Table 5—*Viburnum,* viburnum: stratification treatments and germination test results

	Stratification treatments (days)			Germination percentage	
	Warm period* (first stage)	Cold period† (second stage)	Germination test duration‡	Avg (%)	Samples
V. acerifolium	180–510	60–120	60+	32	5
V. dentatum§	0	0	60	—	—
V. lantanoides	150	75	100	43	3
V. lentago	150–270	60–120	120	51	3
V. nudum var. *cassinoides*	60	90	120	67	2
V. opulus	60–90	30–60	60	60	3+
V. prunifolium	150–270	30–60	60+	75	2
V. rafinesquianum	360–510	60–120	—	—	—
V. recognitum	360–510	75	60+	69	2
V. rufidulum	180–360	0	—	—	—

Sources: Gill and Pogge (1974), Vines (1960).

* Seeds in a moist medium were exposed to diurnally alternating temperatures of 30/20 °C or 30/10 °C, but a constant 20 °C was equally effective for most species (Barton 1958).

† Seeds and medium were exposed to constant temperature of 5 or 10 °C. Temperatures of 1 to 6 °C are preferred now for cold stratification.

‡ At temperatures alternating diurnally from 30 (day) to 20 °C (night).

§ Seeds were collected in Texas; temperature was not critical for germination (Giersbach 1937).

Figure 5—*Viburnum dentatum*, southern arrowwood: seedling development at 1, 2, 11, and 29 days after germination; roots and shoots develop concurrently.

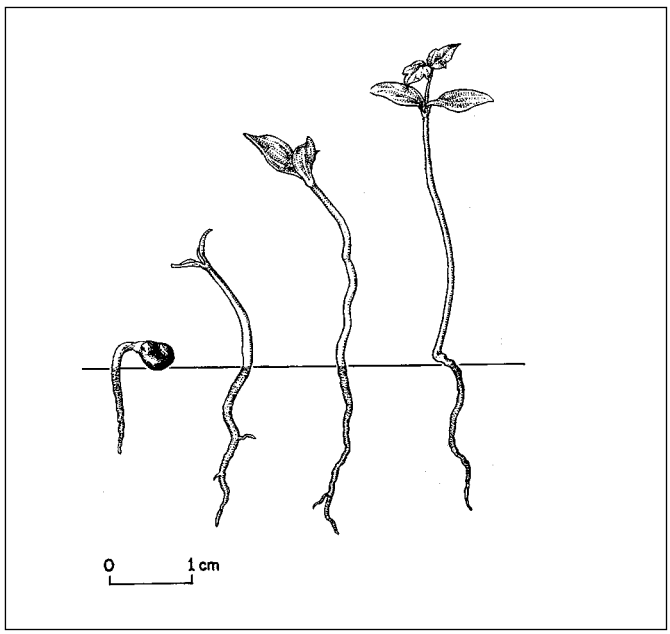
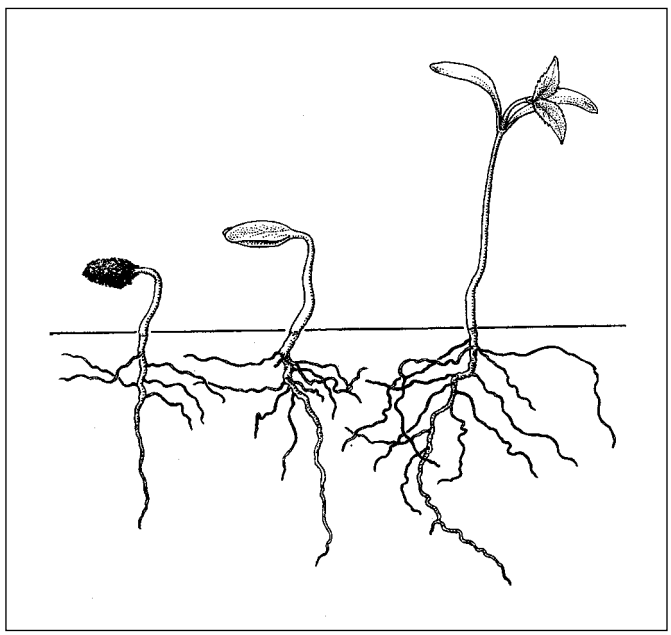


Figure 6—*Viburnum lentago*, nannyberry: seedling development from stratified seed—root development during warm stratification (about 150 days) (**left**); very little development during ensuing cold stratification (about 120 days) for breaking epicotyl dormancy (**middle**); subsequent development at germinating temperatures (**right**).



that seeds need not be handled after their roots emerge during the warm stratification period (Rollins 1970). Seeds of species with more shallow dormancy can be sown in the fall shortly after collection and extraction. For the several species that may be handled in this manner, the latest sowing dates for optimum seedling percentages in the ensuing year are listed in table 6. Sowing done somewhat earlier than these dates gave nearly as good results, but sowing at later dates reduced germination percentages.

The seeds may be broadcast on prepared seedbeds and mulched with sawdust (Rollins 1970). Alternatively, seeds can be sown in drills 20 to 30 cm (8 to 12 in) apart, covered with 12 mm ($^1/_2$ in) of soil, and mulched with straw (Gill and Pogge 1974). Straw mulch must be removed once germination begins, otherwise there is risk of loss due to damp-

Table 6—*Viburnum,* viburnum: latest allowable dates for sowing in nurserybeds and seedling percentages obtained in the following year

Species	Location	Latest allowable sowing date*	Seedling %†
V. acerifolium	New York	May 1	55
V. lantana	Ohio	Oct 21	90
V. lentago	Ohio	Oct 7	75
V. opulus	New York	July 1	87
V. prunifolium	New York	May 1	26
V. recognitum	New York	May 1	32

Sources: Giersbach (1937), Smith (1952).
* Sowing dates later than those listed resulted in reduced seedling percentages.
† Number of seedlings in a nurserybed at time of lifting expressed as a percentage of the number of viable seeds sown.

ing-off fungi. The recommended seedbed density for several viburnums is 215/m² (20/ft²) (Edminster 1947). Seedlings of some species may require shade for best development, although this depends on location and species. The most likely candidates for shading are the arrowwoods, hobblebush (Gould 1966), and mapleleaf viburnum. Seedlings should be ready for outplanting as 1+0 or 2+0 stock. A variety of techniques exist for rooting viburnum species by softwood cuttings, hardwood cuttings, or layering (Dirr and Heuser 1987).

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Verbenaceae—Verbena family

Vitex agnus-castus L.

lilac chastetree

John C. Zasada and C. S. Schopmeyer

Dr. Zasada retired from the USDA Forest Service's North Central Research Station; Dr. Schopmeyer (deceased) retired from the USDA Forest Service's National Office, Washington, DC

Other common names. chaste-tree, monks'-pepper tree, hemptree (Bailey 1949).

Growth habit, occurrence, and use. The genus *Vitex* occurs in both hemispheres in the tropical and subtropical zones. About 380 taxa have been described (Bredenkamp and Botha 1993). Lilac chastetree, a deciduous, strongly aromatic shrub or small tree, is one of the few species in the genus that is native to the temperate zones, but it is not native to North America (Bailey 1949). It has, however, naturalized in much of the southeastern United States.

In Washington on the west side of the Cascades, it attains a height of 1.8 m, increasing in more southerly latitudes to a height of 7.7 m in the low desert of southern California (Williamson 1967). Multiple stems support a broad spreading form, but shade trees with a single stem can be developed by pruning (Williamson 1967).

In the eastern United States, the species is hardy as far north as New York (USDA Hardiness Zone 6), but marginally so; it performs better further south, in USDA Hardiness Zones 8–9 (LHBH 1076; Dirr 1990; Moldenke 1968). This species is less hardy than negundo chastetree (*Vitex negundo* L.), which is also planted as an ornamental (Dirr 1990) and has been cultivated as an ornamental in southern Europe, the Middle East, India, and Brazil (Moldenke 1968). Lilac chastetree was introduced as an ornamental into the United States in 1570 (Rehder 1940). The species has value in shelterbelt plantings (Engstrom and Stoeckeler 1941).

Since the days of Dioscorides in the first century AD, seeds of this species have been noted for their ability to subdue sexual urges in men, hence the name "chastetree" (Moldenke 1968; Polunin and Huxley 1966). This property was recognized as being useful to celibates and this in turn led to the name "monks'-peppertree." However, these properties are questioned today. There is evidence that phytomedicines from the chastetree are useful in the treatment of menstrual disorders in women (Bohnert and Hahn 1990). Because of the aromatic pungency of fresh seeds, however, some people have considered the seeds as having aphrodisiac properties.

Other species (for example, negundo chastetree) are used in tropical and subtropical regions for biomass and fuelwood production because of their rapid growth, ability to coppice, and tolerance of a wide range of site conditions (Verma and Misra 1989).

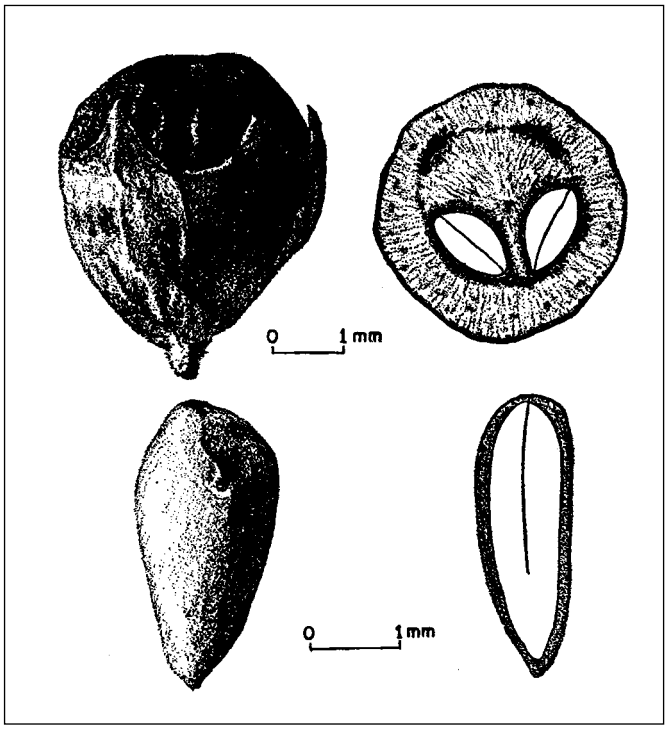
Varieties. Typical plants of the species have lavender flowers, but several other varieties have been cultivated in the United States (Rehder 1940; Dirr 1990). White chastetree, var. *alba* West., has white flowers. Hardy lilac chastetree, var. *latifolia* (Mill.) Loud., is characterized by broader leaflets and greater cold-hardiness. In addition, a form with pink flowers, f. *rosea* Rehder, has been propagated (Dirr 1990; Rehder 1940).

Flowering and fruiting. The fragrant flowers occur in dense spikes about 2.8 cm long; they bloom during the late summer and autumn in the United States (Bailey 1949). In Europe, flowering occurs from June to September (Moldenke 1968; Polunin and Huxley 1966). According to Dirr (1990), the plants will continue to flower as long as new growth is occurring; removing old flowers (deadheading) can prolong flowering.

The pungent fruits are small drupes about 3 to 4 mm in diameter that ripen in late summer and fall (Schopmeyer 1974). Good seedcrops occur almost every year (Engstrom and Stoeckeler 1941). Each drupe contains a rounded 4-celled stone about 3 mm long that is brownish to purple-brown and frequently partially covered with a lighter colored membranous cap. Each stone may contain from 1 to 4 seeds (figure 1) (Schopmeyer 1974).

Collection of fruits; extraction and storage of seeds. The fruits may be gathered in late summer or early fall by picking them from the shrubs by hand or by flailing or stripping them onto canvas or plastic sheets. Seeds can be removed by running the fruits dry through a macerator and fanning to remove impurities (Engstrom and Stoeckeler 1941). Seed weight per fruit weight is about 34 kg of

Figure 1—*Vitex agnus-castus*, lilac chastetree: fruit (**top left**) and transverse section through 2 seeds within a fruit (**top right**); cleaned seed (**bottom left**) and longitudinal section through a seed, with embryo taking up entire seed cavity (**bottom right**)



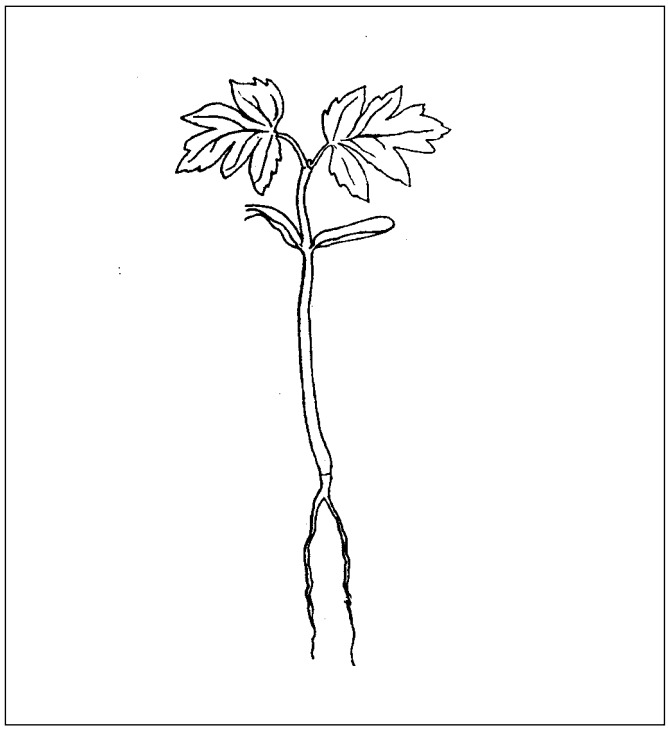
cleaned seed/45 kg of ripe fruit (75 lb/100 lb). Number of cleaned seeds varied from 74,800 to 130,000/kg (34,000 to 59,000/lb) in 4 samples (Schopmeyer 1974). Purity in 2 samples was 80%, and average soundness in 4 samples was 55%. In one test, seeds stored in moist sand and peat at 5 °C or 1 year showed no loss of viability (Schopmeyer 1974).

Germination. Seeds germinate readily without pretreatment (Dirr and Heuser 1987). However, stored seeds may exhibit dormancy that can be overcome by stratification in moist sand and peat for 90 days at about 5 °C. Germination tests should be made in sand flats for 40 days at 21 °C (night) to 30 °C (day) (Schopmeyer 1974). Germinative energy of stratified seeds was 18 to 60% in 10 to 22 days (3 tests). Germinative capacity of untreated seeds was 0.4% in 71 days (1 test); with stratified seeds, 20 to 72% (3 tests) (Schopmeyer 1974).

In another test, fresh seeds collected in January in southern California were sown without treatment in February in a greenhouse in Iowa. Germination was completed (percentage not stated) by April 20 when seedlings were 2 inches tall (King 1932). Germination is epigeal (King 1932) (figure 2).

Nursery practice. Stratified seeds of lilac chastetree should be sown in the spring and covered with 6 mm ($^1/_4$ in) of soil. On the average, about 16% of the viable seeds sown produce usable 2+0 seedlings (Engstrom and Stoeckeler 1941). Lilac chastetree can be readily propagated by greenwood cuttings collected before flowering, by hardwood cuttings in the fall, and layering (LHBH 1976; Dirr and Heuser 1987).

Figure 2—*Vitex agnus-castus*, lilac chastetree: seedling showing cotyledons and first leaves (from drawing by King 1932, used in 1948 edition).



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Vitaceae—Grape family

Vitis labrusca L.

fox grape

Franklin T. Bonner

Dr. Bonner is a scientist emeritus at the USDA Forest Service's Southern Research Station
Mississippi State, Mississippi

Other common names. northern fox grape, plum grape, northern muscadine, swamp grape, wild vine.

Growth habit, occurrence, and use. Fox grape—*Vitis labrusca* L.—a deciduous, woody vine, grows naturally from New England to Illinois and south to Georgia and infrequently, Arkansas (Vines 1960). It may climb on trees to a height of 12 m. Fox grape hybridizes readily with other *Vitis* species, and it has been the most important grape in the development of North American viticulture (Vines 1960), notably the 'Concord' varieties (Cawthon and Morris 1982). The fruits are important as food for many birds and mammals.

Flowering and fruiting. The dioecious flowers are both borne in short panicles, 5 to 10 cm long, in May or June. The fruit clusters usually have fewer than 20 globose berries, 8 to 25 mm in diameter. The berries mature in August to October and drop singly. Mature berries are brownish purple to dull black and contain 2 to 6 brownish, angled seeds that are 5 to 8 mm long (Vines 1960) (figures 1 and 2). Seed maturity is indicated by a dark brown seedcoat (Cawthon and Morris 1982).

Collection, extraction, and storage of seeds. Ripe berries can be stripped from the vines by hand or shaken onto canvas sheets. The seeds can be extracted by placing the berries in screen bags with 1.4-mm openings (approximately 14-mesh) and directing a solid stream of water at about 181 kg (400 lb) of pressure onto them. This removes the skins and pulp, most of which will be washed through the screen. The remaining fragments can be washed off in a pail of water. Seeds can also be extracted by running berries through a macerator or hammermill with water and washing the pulp away (Bonner and Crossley 1974). Six samples of fox grape seeds ranged from 32,900 to 34,000/kg (14,920 to

Figure 1—*Vitis labrusca*, fox grape: seed.

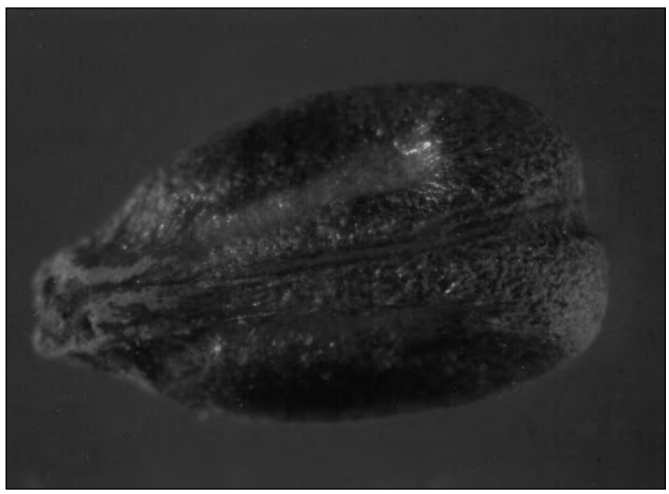
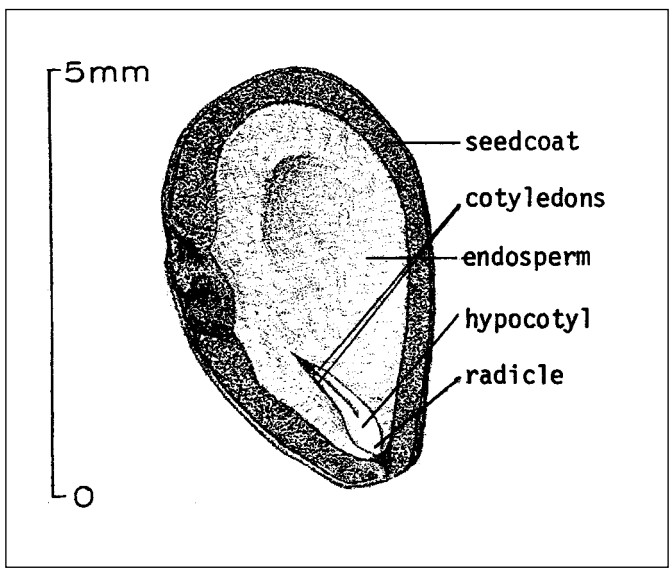


Figure 2—*Vitis labrusca*, fox grape: longitudinal section through a seed.



15,430/lb) at a moisture content of 10%; the average was 34,600 seeds (15,070/lb). No storage data are available for fox grape, but other *Vitis* species have been stored successfully at low moisture contents at 5 °C in sealed containers (Bonner and Crossley 1974; Vories 1981). These results suggest that fox grape seeds are orthodox in storage behavior and can be stored successfully for at least several years.

Pregermination treatments. Fox grape seeds exhibit dormancy that can be overcome by moist stratification at 2 to 5 °C for several months. There are no specific data for fox grape, but a similar wild species—riverbank grape, *V. vulpina* L.—requires 90 days of stratification for germination testing (AOSA 1993) and up to 4 months has been recommended for spring planting in nurseries (Vories 1981). Soaking stratified seeds in solutions of nutrients or growth substances for 12 hours before sowing has also been reported as helpful in Europe (Simonov 1963).

Nursery practice. Seedlings rarely run true to type; hence, propagation by cuttings is common (Vines 1960).

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Arecaceae—Palm family

Washingtonia filifera (L. Linden) H. Wendl.

California washingtonia

Stanley L. Krugman

Dr. Krugman retired from the World Bank and from the USDA Forest Service's National Office, Washington, DC

Synonyms. *Washingtonia filamentosa* (Frenzi) Kuntze, *Neowashingtonia filimentosa (*Frenzi) Sudworth.

Other common names. California Washington-palm, desert-palm, California fan-palm, California-palm.

Growth habit, occurrence, and use. The California washingtonia—the only palm native to California—is the largest of the native palms in the United States (Bomhard 1950). Its sturdy, massive, cylindrical trunk grows to a height of 18 to 23 m and tapers very gradually from a diameter of 51 to 91 cm at the base to slightly less at the top. It has a broad open crown with as many as 50 fan-shaped, much-folded leaves with petioles as long as 1.5 m. Dead leaves may remain on the trunk for many years, forming a dense, thatch-like shroud or skirt about the trunk down to within a few feet of the ground (Sudworth 1908). This species is native to rocky streambeds and edges of other sources of water bordering the Colorado Desert in southeastern California and in Yuma County, Arizona, and northern Baja California, Mexico (Bomhard 1950). It is now widely planted in southern California, Arizona, Texas, and along the Gulf Coast for ornamental and environmental forestry purposes along roads or in small stands.

Geographic races. Studies employing electrophoretic techniques suggest that the current populations in southern California are either relicts or recent recolonizations from seed dispersal from a refugium population in Baja California, Mexico (McClenaghan and Beauchamp 1986).

Flowering and fruiting. In August, small but showy clusters of white, vase-shaped flowers are borne, enclosed initially by a spathe (Jepsen 1910). The mature flower stalk may average 3.7 m in length and extend almost horizontally in the crown (Bomhard 1950). The flowers are perfect and occur annually in great abundance once the tree reaches reproductive maturity. The calyx is tubular and the corolla is funnel-shaped, with the stamens inserted in its tube (Jepsen 1910).

The fruit and seeds mature during December and January. The ripe fruit is a spherical or elongated black berry about 10 to 13 mm long, with thin flesh surrounding a single hemispherical seed (DeMason 1988; Jepsen 1910; Sudworth 1908). The seeds are pale chestnut in color and measure about 6 to 8 mm long by 3 mm thick (figure 1); there are about 2,300 to 2,700 seeds/kg (1,040 to 1,225/lb) (Sudworth 1908). They are flattened somewhat on the ventral side (figure 2). The lance-shaped embryo is located on the round side of the seed near the raphe (DeMason 1988). There is a large cotyledon, an epicotyl, a small root apex, a horny endosperm, and a thin seedcoat (DeMason 1988; Jepsen 1910). The seeds are mature at the time of fruit drop.

Extraction and storage of seeds. The fleshy covering on the seeds should by removed in a macerator. The cleaned seeds then may be stored or sown immediately. Seeds should not be permitted to dry out (DeLeon 1958). Seeds of this species have been stored successfully in sealed containers at 5 °C for up to 6 years (Quick 1968), but long-term storage is not recommended.

Figure 1—*Washingtonia filifera*, California washingtonia: seed.

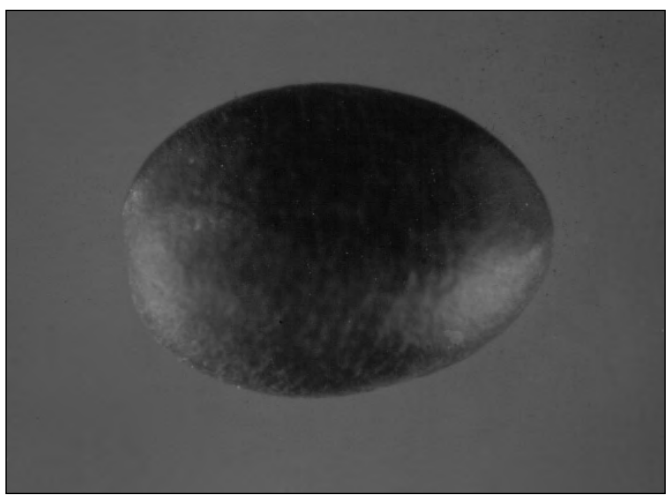
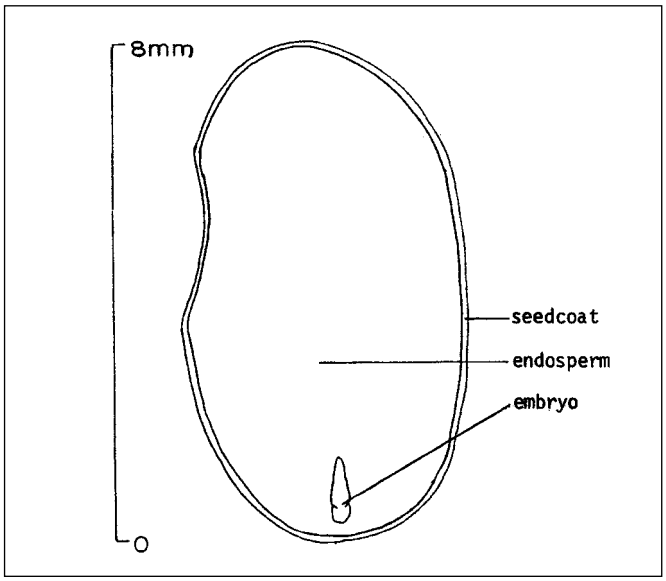


Figure 2—*Washingtonia filifera*, California washingtonia: longitudinal section through the embryo of a seed.



Germination and nursery practice. Fresh seeds with no treatment before sowing have germinated between 80 and 100% in 4 to 15 weeks (Emery 1969; McCurrach 1960). Seeds stored as long as 5 years also germinated well (87%) without a pretreatment. However, the time to reach maximum germination was reduced when stored seeds were stratified at 5 °C for 12 weeks before sowing (Quick 1968). Fresh or stratified seeds can be sown directly in a well-drained seedbed outdoors or in flats or other containers. Many growers prefer to sow the seed in a mixture of peat moss and sand or in just sand. Depth of cover has been 6 to 13 mm ($^1/_4$ to $^1/_2$ in), or a depth equivalent to the thickness of the seed (McCurrach 1960). Bottom heat for the containers has been recommended to speed germination and is also recommended during periods when cold nights can occur (Loomis 1950; Muirhead 1961). It should be noted that there is an allelopathic potential of the dry fruit of this species. Substances that inhibit germination were found in the pericarp (Khan 1982).

Germination is hypogeal (Tomlinson 1960). When a seed germinates, the shoot grows but the seed remains underground. With the appearance of an elongated second leaf, seedlings should be transplanted to individual containers containing soil mix enriched with leaf mold (Muirhead 1961). The transplants should be grown in partial shade to prevent excessive drying of the seedlings. During the subsequent growing period, the seedlings should be acclimated to heat by gradually removing the shade.

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Agavaceae—Century-plant family

Yucca L.

yucca

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Growth habit and occurrence. There are about 30 species of yucca native to North America and the West Indies. Although most of these long-lived, evergreen plants grow in the arid southwestern United States and on Mexican tablelands, yuccas are found up to 2,400 m in elevation in the mountains of Colorado (Arnott 1962; Webber 1953). Four western species are considered here (table 1). Great Plains yucca is a small acaulescent shrub 1 to 2 m tall, with narrow, swordshaped, spine-tipped, upright leaves 6 to 12 mm wide. Soaptree yucca is a medium to large caulescent shrub up to 9 m tall, with similar but wider (5 cm) and longer leaves (Arnott 1962; McKelvey 1947; Webber 1953). Tree-like in form, Joshua tree can exceed trunk lengths of over 3 m, with pseudodichotomous branching and long dark green leaves (Cornett 1991). Extensive stands of this sturdy tree can be found scattered throughout the Mojave Desert. The most common yucca in desert areas is Mohave yucca, a shrub or tree-like yucca reaching 1 to 5 m in height with rosettes at its tips (Jaeger 1940) .

Natural reproduction by seed is limited because of low rainfall (McKelvey 1947; Webber 1953). Most new plants sprout from underground rhizomes. Early growth of seedlings is very slow, and they often retain their succulent juvenile leaves for a year (Webber 1953). Soaptree yucca seedlings observed over a period of time on the Jornada Experimental Range in New Mexico averaged only about 20 cm high when 16 years old (Campbell and Keller 1932). At Joshua Tree National Park, it has been observed that Joshua tree and Mohave yucca grow 10 to 15 cm in their first year and roughly 2.5 cm annually thereafter (CALR 1995).

Uses. Yuccas are an important resource for Native Americans in the Southwest and Mexico. The buds, flowers, and legumes can be eaten raw, roasted, or boiled. The flower stalks of soaptree yucca can also be roasted like mescal. Rope, mats, sandals, baskets, and burlap cloth have been made from the fibers of the leaves. The roots of soaptree yucca, known as *amole*, have saponifying properties and have been used as a soap and as a laxative (Kearney 1969; Webber 1953). Bean and Saubel (1972) report that as a soap plant, Mohave yucca (the roots are called *hunuvat* by the Cahuilla) is one of the most famous in the Southwest. The inflorescent shoots of capsular yuccas are highly palatable to livestock and wildlife, and soaptree yucca has been used as an emergency ration for livestock during periods of drought. The chopped stems, when mixed with feed concentrates such as cottonseed meal, are palatable and nourishing (Kearney 1969; Webber 1953). Around the turn of the century, Joshua tree saw brief but unsuccessful commercial use as paper pulp and surgical splints (McKelvey 1938). These species have been cultivated occasionally as ornamentals; other species not covered here are commonly used horticulturally.

Table 1—*Yucca,* yucca: nomenclature and occurrence

Scientific name & synonym(s)	Common name(s)	Occurrence
***Y. brevifolia* Engelm.**	**Joshua tree,** tree yucca	Mojave Desert to SW Utah & W Arizona
***Y. elata* (Engelm.) Engelm.** *Y. radiosa* (Engelm.) Trel.	**soaptree yucca,** palmilla, soapweed, Spanish-bayonet	SW Texas, NW to central New Mexico & W central Arizona; Iron & Washington Cos., Utah
***Y. glauca* Nutt.** *Y. angustifolia* Pursh	**Great Plains yucca,** beargrass, soapweed, Spanish-bayonet	Texas N through Rocky Mtns & Great Plains to Montana & North Dakota
***Y. schidigera* Roezl ex Ortgies**	**Mojave yucca,** Spanish-dagger	S Mojave Desert, NW Sonoran Desert to Nevada, Arizona, & N Baja California

Source: Little (1979).