J. M.: The heritability of wood characteristics of *Pinus radiata*. Silv. Genet. 13, 68—71 (1964). — Nicholls, J. W. P., and Dadswell, H. E.: Assessment of wood qualities for trees breeding III. In: *Pinus radiata* D. Don. CSIRO Div. For. Prod. Technol. Paper No. 37 (1965). — Paul, B. H.: Variability in wood of Southern pines as influenced by silviculturai practices. U. S. Forest Prod. Lab., Madison Report No. R1923, pp 10 (1952). — Shelbourne, C. T. A.: Tree breeding methods. N. Zeal. For. Serv., Tech. Paper No. 55, pp 43 (1969). — Trendelenburg, R.: Das Holz als Rohstoff. J. F. Lehmann's Verlag, Munich/Berlin. (Translation by the Imperial Forestry Bureau, pp 131—159 (1939)).

Effect of Seed Origin on Coppice Regeneration in Eucalyptus camaldulensis Dehn.')

By Clara Grunwald and Rene Karschon

Forestry Division, Agricultural Research Organization,
Ilanot, Israel.

Introduction

Eucalyptus camaldulensis Dehn. (E. *rostrata* Schlecht.) is one of the most widely grown eucalypts outside Australia. Its plantations are commonly managed as coppice; however, only limited information is available on the dynamics of coppice formation and growth and on its relation to environmental factors and tree size prior to cutting (Ciancio and Morandini, 1971; Jacobs, 1955; Karschon, 1972).

Since ecotypic variation is known to occur in the species (Karschon, 1971, 1974), possible differences in the ability to coppice and in growth rate could be of practical interest when introducing locally better-adapted seed sources and evaluating alternative selection strategies (Burrows, 1970). Investigations along these lines are still lacking.

Accordingly, the objectives of the present research were *(a)* to investigate the annual course and rate of coppice regeneration and its relation to tree size before cutting; and *(b)* to determine differences in coppice regeneration between progenies from different seed sources.

Materials and Methods

The investigation was conducted in an experimental plantation of E. camaldulensis approximately 6.5 years old at Ilanot (32⁰ 18' N, 34⁰ 54' E). The original layout was a split-plot design to test the effect of presence of lignotubers in the planting stock on tree growth, but growth rate was found to be not affected by the type of plants used (Karschon, 1971). Therefore, the sub-plots could be neglected and the coppice trial was analyzed as a randomized-block design with four progenies from bulk provenance collections *(Table* 1) and four replications, each plot consisting of eight trees spaced 3 X 3 m apart.

After measuring the height, girth at breast height (B.H.), and girth at 20 cm above ground, the trees were cut at about 10—15 cm above ground on 2 October 1972. At one-month intervals, counts were made of the number of sprouting stumps and of the number of sprouts per stump, and measurements were taken of the tallest shoot of each stump.

On 3 October 1973 the shoots were thinned according to current practice, leaving 1—3 shoots per stump. The fresh weight of the cut shoots was determined for each stump, to estimate the biomass, since in preliminary trials no statistically significant differences in moisture content were found between progenies (C. Grunwald, unpublished data).

Evaporation from a screened U. S. Weather Bureau Class A pan was 1,482 mm during the 12-month period following the cutting (Fig. 1D). Rainfall in 1972173 was well below the yearly average of 603 mm and amounted to only 410 mm; the first and last effective rains were in the first week of December and of March, respectively.

Table 1. — Means of tree sizes prior to cutting (2 Oct. 1972) and of rates of coppice regeneration (3 Oct. 1973) in four progenies from Australia.

Progeny No.	Provenances	Latitude S	Longitude E	Before cutting			Coppice		
				Height m	Girth at B.H. cm	Girth at 20 cm cm	Maximum height m	Number of shoots	Biomass*) kg
6788	Alice Springs, N. T.	23⁰ 38'	133⁰ 35'	6.33	14.6	21.3	1.66	19.9	1.035
6869	Katherine, N. T.	14⁰ 25'	132⁰ 15'	7.78	18.9	28.3	2.25	16.0	0.977
6949	N of Hughenden, Qld.	20⁰ 43'	144⁰ 21'	8.34	19.8	28.9	2.27	20.1	1.483
6953	Petford, Qld.	17⁰ 20'	144⁰ 57'	9.77	22.2	31.4	2.86	23.5	1.755
			S. E.	0.49	1.6	2.2	0.10	3.6	0.274

*) Fresh weight, excluding 1-3 shoots per stump left after thinning.

141

Results

As shown in *Table 1*, the growth rate before cutting of the four progenies raised from seed differed markedly, depending upon the seed origin. The rate of coppice regeneration varied accordingly, with the fastest-growing progeny (No. 6953) also producing the tallest coppice, largest number of shoots, and greatest biomass.

Figure 1 shows the annual course of coppice regeneration and its relation to pan evaporation. Formation of coppice shoots started in the second month after cutting, prior to the first effective rains. The number of sprouting stumps increased rapidly and within seven months after cutting, by the end of April, all the stumps had regenerated *(Fig. 1A)*. The number of shoots per stump increased steadily until June and then changed but little *(Fig. 1B)*. Height growth measured on the tallest coppice shoot was slow until March, rose steeply until August and then levelled off, without at any time ceasing altogether *(Fig. 1C)*. No clearcut differences between progenies occurred in the patterns of the annual course of coppice formation.

Beginning from February-March, the number of coppice shoots was directly related to tree size before cutting—height, girth at B.H., and girth at 20 cm above ground; the size of the correlation coefficients increased with the number of months after cutting. From April-May onward, the height of the coppice shoots was also directly related to tree size before cutting; also here, the correlation coefficients increased with time, but were always higher than those relating to the number of coppice shoots. The order
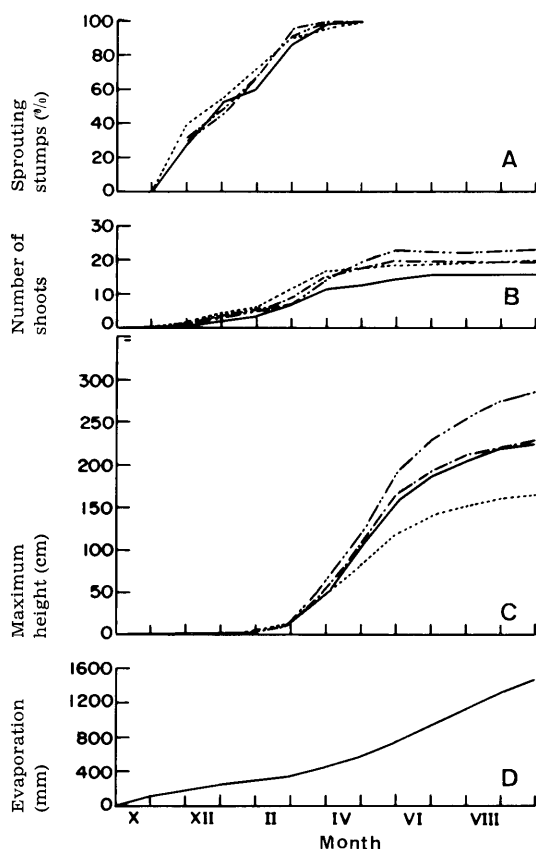

Figure 1. — Annual course of coppice regeneration in four progenies (A—C) and its relation to pan evaporation (D). A — percent of sprouting stumps; B — mean number of shoots per stump; C — mean height (cm) of the tallest shoot; D — cumulative pan evaporation (mm). · · · · · = 6788; ——— = 6869; — · — = 6949; — · · — = 6953.

of sprouting of the stumps was independent of the size of the trees before cutting.

Figure 2 presents scatter diagrams of four progenies and common regression lines for coppice regeneration after 12 months (October 1973) over tree height *(Fig. 2A—C)* and girth at 20 cm prior to cutting *(Fig. 2D—F)*; correlation coefficients were from 0.53 to 0.83 and were significant at the 1% level of probability. Similar results were obtained by plotting regeneration over girth at B.H. before cutting. Differences between regressions for each progeny were not significant.

Discussion and Conclusions

Although in a previous study yields of *E. camaldulensis* in Israel were shown to be directly related to latitude of seed origin in Australia (KARSCHON, 1974), no such relation was obtained in the four progenies; this is believed to be due to the small number and limited latitudinal range (14—23° S) of the seed sources. The apparent relation of tree growth to longitude of seed origin is not in agreement with previous findings (KARSCHON, 1974). Growth of the progenies varied, however, depending upon the seed origin; this, in turn, led to marked variation in the amount and growth rate of the coppice regeneration *(Table 1)*. In our experiment, cutting of *E. camaldulensis* was done at the beginning of October, since in Israel this time of the year is known to produce full and fast regeneration (KARSCHON, 1972). Cutting at different times of the year could be expected to produce fairly similar results, since neither JACOBS (1955) nor CIANCIO and MORANDINI (1971) found a significant relation between season of cutting and coppice growth of eucalypts.

Three stages may be conveniently distinguished in the annual course of coppice regeneration *(Fig. 1)*:

I — A *latent* stage between the time of cutting and the emergence of the first sprouts from the stumps. In the present study this stage lasted for less than two months but may even be shorter (KARSCHON, 1972).

II — A stage of *incipient* coppice formation from November to January—April, when the number and growth rate of coppice shoots is not yet related to the growth potential of the stumps. Its commencement is not determined by the fall of effective rain. During this stage, correlation coefficients between tree size before cutting and regeneration are statistically not significant. Not unexpectedly, the evapotranspiration of the coppice during stages I and II is identical to that of a bare area (KARSCHON, 1972).

III — A stage of *potential* coppice regeneration starting between February and May, when the number and height growth of the coppice shoots are determined by the vigour and size of the stump, resp., of the tree before cutting (and most probably also by the extent of the root system). During this stage, correlation coefficients between tree height and girth, and number and height of coppice shoots, are significant for at least P = 0.05 and increase with time (the potentially highest values of r may possibly be reached even later than 12 months after cutting). During most of this stage until the onset of the rains, the evapotranspiration of the coppice, though slightly higher than that of a bare area, is restricted by soil moisture deficiency and undeveloped leaf area (KARSCHON, 1972).

Although the duration of stage II varied somewhat depending upon seed origin, there were no conspicuous differences between progenies in the general patterns of the annual course of coppice formation *(Fig. 1A—C)*. Dif-
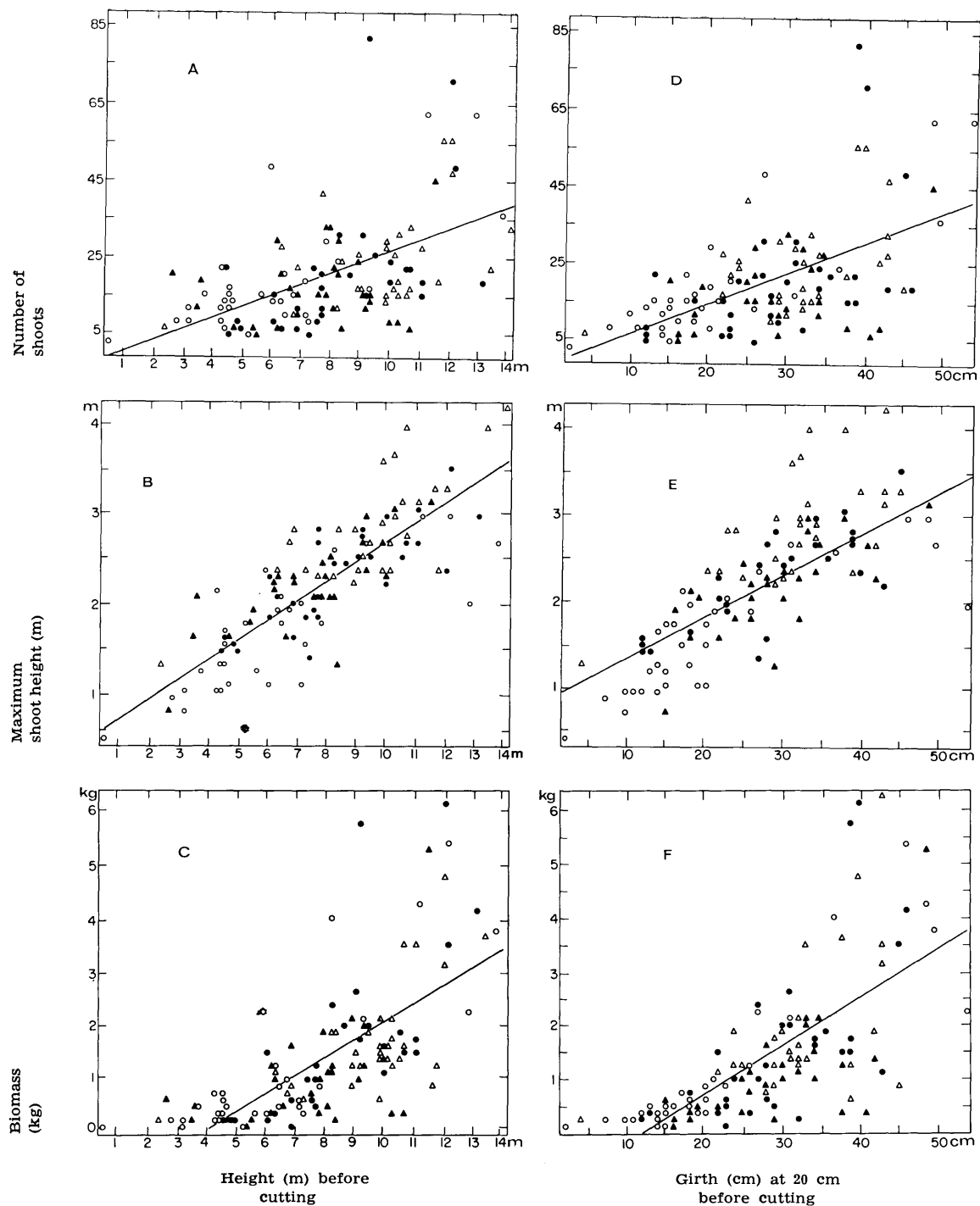
Figure 2. — Linear regressions and scatter diagrams for four progenies of coppice regeneration after 12 months, over tree size prior to cutting. A — number of coppice shoots over tree height (m). Y = —3.77 + 2.94x; r = 0.53**. B — height (m) of tallest coppice shoot over tree height (m). Y = 0.51 +0.22x; r = 0.83**. C — biomass (kg) of coppice (excluding 1—3 shoots per stump left after thinning) over tree height (m). Y = —1.52 + 0.35x; r = 0.70**. D — number of coppice shoots over tree girth (cm) at 20 cm above ground. Y = —3.04 + 0.84x; r = 0.57**. E — height (m) of tallest coppice shoot over tree girth (cm) at 20 cm above ground. Y = 0.82 + 0.05x; r = 0.77**. F — biomass (kg) of coppice (excluding 1—3 shoots per stump left after thinning) over tree girth (cm) at 20 cm above ground. Y = —1.20 + 0.09x; r = 0.70**. o = 6788; ▲ = 6869; ● = 6949; △ = 6953.

ferences in number and height of coppice shoots, however, were the direct result of differences in vigour and growth of the trees prior to cutting, due to differing adaptation of the progenies to site conditions at Ilanot *(Table 1)*.

This dependence is illustrated in *Fig. 2,* showing the relation, 12 months after cutting, between height growth of the tallest shoot, number of shoots and biomass, on the one hand, and tree height and girth before cutting, on the other. This relation agrees with the findings of SIMÔES *et al.* (1972) in *E. saligna* SM. It may be expected to persist for several years, since VENTER (1972) reported a positive correlation between stump diameter and stem diameter in a three-year-old coppice of *E. grandis* HILL (thinned to one stem per stump). Similarly, JACOBS (1955) noted that volume production of eucalypt coppice increases with stump diameter.

143

To conclude, the fastest-growing progeny on a given site may be expected to produce the best coppice, since the number, height and biomass of the regeneration are directly related to tree size before cutting.

Acknowledgements

Summary

Tree growth of *E. camaldulensis* varied with the origin of the seed, thereby determining the amount and rate of coppice regeneration after cutting.

The number of coppice shoots, height of the tallest shoot and biomass were directly related to tree height and girth before coppice cutting.

Key words: Coppice regeneration, *Eucalyptus camaldulensis*, seed provenance, progeny tests.

Zusammenfassung

Das Wachstum von *Eucalyptus camaldulensis* variiert mit der Samenherkunft. Sie ist auch maßgebend für Anzahl und Wuchs der Stockausschläge nach dem Hieb.

Menge des Stockausschlags, Höhe der höchsten Schößlinge und Biomasse stehen in direkter Beziehung zur Baumhöhe und zum Umfang der Ausgangsbäume.

References

Burrows, P. M.: The whole crop concept for coppicing species such as some *Eucalyptus*. In: Proc. 2nd World Consultation on Forest Tree Breeding, Washington 1969, Vol. 1, pp. 744—755 (1970). — Ciancio, O., and Morandini, R.: Esperienze sull'epoca di ceduazione negli eucalitteti di Piazza Armerina. Ann. Ist. sper. Selvicolt. Arezzo 2: 71—162 (1971). — Jacobs, M. R.: Growth Habits of the Eucalypts. Forestry and Timber Bureau, Canberra (1955). — Karschon, R.: Lignotuber occurrence in *Eucalyptus camaldulensis* Dehn. and its phylogenetic significance. Flora, Jena 160: 495—510 (1971). — Karschon, R.: The Course of Coppice Regeneration of *Eucalyptus camaldulensis* Dehn. and its Relation to Evapotranspiration. [Docum.] 7th World Forestry Congress, Buenos Aires 1972 No. 346 (1972). — Karschon, R.: The relation of seed origin to growth of *Eucalyptus camaldulensis* Dehn. in Israel. Israel J. agric. Res. 23 (in press) (1974). — Simões, J. W., Krogh, H. J. O., Ciero Neto, A. D., and Pompeu, R. M.: Influência do vigor das árvores sobre a brotação das touças de eucalipto. IPEF No. 5: 51—56 (1972). — Venter, I.: The effect of stump size on vigour of coppice growth in *Eucalyptus grandis*. For. S. Afr. 13: 51—52 (1972).

Genetic Differences Between American and Chinese Ailanthus Seedlings[1])

By Peter P. Feret and Richard L. Bryant[2])

Department of Forestry and Forest Products,
Virginia Polytechnic Institute and State University,
Blacksburg, Virginia 24061

Introduction

Ailanthus altissima Swingle was introduced to England from Nanking, China (119⁰ E, 32⁰ N) by d'Incarville in 1751 (Davies, 1942). From England it was introduced to North America in the late eighteenth century (Illick and Brouse, 1926; Davies, 1942). Since its introduction to the Unites States ailanthus has been used extensively as an ornamental shade tree and has become extensively naturalized. Moslemi and Bhagquat (1970) concluded that ailanthus wood properties resembled those of ash. Pulp and fiberboard characteristics have been reported by several authors (Narayanamurti and Singh, 1962; Adamik and Braun, 1957; Adamik, 1955; Vidal and Aribert, 1927 and Rawlings and Staidl, 1924).

Because of its potential use as a fiber source and because ailanthus grows on a variety of sites (Anonymus, 1956; Adamik, 1955; Richardson, 1966) it may have economic potential. No genetic investigations of ailanthus have been performed. Its method and recency of introduction into the United States leads to speculation that naturalized populations in the United States may differ genetically from orginal Chinese populations because of possible inbreeding due to a reduced gene pool, or because of adaptation to the North American environment. This study was established to test the hypothesis that ailanthus in the United States is not genetically different from Chinese populations. For this purpose a series of morphological, physiological and biochemical measurements were undertaken.

Material and Methods

In 1971 seed were collected from five mother trees at each of twelve United States sources. In 1972 the People's Republic of China sent seed from five mother trees at each of six sources located in mainland China. The Chinese