted gains was studied for a 50-family seed orchard with one tree per family. The study assumed that the original introductions themselves were not inbred. The inbreeding coefficients for the progeny of all possible matings among the 50 families were calculated by tracing the pedigree of each mating to the common ancestor and computing the probabilities at each level (Li 1976) as shown in Figure 1.

Table 1. Proportion of families per generation in GPOP77.

<u>Generation</u>	<u>% Families</u>
1	27
2	40
3	24
4	9

RESULTS AND DISCUSSION

High genetic variation was observed for height, DBH and volume with the best trees producing 2-3 times more than others. Estimates of individual and family heritabilities of five traits (seven-month seedling height, three- and 64-month coppice growth, height and DBH) were not significantly different (Reddy et al. 1985). At 64 months after harvest, the family and individual heritabilities for coppice height, DBH and volume were 0.65, 0.65 and 0.59, and 0.31, 0.32 and 0.27, respectively.

The inbreeding coefficients (F) for possible crosses ranged from 0 to 0.25 (Table 2). The mean F value for all the matings was low (0.5%) because only 13% of all possible crosses were related. Additionally, in related individuals two or three generations have passed since direct relationship by common ancestry.

Hodgson (1976a) reported a reduction in seed yield of 53% to 98% following self-pollination. In deliberately selfed progenies of *E. grandis*, a loss of 8% to 49% in height growth is reported (Eldridge 1978, Hodgson 1976b). Moreover, selfed progeny were found to be more

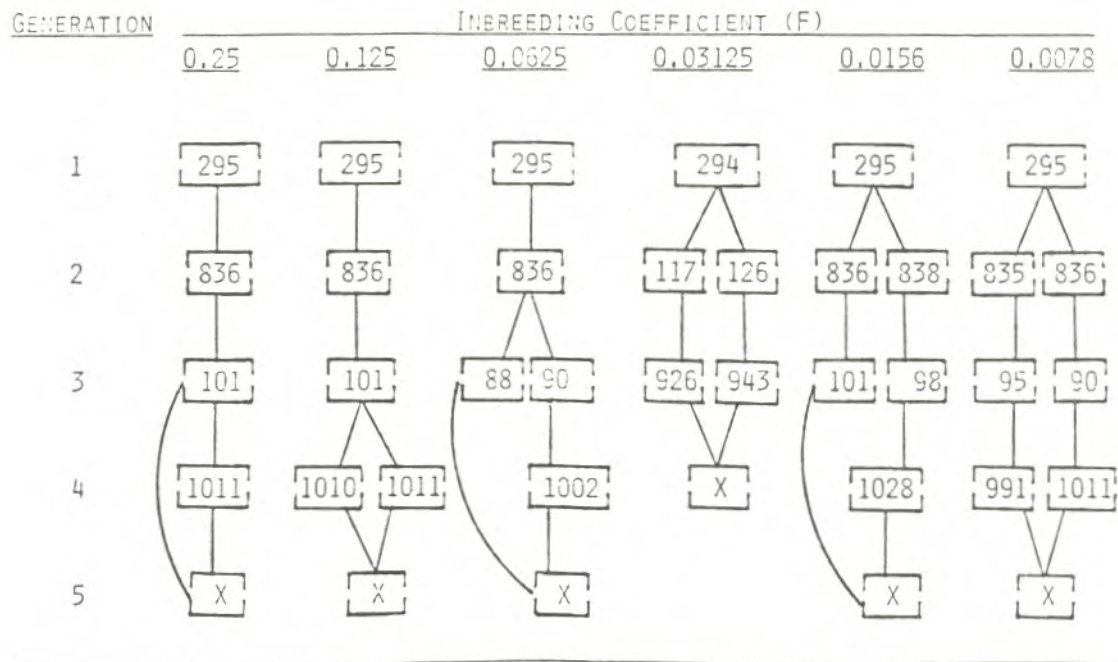


Figure 1. Representative pedigrees and inbreeding coefficients of different degrees of relationships among families in GPOP77.

Table 2. Inbreeding coefficients (F) and number of all matings in a 50-family seed orchard.

	F	Number of Matings	
	0		1064
	0.25		2
	0.125		13
	0.063		6
	0.031		93
	0.016		19
	0.008		28
Mean	0.005	Total	1225

crooked and have 30% abnormal seedlings. The amount of natural selfing that occurs in eucalypts is higher than reported for pines. An average of 7% selfing is reported in many pines (Wright 1976). Published estimates for the degree of natural selfing in eucalypts vary with species: 24% in *E. obliqua* (Brown et al. 1975), 37% in *E. pauciflora* (Phillips and Brown 1977), 23% in *E. delegatensis* (Moran and Brown 1980) and 18% in *E. stoatei* (Hopper and Moran 1981). Eldridge (1978) reported 20% to 40% selfing occurring in *E. grandis* and Van Wyk (1981) estimated an average of 30%. Using a conservative approach for the range of inbreeding depression reported for *E. grandis*, a 50% loss in growth for selfed progenies (F=0.5) amounts to 10% loss for every 10% of inbreeding coefficient.

Using Eldridge's (1978) estimate of 30% natural selfing in seed orchards of *E. grandis*, the mean F value for the offspring of all possible matings will increase due to selfing. Thirty percent of the offspring will have an F of 0.5 and 70% will have an F of 0.005. Thus the estimated inbreeding coefficient of the offspring will be 15.4% (F=0.154). Therefore, the predicted genetic gains from the seed orchard should be decreased by 15.4% to account for the loss due to selfing and mating of relatives.

Based on the results from the 50-family seed orchard, similar adjustments for inbreeding were made for the predicted genetic gains from different selection strategies. This assumed that the mean inbreeding coefficient for the progenies of the families in the seed orchard is the same (F=0.005) for any selection strategy that has a variable number of families and number of trees per family.

The predicted genetic gains that could be achieved through different selection strategies are given in Table 3. Higher genetic gains through family and combined selection than mass selection agrees with the results reported in *E. robusta* (Dvorak et al. 1981). The greatest gain in volume (90%) over the whole population can be achieved when combined selection is performed, selecting the top 100 families with three trees per family. Similar gains can be achieved by selecting one tree from the top 300 families (96%). A gain of 80% can be realized through mass selection of the top 200 trees. Genetic gain through

Table 3. Predicted genetic gains in 64-month coppice volume for alternative improvement strategies with *Eucalyptus grandis*.

<u>Selection Strategy</u>	<u>Genetic Gain (%)</u>
200 best trees	80
300 best trees	69
10 top families (30 trees per family)	41
30 top families (10 trees per family)	61
100 top families (3 trees per family)	90
300 top families (1 tree per family)	86
Clonal propagation of 200 best trees	441

clonal propagation of the best trees shows considerable promise. A gain of 441% is predicted through the clonal propagation of the top 200 trees. This estimate, however, is biased upward by the fact that it assumes 100% survival, which is unrealistic. Nevertheless, it does indicate the potential that exists in clonal propagation.

CONCLUSIONS

Natural selfing is an important factor to be considered in predicting genetic gains. The estimates should be adjusted to account for the inbreeding depression that occurs due to selfing as well as due to mating of related families which share a common ancestor. In this study the mean relationship among families was low (0.5). However, the predicted gains were decreased by 15.4% to account for natural selfing which is reported to be 30% in *E. grandis*.

High genetic variation for growth was observed in *E. grandis* with the best trees producing 2-3 times more than the others. This suggested the obvious potential for improvement through clonal propagation of the best individuals to capture full genetic superiority. Impressive gains are also predicted through combined selection of various selection intensities. A gain of 90% could be achieved by selecting three trees from the top 100 families.

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