MyrtaceaeCMyrtle family

Eucalyptus L=Her.

eucalyptus

Stanley L. Krugman and Craig D. Whitesell

Dr. Krugman retired from the USDA Forest Service=s Washington Office and from the World Bank; Dr. Whitesell retired from the USDA Forest Service=s Pacific Southwest Research Station.

Growth habit, occurrence, and use. The genus *Eucalyptus* comprises more than 523 species and 138 varieties, and new species and varieties are still being described (Blakely 1955; Johnston and Marryatt 1965; Penford and Willis 1961). Some are very tall trees, whereas others are woody shrubs (Jacobs 1979). Eucalypts are mainly native to Australia, but a few species are also native to the Philippines, New Guinea, and Timor (Hall and others 1963). Eucalypts are among the most widely cultivated forest trees in the world for ornamental use, shade, soil and site protection, wood production, and pulp making (Chippendale and others 1969). They are planted in southern Europe, the Middle East, Africa, India, Pakistan, China, North and South AmericaCespecially in Brazil, Uruguay, Chile, and Argentina (Jacobs 1979; Penford and Willis 1961).

This genus was first introduced into the United States with plantings in California and the Hawaiian Islands about 1853 (LeBarron 1962; Penford and Willis 1961). Eucalypts have also been planted, but to a limited extent, in Arizona, Florida, Georgia, Mississippi, and Texas (Geary and others 1983; Hunt and Zobel 1978; Metcalf 1961). About 250 species have been introduced into the United States and most of them are grown in California and Hawaii as ornamentals because of their decorative flowers and pleasing shapes (Jacobs 1979). Bluegum eucalyptus has been the most extensively planted eucalyptus in the United States, mainly in California, for the last 100 years (Metcalf 1961). It was initially grown for timber production but now is rarely used for this purpose. However, it is still widely used for fuel, shelterbelts, windbreaks, and has promise as a low-cost source of hardwood fiber (Krugman 1970). Among the other species that are promising for California conditions are river redgum, manna, mountain-gum, shining, and rosegum eucalyptuses (Ledig 1989). A number of other species are still being tested in California for their general landscape value (Hamilton 1979). In Florida, rosegum, robust, and river redgum eucalyptuses have been widely tested and are most promising as a source of wood fiber (Geary and others 1983; Uhr 1976). In Hawaii, several species, including rosegum, robust, red-ironbark, saligna, and bluegum eucalyptuses, have been planted as windbreaks and for watershed protection, as well as for timber and biofuel production (LeBarron 1962; Whitesell and others 1992). There are numerous other species that hold promise for future fiber production, windbreaks, and for environmental forestry purposes (Fujii 1976; King and Krugman 1980) (table 1).

Geographic races and hybrids. Many eucalypts have an extensive natural distribution, and members of the same species often grow under very different environmental conditions (Boden

1964; Eldridge 1978; Hall and others 1963; Jacobs 1979). Although detailed scientific information as to the development of geographic races is lacking for most species, there is considerable genetic variation in those species with wide natural distribution and it can be assumed that numerous races do exist (Jacobs 1979; Miles 1990). Geographic origin must be considered in selecting a suitable seed source for planting in the United States from species whose natural ranges are very extensive, as with the widely grown river redgum eucalyptus (Eldridge 1975; Karschon 1967; Pryor and Byrne 1969). As a general rule, seed source selection should at least be based on a knowledge of the absolute minimal and maximal temperatures under which the species grows in its native range (Zon and Briscoe 1911). Differential low temperature tolerance has been demonstrated for different sources of broadleaf sallee (*E. camphora* R.T. Baker) and brown-barrel, lemon-gum, and manna eucalyptuses (Boden 1964; Hunt and Zobel 1978). Precipitation appears to be of less importance, but must also be considered in selecting the proper seed source.

Under natural conditions, hybridization between species of the same subgeneric group will take place. It is relatively common in some cases, for example, brown-barrel × narrow peppermint eucalyptus (*E. fastigata* × *radiata*Seibert ex DC.) and robusta × rosegum eucalyptuses (Boden 1964; Jacobs 1979; Penford and Willis 1961; Pryor 1979). A number of hybrids have been described, but their value for planting in the United States must still be demonstrated. When grown under plantation conditions outside their natural habitat, species hybridization will occur more often, and seed collections from small plantations of closely related species should be discouraged if hybrid seeds are not desired (Boden 1964).

Flowering and fruiting. The flower clusters develop enclosed within an envelope formed by 2 bracteolesCsmall leafy structures. These bracteoles split and are shed during development, revealing the flower buds (Boland and others 1980; Penford and Willis 1961). The perfect flowers are white, yellow, or red, often in axillary umbels, corymbose, or paniculate clusters (Blakely 1955). In a few cases, the flowers develop singly as with bluegum eucalyptus, but most often they are in 5- to 10-flowered axillary umbels as in river redgum and manna eucalyptuses (Blakely 1955). Sepals and petals are united to form a cap in the bud, which drops off at anthesis. The stigma is receptive within a few days after the cap drops (Barnard 1967) and pollination is mainly carried out by insects. The ovary has 3 to 6 locules with many ovules. There is a wide range in flowering times for the eucalypts (King and Krugman 1980). In California, some species such as manna eucalyptus may flower all year; other species, such as river redgum and gray ironbark eucalyptuses, flower in the spring; tingiringy-gum and mountain-gum eucalyptus in the summer; rosegum eucalyptus in the fall; and tallowwood eucalyptus in winter (King and Krugman 1980; Krugman 1970, 1974) (table 2).

The fruit is a hemispherical, conical, oblong, or ovoid hard woody capsule 6 to 25 mm in diameter, that is loculicidally dehiscent at the apex by 3 to 6 valves (Blakely 1955; Boland and others 1980). The seeds are numerous and extremely small in most species (table 3) (figure 1). The size of fertile seeds within a given seed collection vary widely. Usually only a few seeds are fertile in a single capsule, and capsule size may influence seed size (Blakely 1955). When more than 1 seed ripens in a locule, the seeds are variously shaped and angular (figure 1). When solitary, the seed will be ovate or orbicular-compressed (Blakely 1955). The seedcoat is most often thin and smooth, but it can be ribbed, pitted, or sculptured in various ways (Blakely 1955; Penford and Willis 1961). Usually the seedcoat is black or dark brown in color as in manna eucalyptus or pale brown as with alpine-ash

eucalyptus (table 3).

The embryo consists of bipartite or 2-lobed cotyledons that are folded or twisted over the straight radicle (Blakely 1955; Krugman 1974). There is no endosperm (Blakely 1955; Krugman 1974) (figure 2). Fruits ripen at various times during the year, depending on the species (table 2). Dispersal is largely by wind within a month or two after ripening for most species, for example, bluegum and shining eucalyptuses. For other species, such as manna eucalyptus, dispersal may not take place until 10 months after ripening (table 2). Good seeds are produced by most species by 10 years of age (Grose 1969). For mature trees the interval between large seed crops is from 2 to 5 years.

Collection of fruits. Collecting mature eucalyptus fruits should present no serious problems, other than reaching the fruit in very tall trees, because for most species there is a relatively long interval between seed ripening and opening of the capsule (table 2). However, it is important to take care to collect only well-developed, closed capsules, because capsules at different stages of maturity—as well as buds, flowers, and empty capsules—will be found on a single branch (Boland and others 1980; Krugman 1974). The capsules should be spread in a thin layer to permit rapid drying and to prevent mold formation (Boland and others 1980; Grose and Zimmer 1958b). The most common method is to air-dry the capsules for a few hours to a few days, depending on the maturity of the capsules (Boland and others 1980; Grose and Zimmer 1958b). Drying temperatures should not exceed 37.7 °C for prolonged periods, because high temperature may strengthen the dormancy of species such as alpine-ash, brown-barrel, shining, and mountain-ash eucalyptuses and tingiringy-gum (Grose 1969; Grose and Zimmer 1958b). Capsules can also be kiln-dried for relatively short periods (Boland and others 1980; Grose 1969). Fruit drying schedules for some of the common species are listed in table 4.

Extraction and cleaning. Once the capsules are open, they should be vigorously shaken to remove the seeds. Shaking is especially important if the capsules are somewhat immature, because viable seeds may not have separated completely from the capsule=s placenta. Thus, unless the capsules are shaken, only infertile seeds will be extracted (Boland and others 1980; LeBarron 1962). When examined, immature capsules may appear empty after the aborted seeds are removed, because viable seeds are normally attached at the base of the capsule (LeBarron 1962). Viable seeds are extracted along with the unfertilized or aborted ovules, which are known collectively as Achaff@ (Boland and others 1980; Grose and Zimmer 1958b). Large impurities such as the remains of twigs, capsules, and leaves can be removed by screening. Smaller impurities can be removed by specific-gravity separators such as the one used in the air-column method (Boland and others 1980; Grose 1969). For a few species, viable seeds can be separated from the remaining chaff by employing sieves of the appropriate mesh size (Boland and others 1980). Because viable seeds and chaff of most species cannot be separated by the usual methods, commercial seed suppliers sell chaff along with the fertile seeds. The proportion by weight of chaff to viable seeds is in the range of 5:1 to 30:1 (Grose and Zimmer 1958b). For some species, such as mountain-ash eucalyptus, the seeds and chaff are identical in size and color; for others, such as river red-gum eucalyptus, the seeds and chaff are similar in color but different in size (table 3). For most species, there are some differences in color and size, so that viable seeds can be separated from chaff to some extent if necessary. Because of their very small size, seeds of eucalyptus species are normally sold by weight with the chaff. The average number of viable seeds plus chaff per weight ranges from 770/g (21,900/oz) for river redgum eucalyptus to 35/g for blackbutt eucalyptus (1,000/oz) (table 5). There may be as many as 2,100

seeds/g (59,500/oz) for river redgum eucalyptus or as few as 7 seeds/g (200/oz) for blackbutt eucalyptus.

Storage. Eucalyptus seeds are orthodox in storage behavior. They should be stored in air-tight containers that are as completely filled as possible to reduce the amount of air (Boland and others 1980). Prior to storage, the seeds should be treated to kill insect pests, by either fumigation or placing paradichlorbenzene crystals in the container (Boland and others 1980).

Eucalypts seeds have germinated after 30 years of storage at room temperature, but the germination was very low (Penford and Willis 1961). Most seeds can be successfully stored for periods up to 10 years in air-tight containers at moisture contents of 4 to 6% and temperatures of 0 to 5 °C (Boland and others 1980; Grose 1969; Grose and Zimmer 1958b). It should be possible to store these seeds successfully for even longer at temperatures below 0 °C (Krugman 1970).

Pregermination treatments. Most eucalyptus seeds need no pretreatment to ensure adequate germination if fresh seeds are used (Boland and others 1980; Grose and Zimmer 1958b). A few species—such as tingiringy-gum and alpine-ash, brown-barrel, shining, and mountain-ash eucalyptuses—are normally dormant at the time of collection and will require pretreatment. Stratification of moist seeds stored in a plastic bag at temperatures of 3 to 5 °C for a period of 3 weeks will break the dormancy of these 5 species, except for alpine-ash eucalyptus, which should be stratified for 4 weeks (Boland and others 1980; Grose 1969). Longer stratification periods of 6 to 8 weeks are often recommended.

Dormancy between different seedlots of the same species can vary considerably. In addition, different methods of extraction and storage can induce dormancy in nondormant seed or strengthen primary dormancy in normally dormant seeds (Krugman 1970). If the seeds fail to germinate after the recommended shorter stratification periods, then a longer period should be tried before the seeds are considered nonviable. Because most seeds are stored before they are used, stratification for 3 to 4 weeks at a temperature of 3 to 5 °C is recommended for all eucalyptus seeds to ensure faster and more uniform germination (Hinkle 1968; Krugman 1970).

In a few cases, chemicals have been employed to overcome seed dormancy. The germination of unstratified and dormant seeds of alpine-ash, brown-barrel, and mountain-ash eucalyptuses was improved by germinating the seeds in a solution of gibberellic acid (Bachelord 1967). However, not all seedlots of the same species responded to gibberellic acid (Krugman 1970).

Germination tests. Standard methods for testing germination in other seeds are not used for eucalyptus seeds because of their small size and the presence of so much chaff, which can exceed the weight of viable seeds. Instead, samples for germination are of equal weight, not number (Boland and others 1980; Grose and Zimmer 1958b; ISTA 1993; Turnbull and Doran 1987). Such methods as the excised-embryo and tetrazolium tests are impractical (Boland and others 1980; Grose and Zimmer 1958b). The International Seed Testing Association (1993) recommends a sample unit of 0.10 to 1.0 g of seed, depending on the species. Seeds are placed on 1 or more layers of moist paper and germinated at a constant temperature of 15 to 35 °C, depending on the species (Grose 1969; Scott 1972). Some species may require alternating temperatures of 20 °C for 16 hours and 30 °C for 8 hours (ISTA 1993). The tests are normally conducted under lights, although lights are not necessary for all species. Recommendations for individual species are listed in table 6. Official rules (ISTA 1993) provide recommendations for many more species. Immature seeds of mountain-ash eucalyptus should be tested under lights (Penford and Willis 1961).

If an approximate estimate of viability is desired, a known weight of dry seeds can be soaked in water and then squashed systematically. All seeds that show a firm white embryo can be recorded as viable (Grose and Zimmer 1958b).

Soundness of eucalyptus seeds is highly variable. Seeds collected from individual trees of bluegum eucalyptus in California showed from 2 to 80% germination after 30 days (Krugman 1970). Germination of from 11 to 98% has been reported for other species (table 7).

Nursery practice. On the United States mainland, eucalyptus seeds are rarely sown directly in the nursery, a practice once common in Hawaii. The most common practice for growing eucalyptus seedlings is to germinate the seeds in small pots, boxes, or wooden flats. Commonly used containers are wooden flats or plastic containers 45 to 50 cm (18 to 20 in) long and 40 to 50 cm (16 to 20 in) wide, and 10 to 12.5 cm (4 to 5 in) deep with good bottom drainage (Hinkle 1968; Jacobs 1955). The planting medium should be porous, friable, and light textured, such as a light, sandy loam (Hinkle 1968; Holmes and Floyd 1969; Willan 1985). The medium must permit good drainage and should not cake or become hard on the surface after watering. Because of possible weed and disease problems, the soil should be sterilized. Various mixtures are also used, with the most common consisting of equal parts (by volume) of sand, soil, and organic matter. The flats are filled to a depth of 7.5 to 10 cm (3 to 4 in) and the soil surface is leveled.

Because of their small size, the seeds are mixed with a little sand, and the mixture then is spread evenly over the soil surface (Hinkle 1968; Jacobs 1955; Penford and Willis 1961). The seeds are covered with 3 mm of fine sand, peat, or sphagnum moss to prevent surface drying.

A newer method to ensure more precision in sowing eucalyptus seeds is to coat them and form a mini-pellet (Geary and Millier 1982; Willan 1985). The seed dressing is usually an inert material serving as a sticker on which other materials can be added. One successful method involves a coating of fine silica sand filler and a polyvinyl alcohol binder (Geary and Millier 1982). In addition, fungicides and insecticides can also be added.

Enough seeds should be sown to raise between 500 and 2,000 plants/flat (table 8). Depending on seed size, this should represent about 7 g (3 oz) of seed/flat (Krugman 1970). The flats should be well watered and drained just before planting and should be protected from wind, heavy rains, and excessive heat. The emerging seedlings may require protection from birds and rodents in some locations.

Seedling care. Germination is epigeal (figure 3), begins in 7 to 10 days, and is completed in 3 to 4 weeks (Boland and others 1980; Jacobs 1955; Krugman 1974). Because the seeds are small and the seedlings very delicate, overhead watering should be with a fine spray and care must be taken to maintain adequate soil moisture.

When the seedlings are about 6 to 8 weeks old and have developed 2 pairs of leaves and a third pair is just visible above the cotyledons, they can be transplanted into suitable containers for further growth (Hinkle 1968; Jacobs 1955).

In transplanting, the seedlings should be lifted by the tip of a sturdy leaf, and not by the soft delicate stem. A dibble should be used to protect the fibrous root system. Prior to lifting, the seedlings should be hardened off by exposure to the open air away from full sunlight and strong winds for a few days to a week. A variety of different containers, from Jiffy J pots to tin cans, have been used with success (Holmes and Floyd 1969; Jacobs 1955). The containers should be large enough to permit the development of strong plants, but small enough to permit ease of

transportation. Tubes should be at least 4 cm (1.5 in) in diameter and 15 to 30 cm (6 to 12 in) long (Jacobs 1955). When metal tubes are employed, they are made so that they can be readily opened in the field and then later cleaned and reused. After transplants are placed in containers, care must be taken to prevent damage to them. Seedlings should be well watered and shaded from full sunlight. Fine gravel can be placed on the surface of the container to restrict slime molds. After several weeks the transplants can be placed in the open so that they can become hardy. They should be ready for outplanting in 4 to 5 months, depending on the species and growing conditions (Jacobs 1955).

Because of the rapid growth of eucalyptus seedlings, care must be taken lest they become pot-bound. Seedlings should not be permitted to grow in small containers for extended periods before outplanting.

Seeds can be sown directly in a standard 1.2-m-wide (4-ft-wide) nursery bed. The soil should be first fumigated to kill weed seeds and pathogens, then watered well and drained before sowing. Because seeds are small, even distribution is difficult when they are broadcast sown. Seeds should be sown in narrow strips or rows, covered with a thin layer of sand or peat, and watered thoroughly (Penford and Willis 1961). Under very hot conditions the nursery beds should be shaded. Young eucalyptus seedlings need a great amount of light, so only moderate shade is recommended. If bareroot stock is desired, the seedlings are left in the beds for about 6 to 12 months. More commonly, the seedlings are lifted after 5 to 10 weeks and planted in individual containers. Because of differences in seed size and purity among species seedlots, the variation in number of seedlings produced, by a given weight of seeds, will vary widely (Zon and Briscoe 1911).

Vegetative propagation. Vegetative propagation by rooting and grafting has been successful in some of the eucalypts. The following species have been rooted successfully: lemon-gum, red-ironbark, river redgum, mountain-ash, robust, desert, mountain-gum, blue-gum, rosegum, and manna eucalyptuses (Blomstedt and others 1991; Jacobs 1979; Linnard 1969; Penford and Willis 1961). But in the main, only shoots with juvenile leaves have been rooted, and these most often from trees younger than 5 years (Jacobs 1979; Penford and Willis 1961). Eucalyptus can also be propagated by grafting. At the present time, vegetative propagation appears to be a practical method for producing eucalypts in large numbers only in countries where labor is inexpensive, for example, Brazil (Jacobs 1979). The production of possibly useful cultivars is both difficult and expensive, for cuttings from mature eucalyptus trees do not readily root (Chippendale and others 1969).

References

Bachelord EP. 1967. Effects of gibberellic acid, kinetin, and light on the germination of dormant seeds of some eucalypt species. Australian Journal of Botany 15: 393B401.

Barnard RC. 1967. Some garden eucalypts. Australian Plants 4:30: 69B70, 71B72.

Blakely WF. 1955. A key to the eucalypts. 2nd ed. Canberra: Forest and Timber Bureau. 359 p.

Blomstedt C, Cameron J, Whiteman P, Chandler SF. 1991. Micropropagation of juvenile *Eucalyptus regnans* (mountain ash). Australian Journal of Botany 39(2): 179B186.

Boden RW. 1964. Hybridization in eucalyptus. Indian Forester 90(9): 581B586.

Boland DJ, Brooker MIH, Turnbull JW. 1980. Eucalyptus seed. Sydney, Australia: Hogbin Poole Pty. Ltd. 191p.

Chippendale GM, Johnston, RD, Kelly S. 1969. Eucalypts. Melborne: Thomas Nelson

(Australia), Ltd. 82 p.
Eldridge KG. 1975. An annotated bibliography of genetic variation in *Eucalyptus camaldulensis*. Trop. For. Pap. 8. Oxford: Oxford University, Department of Forestry. 59 p.
Eldridge KG. 1978. Genetic improvement of eucalypts. Silvae Genetica 27(5): 205B209.
Floyd AG. 1964. Germination test methods for tree seeds. Tech. Pap. 7. Sydney, Australia: Commonwealth Forestry. 15 p.
Fujii DM. 1976. The Nuuanu eucalyptus planting: growth, survival, stand development after 64 years. Res. Note PSW-318. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 5 p.
Ganguli BN. 1966. Application of Czabator's approach to germination studies of *Eucalyptus*. Science and Culture 32(9): 466B468.
Geary TF, Millier WF. 1982. Pelleting small volumes of eucalyptus seeds for precision sowing. South African Forestry Journal 121: 79B83.
Geary TF, Meskimen GF, Franklin EC. 1983. Growing eucalypts in Florida for industrial wood production. Gen. Tech. Rep. SE-23. USDA Forest Service, Southeastern Forest Experiment Station. 43 p.
Grose RJ. 1969. Personal communication: Melbourne, Australia: Commonwealth Forestry.
Grose RJ, Zimmer WJ. 1958a. A description of the seeds of 70 Victorian eucalypts. Bull. 8. Melbourne, Australia: Commonwealth Forestry. 24 p.
Grose RJ, Zimmer WJ. 1958b. The collection and testing of seed from some Victorian eucalypts with results of viability tests. Bull. 10. Melbourne, Australia: Commonwealth Forestry. 14 p.
Hall N, Johnston RD, Marryatt R. 1963. The natural occurrence of the eucalypts. Leafl. 65, 2nd ed. Canberra, Australia: Forestry and Timber Bureau. 122 p.
Hamilton WD. 1979. The landscape eucalyptus tree: an evaluation study 1971B1978. Journal of Arboriculture 5(9): 210B216.
Hinkle EH. 1968. Eucalyptus in Taiwan. Quarterly Journal of Chinese Forestry 1(2): 87B98.
Holmes DA, Floyd AG. 1969. Nursery techniques for raising eucalypts in Jiffy pots on the New South Wales north coast. Res. Note 22. Sydney, Australia: Commonwealth Forestry. 15 p.
Hunt R, Zobel B. 1978. Frost-hardy eucalyptus grow well in the Southeast. Southern Journal of Applied Forestry 2(1): 6-10.
ISTA [International Seed Testing Association]. 1966. International rules for seed testing. Proceedings of the International Seed Testing Association 31(1): 52B106.
ISTA [International Seed Testing Association]. 1993. International rules for seed testing: rules 1993. Seed Science and Technology 21 (Suppl.): 1B259.
Jacobs MR. 1955. Growth habits of the eucalypts. Canberra, Australia: Forestry and Timber Bureau. 262 p.
Jacobs MR. 1979. Eucalypts for planting. For. Ser. 11. Rome: FAO. 677 p.
Johnston RD, Marryatt R. 1965. Taxonomy and nomenclature of eucalypts. Leafl. 92. Canberra, Australia: Forestry and Timber Bureau. 24 p.
Karschon R. 1967. Ecotypic variation in *Eucalyptus camaldulensis* Dehn. In: Contributions on eucalypts in Israel. [National University Institute of Agricultural, Ilanot, and Land Development Authority]: Kiriat Hayim III: 35B53.
King JP, Krugman SL. 1980. Tests of 36 *Eucalyptus* species in northern California. Res. Pap.

PSW-152. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station: 6 p.
Krugman SL. 1970. Observations recorded 1965B1970. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 11 p.
Krugman SL. 1974. *Eucalyptus,* eucalyptus. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 384B392.
Larsen E. 1965. Germination of *Eucalyptus* seed. Leafl. 94. Canberra, Australia: Forestry and Timber Bureau. 16 p.
LeBarron RK. 1962. Eucalypts in Hawaii: a survey of practices and research programs. Misc. Pap. 64. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 24 p.
Ledig FT. 1989. Improvement of eucalypts for fuel and fiber in California. In: Pereira JS, Landsberg JJ, eds. Biomass production by fast growing trees. Proceedings, NATO Advanced Research Workshop, Series E. Dordrecht, The Netherlands: Kluwer Academic Publishers: 231B245.
Linnard W. 1969. Cultivation of eucalypts in the USSR. Forestry Abstracts 30(2): 199B209.
Metcalf W. 1961. Progress with eucalypts in North America [unpublished office report]. Section A, United States mainland. National Report, 2nd World Eucalyptus Conference, Brazil: 1B18.
Miles M. 1990. Principles of species and clonal selection for farm forestry. California Eucalyptus Grower 5(1): 8, 9, 11.
Penford AR, Willis JL. 1961. The eucalypts: botany, cultivation, chemistry, and utilization. New York: Interscience Publishers. 551 p.
Pryor ID. 1979. Reproductive habits of the eucalypt. Unasylva 30(119/120): 42B46.
Pryor LD, Byrne OR. 1969. Variation and taxonomy in *Eucalyptus camaldulensis*. Silvae Genetica 18(3): 64B71.
Scott L. 1972. Viability testing of eucalpt seeds. Leaflet 116. Camberra, Australia: Forestry and Timber Bureau. 24 p.
Toyama S, Moromizato S. 1957. Breeding of eucalyptus trees (report 1): characteristics of eucalyptus seed [in Japanese]. Government Forest Experiment Station (Tokyo) Bulletin 103: 1B24.
Turnbull JW, Doran JC. 1987. Germination of Australian native plant seed. In: Langkamp PJ, ed. Melbourne: CSIRO, Division of Forest Research: 46B57, 186B198.
Uhr SC. 1976. Eucalypt: the wonder tree. American Forests 82(10): 42B43, 59B63.
Whitesell CD, DeBell DS, Schubert TS, Strand RF, Crabb TB. 1992. Short-rotation management of eucalyptus: guidelines for plantations in Hawaii. Gen. Tech. Rep. PSW-GTR 137. Albany, CA: USDA Forest Service Pacific Southwest Research Station. 30 p.
Willan, RL. 1985. A guide to forest seed handling. For. Pap. 20/2. Rome: FAO. 379 p.
Zon R, Briscoe JM. 1911. Eucalypts in Florida. Bull. 87. Washington, DC: USDA Forest Service. 47 p.

Figure 1C*Eucalyptus,* eucalyptus: seeds, × 20.

Figure 2C*Eucalyptus rudis,* desert eucalyptus: longitudinal section thorough a seed, × 50.

Figure 3C*Eucalyptus,* eucalyptus: seedling development for manna eucalyptus at 1 day (A) and 8 days (B) and desert eucalyptus at 42 days (C).

Table 1C*Eucalyptus,* eucalyptus: nomenclature and natural and extended ranges

Scientific name & synonym(s)	Common names	Natural range	Extension
E. camaldulensis **Dehnhardt** *E. rostrata Schldl.*	**river redgum eucalyptus,** red-gum, long-beak eucalyptus	Australia	California, Hawaii, & Arizona
E. citriodora **Hook.**	**lemon-gum eucalyptus,** lemon eucalyptus, lemon-gum	Central & N Queensland, Australia	California & Hawaii
E. dalrympleana **Maiden**	**mountain-gum eucalyptus,** white-gum, dalrymple eucalyptus	SE Australia	California & Hawaii
E. delegatensis **R.T. Baker** *E. gigantea* Hook. f.	**alpine-ash eucalyptus,** delegate eucalyptus	SE Australia	California
E. fastigata **H. Deane & Maiden**	**brown-barrel eucalyptus**, cuttail eucalyptus	SE Australia	California
E. glaucescens **Maiden & Blakey**	**tingiringy-gum**	SE Australia	California
E. globulus **Labill.**	**bluegum eucalyptus**, bluegum, Tasmania bluegum, Tasmanian blue eucalyptus	SE Australia	California, Hawaii, & Arizona
E. grandis **W. Hill ex Maiden**	**rosegum eucalyptus,** tooler eucalyptus.	E Australia	California, Florida, & Hawaii
E. microcorys **F. Muell.**	**tallowwood eucalyptus**	E Australia	California
E. nitens **(H. Deane & Maidon) Maiden**	**shining eucalyptus,** silver-top shining-gum	SE Australia	California & Hawaii
E. obliqua **L'Her.**	**messmate stingybark eucalyptus**	SE Australia	California
E. paniculata **Sm.**	**gray ironbark eucalyptus,** ironbark	E Australia	California & Hawaii
E. pilularis **Sm.**	**blackbutt eucalyptus**	E Australia	California & Hawaii
E. regnans **F. Muell.**	**mountain-ash eucalyptus,** swamp-gum giant eucalyptus	SE Australia	California
E. robusta **Sm.** *E. miltiflora* Poir.	**robusta eucalyptus,** swamp-mahogany, beakpod eucalyptus	E Australia	California, Florida, Hawaii, & West Indies
E. rudis **Sm.**	**desert eucalyptus,** moitch	W Australia	California & Florida

***E. saligna* Sm.**	eucalyptus, desert-gum **saligna eucalyptus,** Sidney bluegum eucalyptus, flooded-gum	E Australia	California & Hawaii
***E. sideoxylon* A. Cunningham**	**red-ironbark eucalyptus,** mulga ironbark eucalyptus, red-ironbark	SE Australia	California & Hawaii
***E. viminalis* Labill.**	**manna eucalyptus,** ribbon eucalyptus, white-gum, ribbongum	SE Australia	California & Hawaii

Sources: Chippendale and others (1969), Johnston and Marryat (1965), Krugman (1974).

Table 2C*Eucalyptus,* eucalyptus: height at maturity and phenology of flowering and fruiting of trees grown in California

Species	Height at maturity (m)	Flowering dates	Fruit ripening dates	Seed dispersal dates
E. camaldulensis	18B36	FebBApr	JulyBOct	Begins 8B9 months after flowering
E. citriodora	24B39	NovBJan	MayBAug	C
E. dalrympleana	18B36	JuneBAug	AugBOct	OctBNov
E. delegatensis	30B83	AprBJune	AprBJuly	MayBJuly
E. fastigata	18B60	AprBMay	JulyBAug	C
E. glaucescens	4B12	JulyBAug	MayBSept	NovBFeb
E. globulus	45B54	NovBApr	OctBMar	OctBMar
E. grandis	42B54	SeptBNov	C	C
E. microcorys	30B45	DecBFeb	C	C
E. nitens	30B90	AprBJuly	MayBJune	MayBJune
E. obliqua	15B75	AprBJuly	MayBAug	C
E. paniculata	24B42	FebBMay	C	C
E. pilularis	36B60	DecBMar	Jan-April	All year
E. regnans	52B105	AprBJuly	JuneBSept	C
E. robusta	24B27	JanBMar	C	C
E. rudis	9B15	JanBMar	C	C
E. saligna	15B45	AprBJune	OctBDec	C
E. sideroxylon	12B30	JuneBSept	C	C
E. viminalis	15B45	All year	12 months after flowering	20B22 months after flowering

Source: Krugman (1970).

Table 3C*Eucalyptus,* eucalypus: description of viable seeds and chaff

	Seed size (mm)			
Species	Length	Width	Seed color	Chaff color
E. camaldulensis	.75B1.75	0.5B1.0	Yellow-brown	Yellow-brown to orange
E. citriodora	4.25	2.5	Black	Brownish red
E. delegatensis	1.25B3.75	1.0B1.75	Pale brown or brown	Pale brown or brown
E. fastigata	1.25B3.25	0.5B1.25	Pale brown or brown	Pale brown or brown
E. glaucescens	1.25B2.5	1.0B1.75	Black or dark brown	Pale red-brown
E. globulus	2.25	1.75	Dark brown	Brownish red
E. nitens	1.25B2.5	1.0B1.75	Black or dark brown	Pale red-brown
E. obliqua	1.0B2.0	0.75B1.25	Dark brown	Orange-brown or brown
E. regnans	1.25B2.5	0.5B1.25	Pale brown or brown	Pale brown or brown
E. robusta	1.5	0.75	Dark brown	Brownish red
E. saligna	1.25	1.0	Black	Brownish red
E. sideroxylon	1.0B2.0	.75B1.5	Dark brown or black	Orange-brown
E. viminalis	1.25B2.5	1.5	Black or dark brown	Pale red-brown

Sources: Grose and Zimmer (1958a), Krugman (1974), Toyama and Moromizato (1957).

Table 4C*Eucalyptus,* eucalyptus: fruit drying schedules

	Air drying		Kiln drying	
Species	Temp. (°C)	Time (days)	Temp. (°C)	Time (hrs)
E. camaldulensis	32	1	59	3
E. delegatensis	32	3	59	6
E. globulus	21	5	C	C
E. obliqua	32	3	59	5
E. regnans	32	3	59	6
E. sideroxylon	21	4	C	C
E. viminalis	21	6	C	C

Table 5C*Eucalyptus,* eucalyptus: seed yield data

	Viable seeds/(wt of seed + chaff)				
	Range		Average		
Species	/g	/oz	/g	/oz	Samples
E. camaldulensis	65B2,100	1,800B59,500	770	21,900	41
E. citriodora	80B220	2,200B6,200	140	4,000	15
E. dalrympleana	65B285	1,800B8,100	195	5,500	7
E. delegatensis	40B125	1,100B3,500	75	2,100	13
E. fastigata	90B210	2,500B5,900	150	4,300	6
E. glaucescens	40B120	1,000B3,000	35	2,000	2
E. globulus	20B70	500B9,100	150	2,500	10
E. grandis	200B1,200	5,600B34,000	700	20,000	13
E. microcorys	530B900	1,500B25,600	85	6,800	22
E. nitens	230B550	6,600B15,700	385	10,900	7
E. obliqua	20B160	500B4,500	85	2,400	18
E. paniculata	65B340	1,800B9,600	75	5,000	8
E. pilularis	7B85	200B2,400	35	1,000	28
E. regnans	20B530	600B15,000	315	8,900	11
E. robusta	220B700	6,200B20,000	390	11,000	12
E. rudis	270B1,100	7,600B31,000	600	17,000	9
E. saligna	85B915	2,400B26,000	460	13,000	9
E. sideroxylon	65B440	1,800B12,500	240	6,800	16
E. viminalis	265B445	7,500B12,600	350	10,000	6

Sources: Grose and Zimmer (1958b), Larsen (1965).

Table 6C*Eucalyptus,* eucalyptus: germination test conditions

Species	Daily light exposure (hrs)	Temp. (°C)	Duration (days)
E. camaldulensis	24	35	14
E. citriodora	0	25	14
E. dalrympleana	24	25	14
*E. delegatensis*H	0	20	14
*E. fastigata*I	0	25	14 or 21
*E. glaucescens*I	24	20	14 or 21
E. globulus	24	25	14
E. grandis	0	25	14
E. microcorys	24	20 (20/30)'	28
*E. nitens*I	24	20	14 or 21
E. obliqua	0	20	14
E. paniculata	24	20 (20/30)'	28
E. pilularis	0	20	14
*E. regnans*I	24	25	21
E. robusta	24	20	28
E. rudis	24	35	14
E. saligna	24	25	28
E. sideroxylon	24	20	14
E. viminalis	24	25	14

Sources: Grose (1969), ISTA (1966, 1993).

* Seeds germinated on 2 layers of moist, filter paper in a petri dish (Grose 1969).

H Prechilled for 28 days at 3.3 to 5 °C (Grose 1969).

I Prechilled for 21 days at 3.3 to 5 °C (Grose 1969).

' Treated at 20 °C for 16 hours, then 30 °C for 8 hours.

Table 7C*Eucalyptus,* eucalyptus: germination test results

Species	% Germination	Duration of test (days)
citriodora	51	15
E. grandis	98	29
E. microcorys	76	24
E. pilularis	11	29
E. robusta	84	18
	100	21
E. sideroxylon	69	49

Sources: Floyd (1964), Ganguli (1966), Krugman (1974), Scott (1972).

Table 8C*Eucalyptus,* eucalyptus: seedlings produced per weight of seeds

Species	Seedlings produced/seed wt /g	/oz
camaldulensis	175	5,000
E. citriodora	60	1,700
E. glaucescens	99	2,830
E. globulus	28	800
E. microcorys	7	180
E. paniculata	6	160
E. robusta	14	400
E. viminalis	111	3,160