Ericaceae—Heath family

# *Vaccinium* L.

## blueberry, cranberry

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**Occurrence, growth habit, and uses.** There are about 150 to 450 species (the number varies by authority) of deciduous or evergreen shrubs (rarely trees or vines) in *Vaccinium* (Huxley 1992b; LHBH 1976; Vander Kloet 1988). The majority of species are native to North and South America and eastern Asia (LHBH 1976; Vander Kloet 1988). Some of the more commonly cultivated North American species are listed in table 1. Like other members of the Ericaceae, *Vaccinium* species require an acidic (pH 4.0 to 5.2) soil that is moist, well drained, and high in organic matter (3 to 15%). Symptoms of mineral nutrient deficiency arise if soil pH exceeds optimum levels (LHBH 1976). Sparkleberry is one exception that grows well in more alkaline soils (Everett 1981). Many species of *Vaccinium* establish readily on soils that have been disturbed or exposed (Vander Kloet 1988).

Many species of *Vaccinium* are rhizomatous, thus forming multi-stemmed, rounded to upright shrubs or small trees ranging in height from 0.3 to 5.0 m (table 1). Cranberry forms a dense evergreen ground cover about 1 m in height (Huxley 1992b; Vander Kloet 1988).

Several species of *Vaccinium* are valued for their edible fruits. Historically, Native Americans consumed blueberries fresh or dried them for winter consumption (Vander Kloet 1988). In addition, they steeped the leaves, flowers, and rhizomes in hot water and used the tea to treat colic in infants, to induce labor, and as a diuretic (Vander Kloet 1988). Currently, most commercial blueberry production occurs in North America, where highbush blueberry accounts for more than two-thirds of the harvest (Huxley 1992a). Another species, rabbiteye blueberry, is more productive, heat resistant, drought resistant, and less sensitive to soil pH than highbush blueberry, but it is less cold hardy (Huxley 1992a; LHBH 1976). In more northern latitudes, the low-growing lowbush and Canadian blueberry bushes occur in natural stands. Their fruits are harvested for processing or the fresh fruit market (LHBH 1976).

Although cranberry has been introduced successfully into cultivation in British Columbia, Washington, and Oregon, Wisconsin and Massachusetts remain the largest producers; the crops for 2000 were estimated at 2.95 and 1.64 million barrels, respectively (NASS 2001).

Evergreen huckleberry grows along the Pacific Coast and is valued for its attractive foliage, which is often used in flower arrangements (Everett 1981). Species of *Vaccinium* also are prized as landscape plants. Lowbush forms are used to form attractive ground covers or shrubs. Two cultivars of creeping blueberry (*V. crassifolium* Andrews)—'Wells Delight' and 'Bloodstone'—form dense ground covers usually < 20 cm in height, varying only in texture and seasonal color change (Kirkman and Ballington 1985). Shrub-forming species add interest to the landscape with their attractive spring flowers and brilliantly colored fall foliage (Dirr 1990). Bird lovers also include *Vaccinium* spp. in their landscapes as the shrubs attract many birds when fruits ripen. In the wild, species of *Vaccinium* also serve as a source of food for many mammals (Vander Kloet 1988).

**Geographic races and hybrids.** Breeding programs have focused on improvement of species of *Vaccinium* since the early 20th century (Huxley 1992a). As a result, numerous hybrids and cultivars exist, each suited to specific growing conditions.

**Flowering and fruiting.** Perfect flowers are borne solitary or in racemes or clusters and are subterminal or axillary in origin (Vander Kloet 1988). White flowers, occasionally with a hint of pink, occur in spring or early summer, usually before full leaf development (table 2) (Dirr 1990). Rabbiteye and lowbush blueberries are generally self-sterile and must be interplanted to ensure fruit-set. Highbush blueberries are self-fertile, although yields can be improved by interplanting with different cultivars (Huxley 1992a). When mature, fruits of blueberries are many-seeded berries (figure 1), blue to black in color, often glaucous, ranging in size from 6.4 to 20 mm in diameter with a per-

**Table 1**—*Vaccinium,* blueberry and cranberry: nomenclature, plant height, and natural occurrence

| Scientific name & synonym(s) | Common name(s) | Plant height (cm) | Occurrence |
|---|---|---|---|
| ***V. angustifolium* Ait.**<br>*V. lamarckii* Camp<br>*V. nigrum* (Wood) Britt.<br>*V. angustifolium*<br>var. *hypolasium* Fern.<br>var. *laevifolium* House<br>var. *nigrum* (Wood) Dole<br>var. *brittonii* Porter ex Bickn. | **lowbush blueberry,**<br>late sweet blueberry,<br>low sweet blueberry | 18 ± 9 | Labrador & Newfoundland; W to Manitoba & Minnesota; S to Illinois, Delaware, & Pennsylvania; mtns of Virginia & West Virginia |
| ***V. arboreum* Marsh.**<br>*V. arboreum* var. *glaucescens* (Greene) Sarg.<br>*Batodendron andrachniforme* Small<br>*Batodendron arboreum* (Marsh.) Nutt. | **sparkleberry,**<br>farkleberry | 311 ± 102 | Virginia to central Florida, W to E Texas, central Oklahoma & SE Mississippi |
| ***V. corymbosum* L.**<br>*V. constablaei* Gray<br>*V. corymbosum* var. *albiflorum* (Hook.) Fern.<br>*V. corymbosum* var. *glabrum* Gray<br>*Cyanococcus corymbosus* (L.) Rydb.<br>*Cyanococcus cuthbertii* Small | **highbush blueberry,**<br>American blueberry,<br>swamp blueberry | 230 ± 60 | Atlantic Coast; W to E Texas & Illinois; absent from Mississippi, central Ohio, W Kentucky, W Tennessee, West Virginia, & central Pennsylvania |
| ***V. macrocarpon* Ait.**<br>*Oxycoccus macrocarpus* (Ait.) Pursh | **cranberry,** large cranberry, American cranberry | 6 ± 3 | Newfoundland, W to Minnesota, S to N Illinois, N Ohio, & central Indiana; Appalachian Mtns to Tennessee & North Carolina |
| ***V. myrtilloides* Michx.**<br>*V. angustifolium* var *myrtilloides* (Michx.) House<br>*V. canadense* Kalm ex A. Rich.<br>*Cyanococcus canadensis* (Kalm ex A. Rich) Rydb. | **Canadian blueberry,**<br>velvet-leaf blueberry,<br>velvetleaf huckleberry,<br>sour-top blueberry | 35 ± 14 | Central Labrador to Vancouver Island, Northwest Territories SE to Appalachian Mtns |
| ***V. ovatum* Pursh.** | **California huckleberry,**<br>evergreen huckleberry,<br>shot huckleberry | 82 ± 42 | Pacific Coast, British Columbia to California |
| ***V. oxycoccos* L.**<br>*V. palustre* Salisb.<br>*Oxycoccus palustris* Pers.<br>*Oxycoccus quadripetalus* Gilib. | **small cranberry** | 2 ± 1 | North American boreal zone to the Cascade Mtns in Oregon & to Virginia in the Appalachian Mtns |
| ***V. virgatum* Ait.**<br>*V. virgatum* var. *ozarkense* Ashe<br>*V. virgatum* var. *speciosum* Palmer<br>*V. parviflorum* Gray; *V. amoenum* Ait.<br>*V. ashei* Rehd.; *V. corymbosum* var. *amoenum* (Ait.) Gray<br>*Cyanococcus virgatus* (Ait.) Small<br>*Cyanococcus amoenus* (Ait.) Small | **rabbiteye blueberry,**<br>smallflower blueberry | 300 ± 100 | SE United States |
| ***V. vitis-idaea* L.** | **lingonberry,** cowberry, foxberry, mountain cranberry | 7 ± 3 | New England & scattered throughout Canada; native to Scandinavia |

**Sources:** GRIN (1998), Huxley (1992b), Vander Kloet (1988).

sistent calyx (table 3) (LHBH 1976). Cranberry fruits are many-seeded berries that are red at maturity and range from 1 to 2 cm in diameter (Huxley 1992b).

**Collection of fruits, seed extraction, and cleaning.** Small quantities of ripe fruits may be collected by hand-picking. Larger quantities, however, are usually harvested mechanically (Huxley 1992a). To extract seeds, fruits should be placed in a food blender, covered with water, and thoroughly macerated using several short (5-second) power bursts. More water is added to allow the pulp to float while the sound seeds (figures 2 and 3) settle to the bottom. Repeating this process several times may be necessary to achieve proper separation of seeds and pulp (Galletta and Ballington 1996). Seed weights are listed in table 3.

**Table 2**—*Vaccinium,* blueberry and cranberry: phenology of flowering and fruiting for cultivated species

| Species | Flowering | Fruit ripening | Mature fruit color |
|---|---|---|---|
| *V. angustifolium* | May–June | July–Aug | Blue to black; glaucous |
| *V. arboreum* | May–June | Oct–Dec | Shiny black to glaucous blue |
| *V. corymbosum* | June | June–Aug | Dull black to blue & glaucous |
| *V. macrocarpon* | May–June | Sept–Oct | Red |
| *V. myrtilloides* | — | — | Blue & glaucous |
| *V. ovatum* | Mar–July | Aug–Sept | Blue & glaucous to dull black |
| *V. virgatum* | Mar–May | June–Aug | Black or glaucous blue |
| *V. vitis-idaea* | May–June | Aug | Red |

**Source:** Ballington (1998), Crossley (1974), Dirr (1990), Vander Kloet (1988)

**Figure 1**—*Vaccinium*, blueberry: fruits (berries) of *V. angustifolium*, lowbush blueberry (**top**); *V. corymbosum*, highbush blueberry (**bottom**).

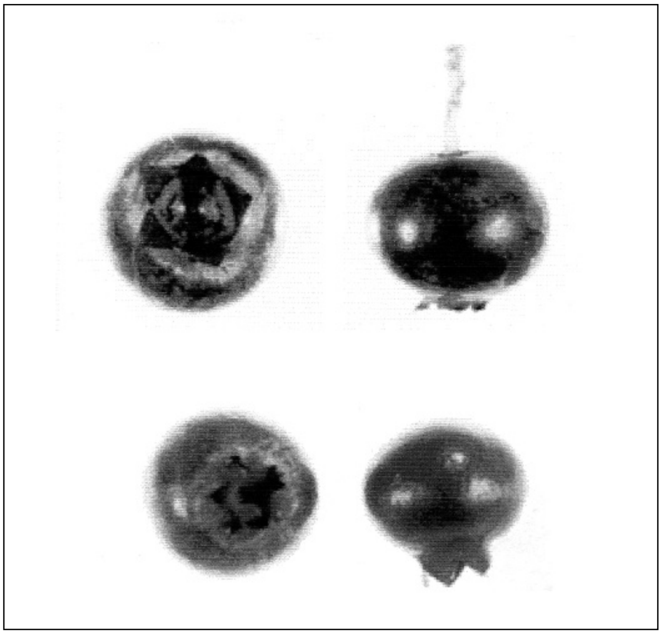


**Table 3**—*Vaccinium,* blueberry and cranberry: fruit and seed sizes of cultivated species

| Species | Berry diameter (mm) | Cleaned seeds/weight /kg | Cleaned seeds/weight /lb |
|---|---|---|---|
| *V. angustifolium* | 8 ± 1 | $3.90 \times 10^6$ | $1.45 \times 10^6$ |
| *V. arboreum* | 8 ± 1 | $1.01 \times 10^6$ | $4.59 \times 10^5$ |
| *V. corymbosum* | 8 ± 1 | $2.20 \times 10^6$ | $1.00 \times 10^6$ |
| *V. macrocarpon* | 12 ± 2 | $1.09 \times 10^6$ | $4.95 \times 10^5$ |
| *V. myrtilloides* | 7 ± 1 | $3.81 \times 10^6$ | $1.73 \times 10^6$ |
| *V. ovatum* | 7 ± 1 | $2.99 \times 10^6$ | $1.36 \times 10^6$ |
| *V. oxycoccos* | 9 ± 2 | $1.46 \times 10^6$ | $6.62 \times 10^5$ |
| *V. virgatum* | 12 ± 4 | — | — |
| *V. vitis-idaea* | 9 ± 1 | $3.54 \times 10^4$ | $1.61 \times 10^4$ |

**Sources:** Huxley (1992b), Vander Kloet (1988).

**Seed storage.** There have been no long-term studies of blueberry seed storage, but there is enough information to suggest that the seeds are orthodox in their storage behavior. Sparkleberry seeds, for example, still germinated after being buried in the soil for 4 years in Louisiana (Haywood 1994). Aalders and Hall (1975) investigated the effects of storage temperature and dry seed storage versus whole-berry storage of lowbush blueberry. Seeds extracted from fresh berries and sown immediately germinated with 80% success. However, seeds stored dry at room temperature exhibited poor germination. Seeds stored dry at –23, –2, or 1 °C germinated in higher percentages than those stored in berries (uncleaned) at the same temperatures. Germination was not significantly different among the temperatures for dry stored seeds, nor between dry and whole-berry storage at –23 °C. However, if storage temperature was maintained at –2 or 1 °C, dry storage proved preferable to whole-berry storage.

**Pregermination treatments**. It has been well established that seeds of various species of *Vaccinium* are photoblastic and require several hours of light daily for germination (Devlin and Karczmarczyk 1975, 1977; Giba and others 1993, 1995; Smagula and others 1980). Although much debated, it appears that seeds of some *Vaccinium* species do not require any pretreatment for satisfactory germination. Devlin and Karczmarczyk (1975) and Devlin and others (1976) demonstrated that cranberry seeds would germinate after 30 days of storage at room temperature if light requirements were fulfilled during germination. Aalders and Hall (1979) reported that seeds of lowbush blueberry will germinate readily if they are extracted from fresh fruit and sown immediately. The literature regarding pretreatments for highbush blueberry is not conclusive. However, cold requirements among the various species appear to be species-specific. Although seeds of many species will germinate if sown immediately after they are extracted from fresh fruit, a dry cold treatment of 3 to 5 °C for about 90 days may increase germination or become necessary if seeds are allowed to dry (Ballington 1998). Gibberellic acid ($GA_3$ or $GA_{4+7}$) treatment has been shown to promote germination. Although GA does not increase total germination, it reduces the hours of light necessary or in some instances overcomes the light requirement, thus stimulating early and uniform germination (Ballington 1998; Ballington and others 1976; Devlin and Karczmarczyk 1975; Giba and others 1993; Smagula and others 1980).

**Germination tests.** In studies to investigate the light requirement for seed germination of lowbush blueberry, Smagula and others (1980) found that seeds germinated in light exhibited an increase in both germination rate and cumulative germination in comparison to seeds germinated in darkness. Gibberellic acid treatment enhanced germination in the light as well as dark germination, with 1,000 ppm (0.1%) sufficient to overcome dark inhibition. Seed germination of highbush blueberry can be enhanced by $GA_3$ (Dweikat and Lyrene 1988). In 4 weeks, 4% germination of nontreated seeds was reported, whereas 50% germination of seeds treated with 900 ppm $GA_3$ (0.09%) was reported. Higher concentrations did not significantly affect germination. Ballington and others (1976) found that GA treatments did not influence the final germination percentage of seeds of 'Tifblue' rabbiteye blueberry. However, treatment of seeds with 100 (0.01%), 200 (0.02%), or 500 ppm (0.05%) $GA_{4+7}$ resulted in seedlings that reached transplanting size 2 to 4 weeks earlier than did control or $GA_3$ treatments. The effects of GA treatment on seed germination of cranberry is similar. Devlin and Karczmarczyk (1977) found that cranberry seeds failed to germinate without light. However, seeds treated with 500 ppm GA showed 69% germination after 20 days in the dark following treatment. They also reported that, under low light conditions, GA stimulated early germination.

Aalders and others (1980) demonstrated that seed size may be an indication of seed viability in clones of lowbush blueberry. Seeds that passed through a screen with openings of 600 $\mu$m germinated poorly (1 to 14%), whereas seeds retained on that screen germinated in higher percentages (5 to 74%). In general, they reported that larger seeds germinated in higher percentages, although optimal size was clone specific.

**Nursery practice and seedling care.** Due to seedling variability, sexual propagation is normally restricted to breeding programs. Seeds $\geq$ 600 $\mu$m in diameter should be allowed to imbibe a solution of 200 to 1000 ppm (0.02 to 0.1%) GA before being sown on the surface of a suitable medium and placed under mist to prevent desiccation. Germination during periods of high temperature should be avoided if no GA treatment is applied, as Dweikat and Lyrene (1989) have suggested that high temperatures may inhibit germination. Seedlings should be transplanted to a site with ample moisture where an appropriate pH can be maintained. For field production, soil should contain high amounts of organic matter, and plants should be mulched with 10 to 15 cm of organic matter (Huxley 1992a).

Asexual propagation—by division and also by rooting softwood or hardwood stem cuttings—is widely practiced commercially for clonal propagation (Huxley 1992a). Lowbush blueberry can be propagated easily from rhizome cuttings 10 cm ( 4 in) in length taken in early spring or autumn (Dirr and Heuser 1987). However, the new shoots form flower buds almost exclusively, and the resulting plants develop slowly due to excessive flowering (Ballington 1998). Successful propagation of highbush and rabbiteye blueberry by means of softwood or hardwood cuttings has also been reported (Mainland 1993). A much easier species to root, cranberry can be propagated by stem cuttings taken any time during the year and treated with 1,000 ppm (0.1%) indolebutyric acid (IBA) (Dirr and Heuser 1987). Micropropagation procedures for various species of *Vaccinium* have also been reported (Brissette and others 1990; Dweikat and Lyrene 1988; Lyrene 1980; Wolfe and others 1983). These procedures involve rapid *in vitro* shoot multiplication followed by *ex vitro* rooting of microcuttings, utilizing standard stem cutting methods.

**Figure 2**—*Vaccinium*, blueberry: seeds of *V. angustifolium*, lowbush blueberry (**A**); *V. arboreum*, sparkleberry (**B**); *V. virgatum*, rabbiteye blueberry (**C**); *V. corymbosum*, highbush blueberry (**D**); *V. macrocarpon*, cranberry (**E**); *V. myrtilloides*, Canadian blueberry (**F**); and *V. ovatum*, California huckleberry (**G**).

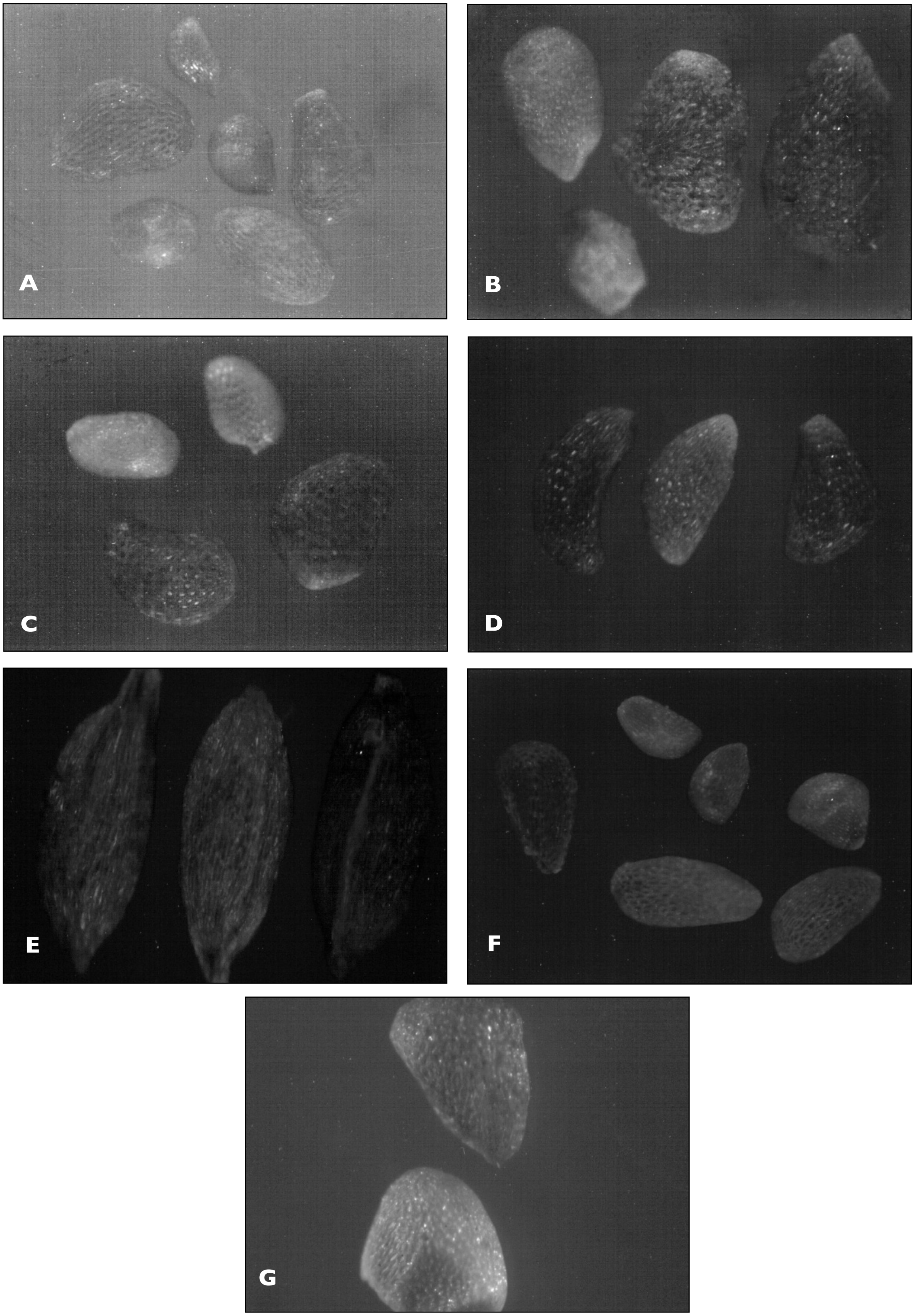
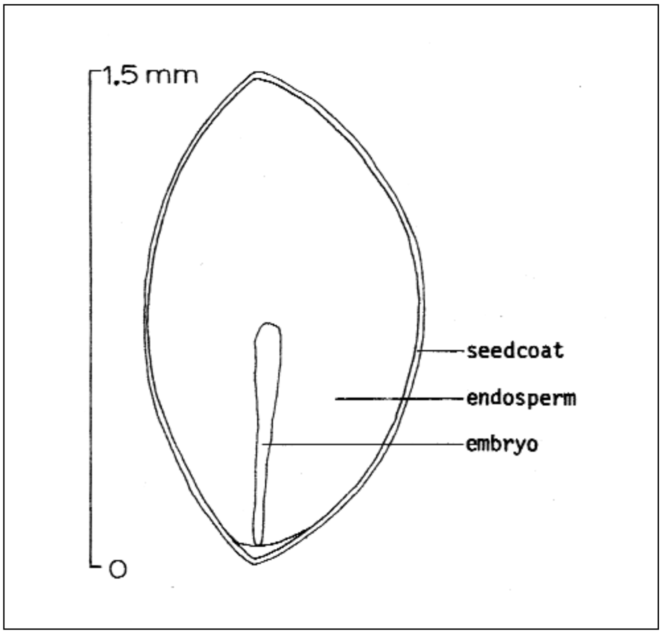


**Figure 3**—*Vaccinium corymbosum*, highbush blueberry: longitudial section of a seed.

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Euphorbiaceae—Spurge family

# *Vernicia fordii* (Hemsl.) Airy-Shaw

## tung-oil tree

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**Synonyms.** *Aleurites fordii* Hemsl.

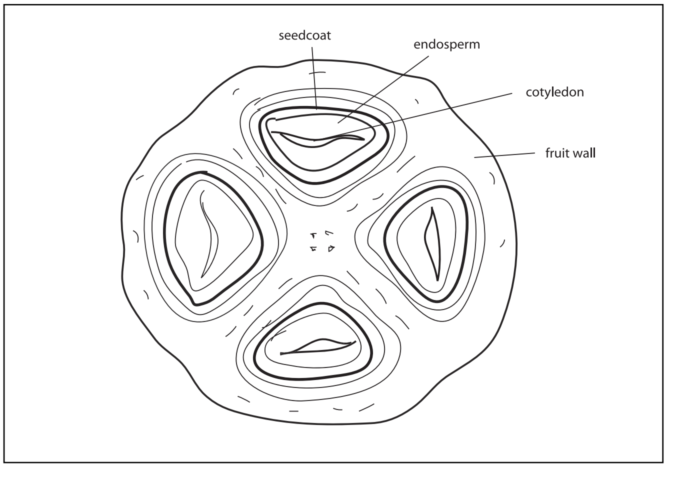
**Occurrence and uses.** Tung-oil tree—*Vernicia fordii* (Hemsl.) Airy-Shaw—is a native of central Asia. The species was introduced into the southern United States in 1905 as a source of tung oil (a component of paint, varnish, linoleum, oilcloth, and ink) that is extracted from the seeds. The use of this ingredient has declined in recent years in this country, but there are numerous research and breeding programs still underway in Asia. Extensive plantations were established along the Gulf Coast from Texas to Florida, and the tree has become naturalized (invasive) in some areas (Brown 1945; Brown and Kirkman 1990; Vines 1960). It has also been planted in Hawaii (Little 1979). Tung-oil tree is small, with a rounded top, and seldom reaches more than 10 m in height in the United States (Vines 1960).

**Flowering and fruiting.** Flowering is monoecious, but sometimes all staminate, or rarely all pistillate (Potter and Crane 1951). The white pistillate flowers with red, purple, or rarely yellow throats appear just before the leaves start to unfold in the spring. Borne in conspicuous, terminal cymes approximately 3.7 to 5 cm in diameter, the flowers create a showy display in large plantations. The fruits are 4-celled indehiscent drupes (figure 1), 3 to 7.5 cm in diameter, that ripen in September to early November (Bailey 1949; Potter and Crane 1951; Vines 1960). The seeds, 2 to 3 cm long and 1.3 to 2.5 cm wide, are enclosed in hard, bony endocarps (figures 2 and 3). They are sometimes referred to as stones or nuts. There may be 1 to 15 seeds per fruit, but the average is 4 to 5 (Potter and Crane 1951). The seeds are poisonous. Fruit production begins at about age 3, with commercial production by age 6 or 7 (Potter and Crane 1951). Good trees will yield 45 to 110 kg of seeds annually (Vines 1960).

**Collection, cleaning, and storage.** Fruits are shed intact in October or November (McCann 1942) and seeds may be collected from the ground. The fruit hulls should be removed as there is some evidence that hull fragments delay germination (Potter and Crane 1951). Cleaning is not a major problem. There are no definitive storage data for tung-oil tree seeds, but they are considered short-lived and are normally planted the spring following harvest. Their high oil content suggests that storage for long periods may be difficult.

**Figure 1**—*Vernicia fordii*, tung-oil tree: immature fruit (photo courtesy of Mississippi State University's Office of Agricultural Communications).

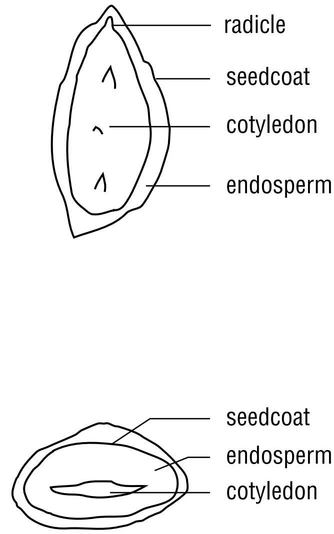
**Figure 2**—*Vernicia fordii*, tung-oil tree: cross-section of a fruit (adapted from McCann 1942).



**Germination.** No pretreatments are usually needed for germination. Seeds may be planted dry, or soaked in water for 2 to 5 days before sowing. The latter treatment is said to speed emergence (Potter and Crane 1951). Seeds typically germinate in 4 to 5 weeks (Vines 1960). Some growers have stratified seeds overwinter in moist sand at 7 °C (Potter and Crane 1951), but there does not appear to be much need for this treatment. There are no standard germination test prescriptions for this species.

**Nursery practices.** Seedling production of tung-oil tree is usually in row plantings instead of beds. Seeds should be planted 5 cm (2 in) deep, 15 to 20 cm (6 to 8 in) apart, in rows 1.5 m (5 ft) apart (Potter and Crane 1951). A good transplant size is 30 to 60 cm (1 to 2 ft). The tree can also be propagated vegetatively with hardwood cuttings (Vines 1960).

**Figure 3**—*Vernicia fordii*, tung-oil tree: longitudinal (**top**) and median (**bottom**) cross-sections of seeds.

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*Caprifoliaceae—Honeysuckle family*

# *Viburnum* L.

## viburnum

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**Growth habit, occurrence, and use.** Among the 135 or so viburnum species, 12 that are either native to North America or have been introduced are discussed here (table 1). All 12 species are deciduous shrubs or small trees. Their characteristics place the viburnums among the most important genera for wildlife food and habitat and environmental forestry purposes. The attractive foliage, showy flowers, and fruits of viburnums have ensured their widespread use as ornamental plants as well. The fruits of most species are eaten by white-tailed deer (*Odocoileus virginianus*), rabbits (*Sylvilagus floridanus*), chipmunks (*Tamias striatus*), squirrels (*Sciurus* spp.), mice (*Reithrodontomys* spp.), skunks (*Mephitis mephitis*), ruffed grouse (*Bonasa umbellus*), ring-necked pheasants (*Phasianus colchicus*), turkeys (*Meleagris gallopavo*), and many species of songbirds. The twigs, bark, and leaves are eaten by deer, moose (*Alces americana*), rabbits, and beaver (*Castor canadensis*) (Martin and others 1951). The fruits of hobblebush, nannyberry, blackhaw, and

**Table 1**—*Viburnum,* viburnum: nomenclature and occurrence

| Scientific name & synonym(s) | Common name(s) | Occurrence |
|---|---|---|
| ***V. acerifolium*** **L.** | **mapleleaf viburnum,** dock-mackie, mapleleaf arrowwood, & Texas possum-haw | Minnesota to Quebec, S to Florida |
| ***V. dentatum*** **L.**<br>*V. pubescens* (Ait.) Pursh | **southern arrowwood,** roughish arrowwood, arrowwood viburnum | Massachusetts, S to Florida & E Texas |
| ***V. lantana*** **L.** | **wayfaringtree,** wristwood, wayfaringtree virbunum | Native of Europe & W Asia; introduced from Connecticut to Ontario |
| ***V. lantanoides*** **Michx.**<br>*V. alnifolium* Marsh.<br>*V. grandifolium* Ait. | **hobblebush**, hobblebush viburnum, moosewood, tangle legs, witch-hobble | Prince Edward Island to Michigan, S to Tennessee & Georgia |
| ***V. lentago*** **L.** | **nannyberry,** blackhaw, sheepberry, sweet viburnum | Quebec to Saskatchewan, S to Missouri, Virginia, & New Jersey |
| ***V. nudum* var. *nudum*** **L.**<br>*V. cassinoides* L. | **possumhaw,** swamphaw | Coastal Plain, from Connecticut to Florida & Texas; N to Arkansas & Kentucky |
| ***V. nudum*** var. ***cassinoides*** **(L.) Torr. & Gray** | **witherod viburnum,** wild-raisin, witherod | Newfoundland to Manitoba, S to Indiana, Maryland, & mtns of Alabama |
| ***V. opulus*** **L**<br>*V. opulus* var. *amerieanum* Ait.<br>*V. trilobum* Marsh. | **European cranberrybush,** cranberrybush, Guelder rose, highbush-cranberry | Native of Europe; escaped from cultivation in N US & Canada |
| ***V. prunifolium*** **L.** | **blackhaw,** stagbush, sweethaw | Connecticut to Michigan, S to Arkansas & South Carolina |
| ***V. rafinesquianum*** **J. A. Schultes**<br>*V. affine* Bush ex Schneid.<br>*V. affine* var. *hypomalacum* Blake | **downy arrowwood,** Rafinesque viburnum | Manitoba to Quebec, S to Arkansas & Kentucky |
| ***V. recognitum*** **Fern.** | **smooth arrowwood,** arrowwood | New Brunswick to Ontario, S to Ohio & South Carolina |
| ***V. rufidulum*** **Raf.** | **rusty blackhaw,** southern blackhaw, bluehaw, blackhaw, southern nannyberry | Virginia to Kansas, S to E Texas & N Florida |

**Sources:** Dirr and Heuser (1987), Little (1979), Vines (1960).

European cranberrybush are eaten by humans also (Gill and Pogge 1974). Medicinal uses have been found for fruits of European cranberrybush, blackhaw, hobblebush, and rusty blackhaw (Gould 1966; Krochmal and others 1969; Vines 1960). Most species prefer moist, well-drained soils, but drier soils are suitable for some, notably blackhaw, mapleleaf viburnum, and witherod viburnum. Soil texture and pH requirements are less critical than in most other genera; hobblebush, mapleleaf viburnum, and nannyberry are particularly tolerant of acidic soil (Rollins 1970; Spinner and Ostrum 1945). Most species are also shade tolerant, particularly hobblebush, mapleleaf viburnum, and the 3 arrowwoods (Gould 1966; Hottes 1939). The species that more typically thrive in the open or in partial shade include blackhaw, European cranberrybush, nannyberry, and witherod viburnum.

**Flowering and fruiting.** The small white, or sometimes pinkish, flowers are arranged in flattened, rounded, or convex cymes (figure 1). Flowers are typically perfect, but the marginal blossoms in hobblebush and European cranberrybush are sterile. In some cultivated varieties of European cranberrybush, all flowers may be sterile (Rollins 1970). Flowering and fruit ripening dates are mostly in May–June and September–October, respectively, but vary among species and localities (table 2). Pollination is primarily by insects (Miliczky and Osgood 1979). The fruit is a 1-seeded drupe 6 to 15 mm in length, with soft pulp and a thin stone (figures 2, 3, and 4). As viburnum drupes mature, their

**Figure 1**—*Viburnum lentago*, nannyberry: cluster of fruits (a compound cyme) typical of the genus.

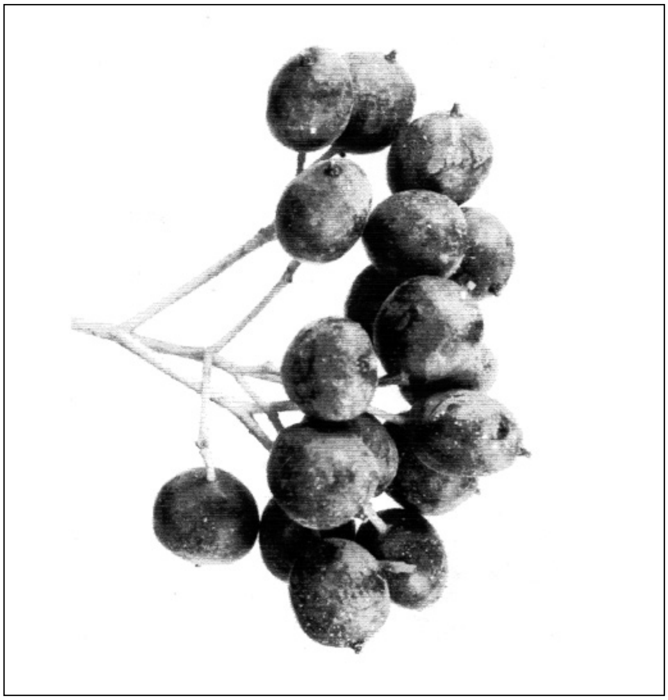


**Table 2**—*Viburnum*, viburnum: phenology of flowering and fruiting

| Species | Location | Flowering | Fruit ripening | Seed dispersal |
|---|---|---|---|---|
| *V. acerifolium* | Midrange | May–Aug | July–Oct | Fall |
| | West Virginia | — | Late Oct | Nov–Dec |
| | South | Apr–May | Late July | Fall–Spring |
| *V. dentatum* | Midrange | May–June | Sept–Oct | to Dec |
| | Extremes | June–Aug | July–Nov | to Feb |
| *V. lantana* | Midrange | May–June | Aug–Sept | Sept–Feb |
| *V. lantanoides* | Midrange | May–June | Aug–Sept | Fall |
| | West Virginia | — | Late Sept | Oct–Nov |
| | New York | May | Aug–Sept | Aug–Oct |
| *V. lentago* | Midrange | May–June | Sept–Oct | Oct–May |
| | Extremes | Apr–June | Mid July | Fall–Spring |
| *V. nudum* var. *nudum* | South | Apr–June | Sept–Oct | — |
| *V. nudum* var. *cassinoides* | Midrange | June–July | Sept–Oct | Oct–Nov |
| | Extremes | May–July | July–Oct | — |
| *V. opulus* | Midrange | May–June | Aug–Sept | Mar–May |
| | Extremes | May–July | Sept–Oct | Oct–May |
| *V. prunifolium* | Midrange | Apr–May | Sept–Oct | to Mar |
| | Extremes | Apr–June | July–Aug | Oct–Apr |
| *V. rafinesquianum* | Midrange | June–July | Sept–Oct | Oct |
| | Extremes | May–June | July–Sept | — |
| *V. recognitum* | North | May–June | Aug–Sept | to Dec |
| | South | Apr–May | July–Aug | to Feb |
| *V. rufidulum* | South | Mar–Apr | Sept–Oct | Dec |
| | North | May–June | — | — |

**Sources**: Brown and Kirkman (1990), Donoghue (1980), Gill and Pogge (1974).

**Figure 2**—*Viburnum*, viburnum: single fruits (drupes) of *V. nudum* var. *cassinoides*, witherod viburnum (**top left**); *V. lentago*, nannyberry (**top right**), *V. rafinesquianum*, downy arrowwood (**bottom left**); and *V. opulus*, cranberrybush (**bottom right**).

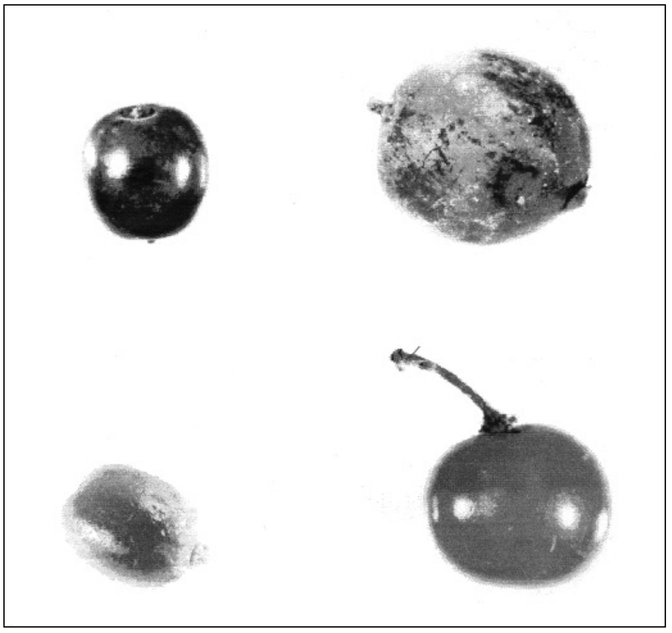
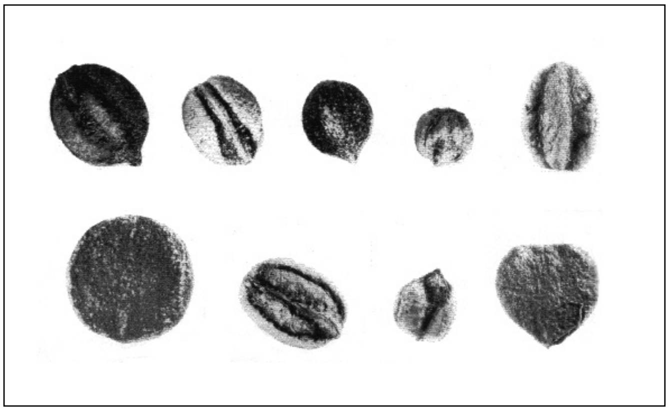
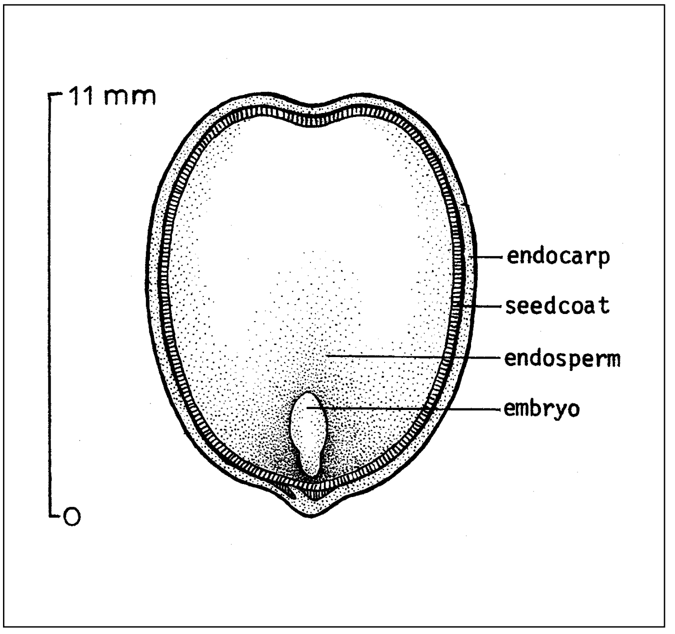


**Figure 3**—*Viburnum*, viburnum: cleaned seeds (stones) of (**top left to right**) *V. acerifolium*, mapleleaf viburnum; *V. lantanoides*, hobblebush; *V. nudum* var. *cassinoides*, witherod viburnum; *V. dentatum*, southern arrowwood; *V. lantana*, wayfaringtree; and (**bottom left to right**) *V. lentago*, nannyberry; *V. rafinesquianum*, downy arrowwood; *V. recognitum*, smooth arrowwood; *V. opulus*, European cranberrybush.



skins change in color from green to red to dark blue or black when fully ripe (Fernald 1950; Vines 1960). This color change is a reliable index of fruit maturity for most members of the genus in North America. The drupes of European cranberrybush, however, remain orange to scarlet when fully ripe (Fernald 1950). Age of viburnums at first fruiting varies among species, from 2 to 3 years up to 8 to 10 years (table 3). Production is usually meager in early

**Figure 4**—*Viburnum lentago*, nannyberry: longitudinal sections through a stone.




fruiting years, but most species produce fruit nearly every year. Species such as mapleleaf viburnum and hobblebush that grow in deep shade seldom produce large crops (Gould 1966). Much of the wildlife-habitat and ornamental value in viburnums is due to persistence of their fruits through winter (table 2). Dispersal is accomplished by animals or gravity.

**Collection, extraction, and storage.** The drupes may be hand-picked when their color indicates full physiological maturity (dark blue or black). After collection, care must be taken to prevent overheating as with all fleshy drupes. If whole drupes are to be sown, they should be spread out to dry before storage. If seeds are to be extracted, drying should be minimized to prevent toughening of the drupe coats. Extraction is recommended because there are good indications that cleaned seeds show higher levels of germination (Smith 1952). Extraction can be easily accomplished by maceration with water. Because good seeds should sink in water, the pulp can be floated off. An alternative method is to wash the pulp through screens with hoses. The seeds should then be dried for storage. Viburnum seeds are orthodox in storage behavior. Viability of air-dried seeds was maintained for 10 years by storage in a sealed container at 1 to 4 °C (Heit 1967). Whole fruits can be stored similarly (Chadwick 1935; Giersbach 1937). Average seed weight data are listed in table 4. Soundness in seed lots of several species has ranged from 90 to 96% (Gill and Pogge 1974).

**Germination.** Seeds of most viburnum species are difficult to germinate. The only official testing recommendation for any viburnum is to use tetrazolium staining (ISTA

**Table 3**—*Viburnum,* viburnum: growth habit, height, seed-bearing age, and seedcrop frequency

| Species | Growth habit | Height at maturity (m) | Year first cultivated | Seed-bearing age (yrs) | Years between large seedcrops |
|---|---|---|---|---|---|
| *V. acerifolium* | Erect shrub | 2 | 1736 | 2–3 | 1 |
| *V. dentatum* | Erect shrub | 5 | 1736 | 3–4 | — |
| *V. lantana* | Shrub or tree | 5 | — | — | — |
| *V. lantanoides* | Erect or trailing shrub | 3 | 1820 | — | 3 or 4 |
| *V. lentago* | Shrub of tree | 10 | 1761 | 8 | 1 |
| *V. nudum* var. *nudum* | Shrub or tree | 1.8 | — | — | — |
| *V. nudum* var. *cassinoides* | Erect shrub | 3 | 1761 | — | 1 |
| *V. opulus* | Erect shrub | 4 | — | 3–5 | — |
| *V. prunifolium* | Shrub or tree | 5 | 1727 | 8–10 | 1 |
| *V. rafinesquianum* | Shrub | 2 | 1830 | — | — |
| *V. recognitum* | Erect shrub | 3 | — | 5–6 | — |
| *V. rufidulum* | Shrub or tree | 3.5 | — | 5 | — |

**Source:** Gill and Pogge (1974).

**Table 4**—*Viburnum,* viburnum: fruit and seed weight and yield data

| | Dried fruits/wt | | Cleaned seeds/weight | | | | |
|---|---|---|---|---|---|---|---|
| | | | Range | | Average | | |
| Species | /kg | /lb | /kg | /lb | /kg | /lb | Samples |
| *V. acerifolium* | 10,600 | 4,800 | 24,050–36,600 | 10,900–16,600 | 28,000 | 13,100 | 5 |
| *V. dentatum* | — | — | 32,200–71,900 | 14,600–32,600 | 45,000 | 20,400 | 6 |
| *V. lantana* | — | — | 9,250–29,100 | 4,200–13,200 | 19,200 | 8,700 | 2 |
| *V. lantanoides* | 16,700 | 7,580 | — | — | 25,350 | 11,500 | 11 |
| *V. lentago* | 4,850 | 2,200 | 4,850–27,350 | 2,200–12,400 | 13,000 | 5,900 | 21 |
| *V. nudum* var. *cassinoides* | 6,600 | 3,000 | 55,100–63,950 | 25,000–29,000 | 60,850 | 27,6003 | |
| *V. opulus* | 12,100 | 5,500 | 20,700–39,250 | 9,400–17,800 | 30,000 | 13,600 | 12 |
| *V. prunifolium* | — | — | 8,800–13,230 | 4,000–6,000 | 10,600 | 4,800 | 5 |
| *V. rufidulum* | 5,200 | 2,360 | — | — | — | — | — |

**Source:** Gill and Pogge (1974).

1993). Most species have an apparent embryo dormancy and some have impermeable seedcoats as well (Gill and Pogge 1974). Dormancy in seeds of southern species is more readily overcome than in seeds of northern species. Seeds of the more northern forms need warm stratification for development of the radicle, followed by cold stratification to break dormancy in the epicotyl (shoot). European cranberrybush germinated 97% after 14 weeks of alternating temperatures between 20 and 2 °C (Fedec and Knowles 1973). For this reason, seeds of northern species seldom germinate naturally until the second spring after they ripen. In contrast, seeds of some southern viburnums usually complete natural germination in the first spring after seedfall. They ordinarily do not exhibit epicotyl dormancy and do not require cold stratification. Among the 12 species discussed here, only possumhaw and southern arrowwood from the southern part of its range may not need cold stratification (table 5 and figure 5) (Barton 1951; Giersbach 1937). Scarification of seeds has not improved germination (Barton 1958). Germination tests of stratified seeds have been made in sand or soil, but modern procedures would use moist paper blotters. The commonly suggested temperatures are alternating from 20 °C (night) to 30 °C (day) (table 5), but European cranberrybush is reported to germinate well at a constant 20 °C (Fedec and Knowles 1973).

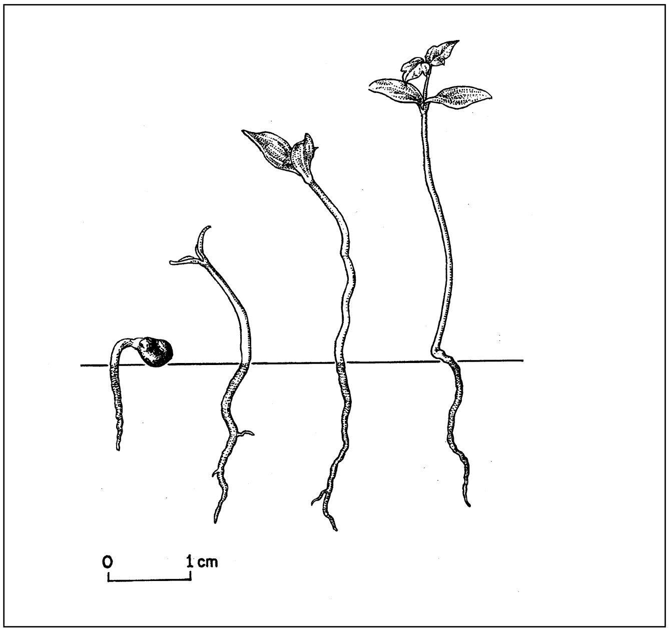
**Nursery practice.** The warm-cold stratification sequence (table 5) can be accomplished in nurserybeds. Seeds or intact drupes can be sown in the spring, to allow a full summer for root development (figure 6). The ensuing winter temperatures will provide the cold stratification needed to break epicotyl dormancy. The principal advantage of this method, compared to stratification in flats or trays, is

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

| | Stratification treatments (days) Warm period* (first stage) | Stratification treatments (days) Cold period† (second stage) | Germination test duration‡ | Germination percentage Avg (%) | Germination percentage 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 | — | — | — |

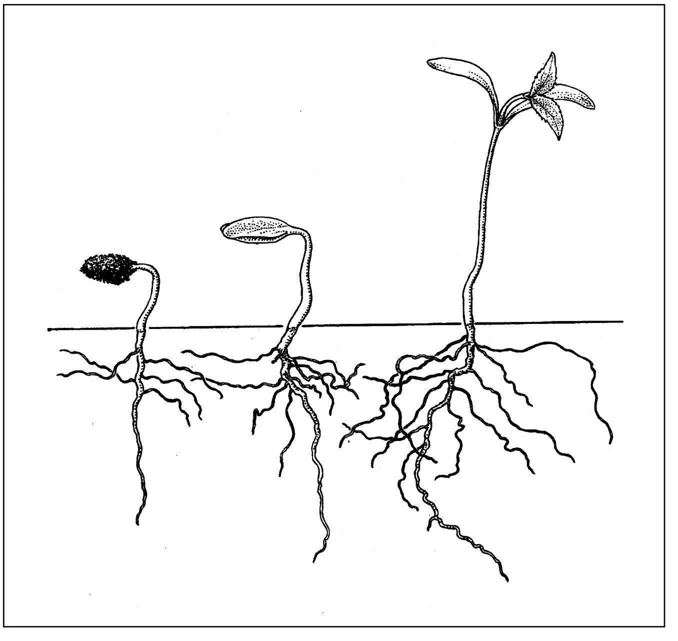
**Sources**: Gill and Pogge (1974), Vines (1960).
* Seeds in a moist medium were exposed to diurnally alternating temperatures of 30/20 °C or 30/10 °C, but a constant 20 °C was equally effective for most species (Barton 1958).
† Seeds and medium were exposed to constant temperature of 5 or 10 °C. Temperatures of 1to 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.




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.

**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**).



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).

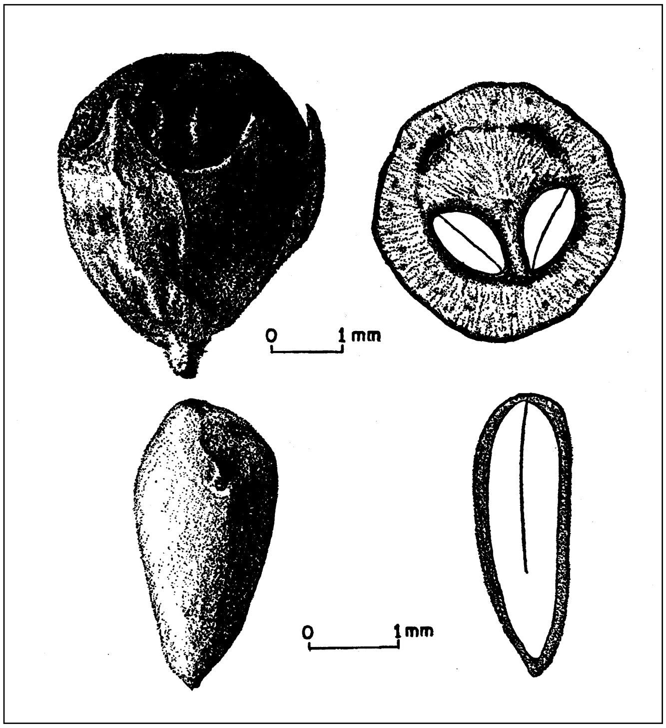
**Varieties.** Typical plants of the species have lavender flowers, but several other varieties have been cultivated in the United States (Rehder 1940; Dirr 1990). White chastetree, var. *alba* West., has white flowers. Hardy lilac chastetree, var. *latifolia* (Mill.) Loud., is characterized by broader 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**)



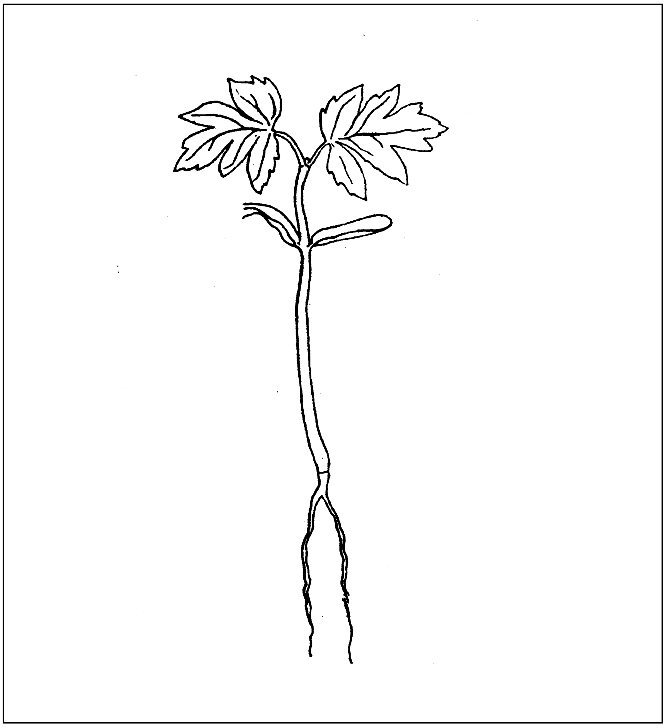

cleaned seed/45 kg of ripe fruit (75 lb/100 lb). Number of cleaned seeds varied from 74,800 to 130,000/kg (34,000 to 59,000/lb) in 4 samples (Schopmeyer 1974). Purity in 2 samples was 80%, and average soundness in 4 samples was 55%. In one test, seeds stored in moist sand and peat at 5 °C or 1 year showed 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

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**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.

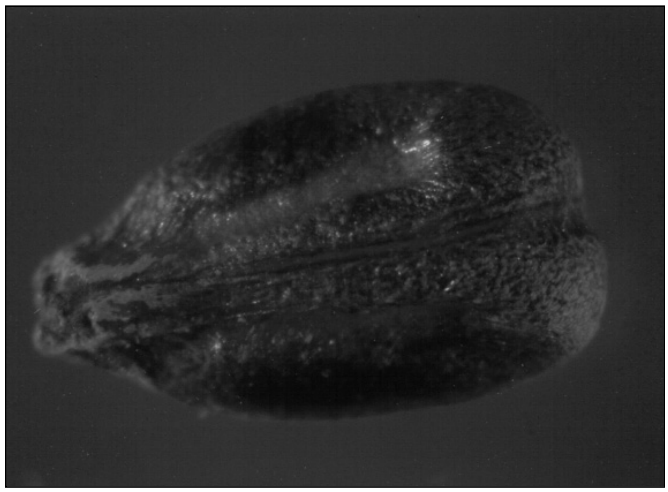
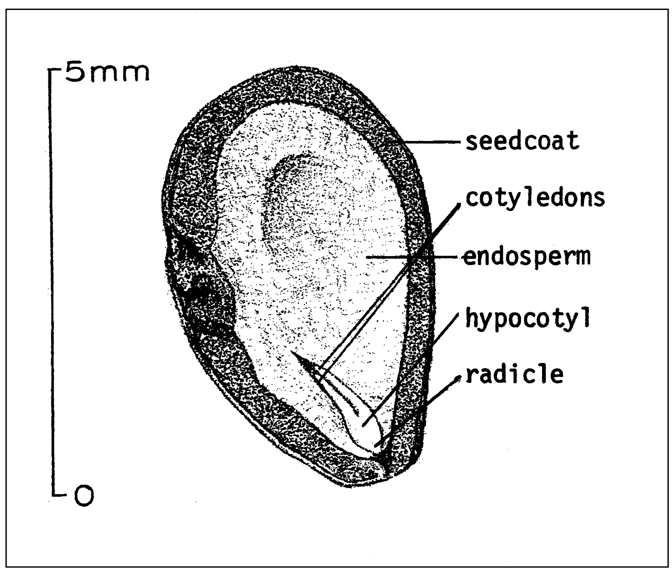


**Figure 2** —*Vitis labrusca*, fox grape: longitudinal section through a seed.



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

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**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.

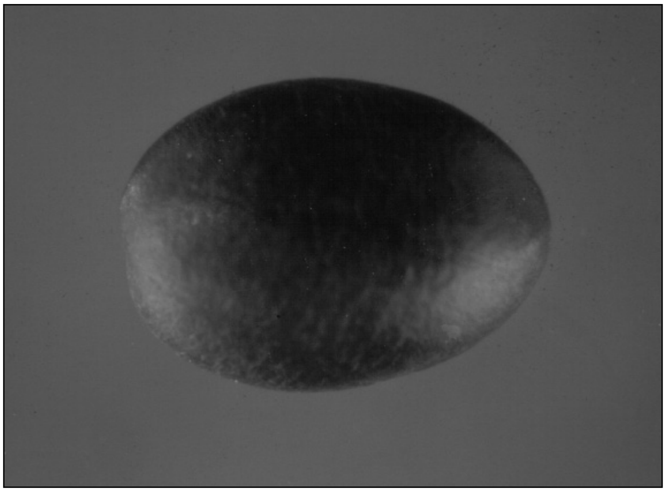
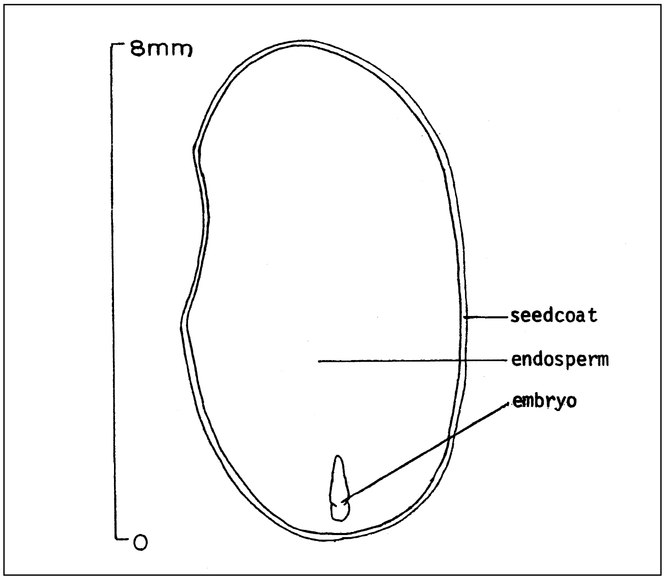


**Figure 2**—*Washingtonia filifera*, California washingtonia: longitudinal section through the embryo of a seed.




**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

Robert R. Alexander, Floyd W. Pond, and Jane E. Rodgers

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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.**<br>*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.**<br>*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).

**Flowering and fruiting.** The greenish to creamy white flowers are perfect. They appear on terminal panicles from mid-May to mid-July (table 2). Under favorable environmental conditions, plants begin bearing flowers when about 5 to 6 years old. Soaptree yucca bears about 75 to 200 flowers per stalk, but only about 30% of these produce fruits (Campbell and Keller 1932). The fruit is a dehiscent capsule containing 120 to 150 flat, ovoid, black seeds (Campbell and Keller 1932; Ellis 1913). Capsules ripen from mid-July to late September (table 2). Seeds (figures 1 and 2) are wind disseminated in September and October.

Yucca pollination seldom occurs without the aid of females of 2 moth species—the yucca moth, *Pronuba yuccasella* (Riley), and *Prodoxus quinquepunctellus* (Chambers). These moths gather the pollen, place it in the stigmatic tube, and lay their eggs. The larvae feed exclusively on the maturing seeds but usually consume only a small (20%) portion (Bailey 1962; Ellis 1913; McKelvey 1947; Webber 1953).

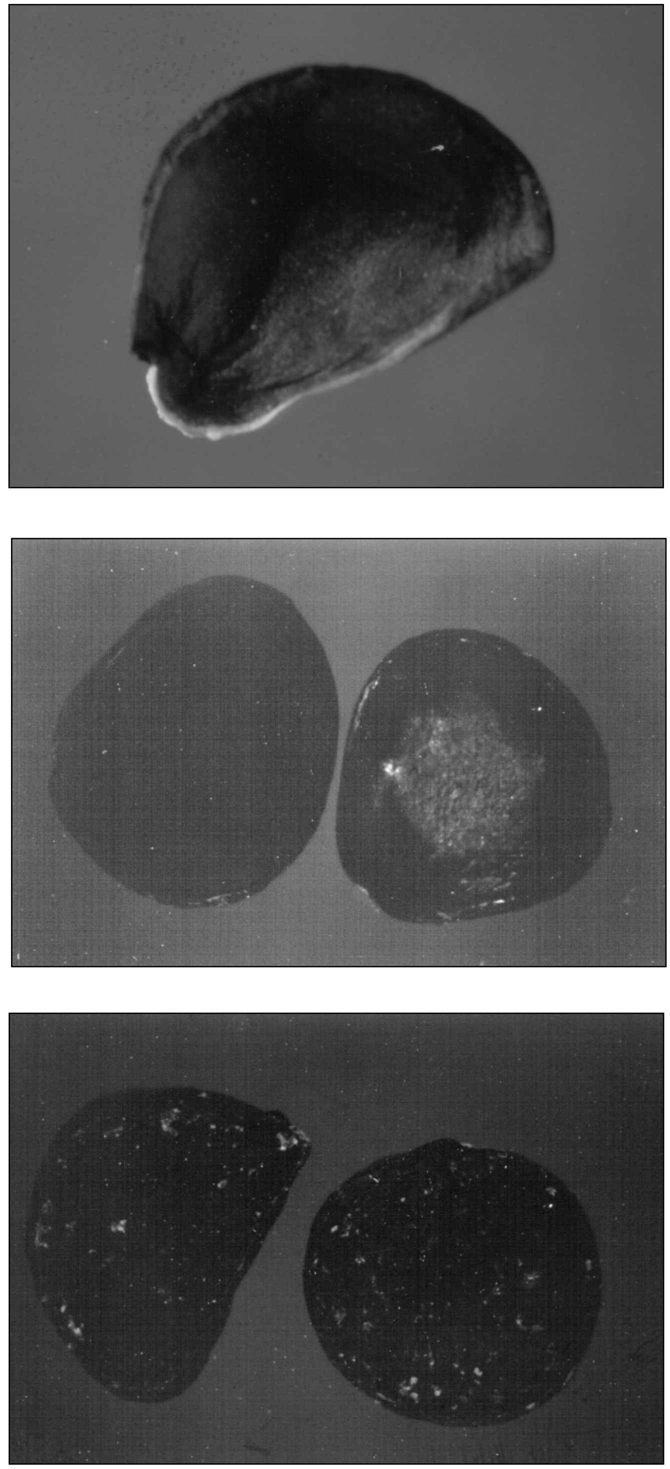
**Collection of fruits.** Because the capsules are dehiscent, fruits should be collected just before or at the time the capsules open. They may be picked by hand or stripped from the plants onto canvas (Alexander and Pond 1974).

**Extraction and storage of seeds.** Seeds are easily extracted from dry capsules by hand if the sample is small (Alexander and Pond 1974). With larger samples, dry capsules should be run through a tumbler, revolving box, or drum with screen sides that permit the seeds to fall out. Chaff and other debris can then be winnowed or screened out. Cleaned seeds average 50,000/kg (22,680/lb) for soaptree and Great Plains yuccas (Arnott 1962) and 9,250/kg (4,200/lb) for Joshua tree and Mohave yucca. Seeds have been satisfactorily stored dry at room temperatures, so although no storage tests have been done, the seeds are obviously orthodox in storage behavior.

**Pregermination treatments.** Pretreatment is apparently not needed for successful germination (Arnott 1962), but there is evidence that yuccas exhibit some degree of hardseededness (Webber 1953). The germination period can be reduced by soaking seeds in water for 24 hours at room temperatures or by mechanically scarifying or removing the hard seedcoat at the hilum end.

**Germination tests.** Germination tests for soaptree and Great Plains yuccas have been run at temperatures between 28 and 32 °C, with soaked seeds placed between the folds of moist cotton. The germinative energy of both species after 4 days varied from 45 to 98% (72 samples), with the majority of the samples tested ranging from 80 to 90% (Webber 1953). Tests have also been run in flats in a greenhouse with untreated seeds. Germination after 20 days was 96% for soaptree yucca and 80% for Great Plains yucca (Arnott 1962). After 5 months, however, only 20% of the Great Plains yucca seeds sown had produced living seedlings, whereas all the soaptree yucca germinants were still alive.

**Figure 1**—*Yucca*, yucca: seeds of *Y. elata*, soaptree (**top**); *Y. brevifolia*, Joshua tree (**center**); *Y. schidigera*, Mojave yucca (**bottom**).



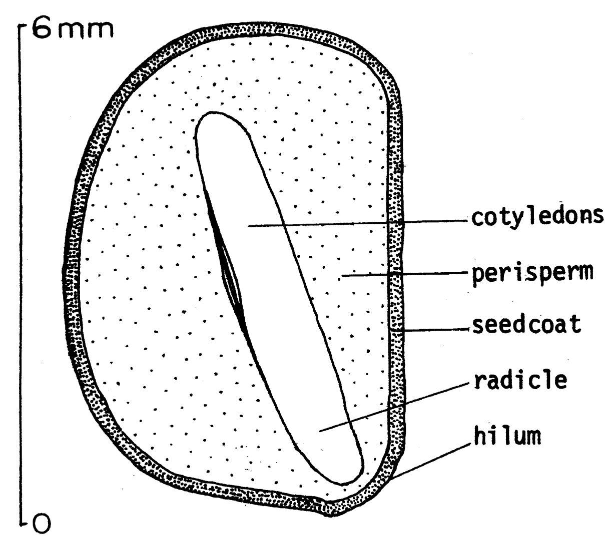
Germination tests of Joshua tree seeds found maximum germination at 20 to 25 °C and inhibition at 10 to 15 °C

**Table 2**—*Yucca,* yucca: phenology of flowering and fruiting

| Species | Location | Flowering | Fruit ripening | Seed dispersal |
|---|---|---|---|---|
| *Y. brevifolia* | — | Mar 1–Apr 1 | July 1–Aug 1 | — |
| *Y. elata* | S Arizona, New Mexico, & Texas | May 15–July 15 | Aug 1–late Sept | Sept–Oct |
| *Y. glauca* | E Colorado | May 15–June 30 | July–Aug | Sept |
| *Y. schidigera* | — | Late Mar–early May | Aug–Sept | — |

**Sources:** Kay and others (1977), Kearney and Peebles (1969), McKelvey (1937), Webber (1953).

**Figure 2**—*Yucca elata*, soaptree yucca: longitudinal section through the embryo of a seed.




(McCleary and Wagner 1973). Seeds do not require scarification for germination (CALR 1995; Went 1948). Kay and others (1977) found that germination remained around 90% for sealed seeds in 3 environments (room temperature, 4 °C, and –15 °C) even after 35 months in storage. Germination treatments are similar for Mohave yucca (CALR 1995).

**Nursery practice and seedling care.** Most plants in botanical gardens or landscape plantings have been either 2- to 3-year-old wildings transplanted from the field or vegetative propagules. Joshua Tree National Park has successfully transplanted older Mohave yucca and Joshua tree specimens (CALR 1995). A few individuals and private nurseries have raised yucca plants from seeds. Good germination was obtained by soaking seeds in water at room temperature for at least 24 hours before sowing in the spring. Germination usually begins in 1 to 2 weeks but may continue for 2 to 3 years. Seedlings should be mulched the first winter if there is danger of frost. Seedlings should be ready for outplanting the second year (Hester 1933; Webber 1953). Yucca seedlings are foraged upon by mule deer (*Odocoileus hemionus*), rabbits (*Sylvilagus* spp.), woodrats (*Neotoma* spp.), and ground squirrels (*Citellus* spp.) (Cornett 1991).

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Zamiaceae—Sago-palm family

# *Zamia pumila* L.

## coontie

W. Gary Johnson

Mr. Johnson retired from the USDA Forest Service's National Seed Laboratory

**Synonyms.** *Zamia angustifolia* Jacq., *Z. debilis* Ait., *Z. floridana* A. DC., *Z. integrifolia* Ait., *Z. latifoliolata* Preneloup, *Z. media* Jacq., *Z. portoricensis* Urban, *Z. silvicola* Small, and *Z. umbrosa* Small.

**Other common names.** Florida arrowroot, sago [palm] cycad, comptie, Seminole-bread.

**Growth habit, occurrence, and use**. Coontie is a cycad (a low, palm-like plant) with the trunk underground or extending a short distance above ground. It is native to Georgia, Florida, and the West Indies and is found in pine–oak woodlands and scrub, and on hammocks and shell mounds. About 30 *Zamia* species are native to the American tropics and subtropics. *Zamia* classification in Florida has long been the subject of controversy. Traditionally, several species have been recognized, but many botanists now believe that all *Zamia* taxa in Florida belong to a single species (FNAEC 1993).

The taproot gradually contracts, pulling the plant downward, leaving only the upper part of the stem above soil level. Coontie fixes nitrogen in upward-growing branching roots that terminate in nodules with cyanobacteria (Dehgan 1995). Coontie lacks lateral buds and thus has no true lateral branches. However, branching sometimes does occur, by division of the terminal bud (Dehgan 1995). The leaves are pinnately compound with dichotomously branched parallel veins. The seeds remain attached to the seedlings for 2 or more years after germination. The cotyledons never emerge from the seed (Dehgan 1995).

Coontie was once common to locally abundant but is now considered endangered in Florida. The starchy stems of coontie, after water-leaching to remove a poisonous glycoside, were eaten by the native people and early settlers (FNAEC 1993; Witte 1977). It is considered a good candidate for local landscaping (Witte 1977).

**Flowering and fruiting.** Coontie is a cycad, a cone-bearing gymnosperm, with male and female cones appearing on different plants. The male cones are cylindrical, 5 to 16 cm long, and often clustered 2 to 5 per plant. The female cones are elongate-ovoid, up to 5 to 19 cm long (LHBH 1976; FNAEC 1993). The period of receptivity and maturation of seed is December to March (FNAEC 1993). Insects (usually beetles or weevils) pollinate coontie. Good seed set is helped by hand-pollination (Dehgan 1995).

**Collection of cones, extraction, and storage.** Two seeds are produced per cone scale. The seeds are drupe-like, bright orange, 1.5 to 2 cm long (FNAEC 1993). The seeds may be collected from dehiscing cones in the winter (January in Gainesville, Florida). The pulpy flesh should be partially dried by spreading out the seeds to air-dry for about a month. Then, the pulp should be removed and the seeds should be washed, scrubbed, and air-dried (Witte 1977). Another method involves soaking the seeds 24 hours in water, then putting the seeds with moist sand in a wide-mouth jar and using a variable-speed drill with an attached long-stemmed wire brush to remove the fleshy seed coat (sarcotesta) without damaging the stony layer (sclerotesta) (Dehgan and Johnson 1983). Seeds stored for 1 year at 5 °C germinated as well as or better than fresh seeds (Witte 1977).

**Pregermination treatments and germination tests.** The fleshy seedcoats contain a growth inhibitor; the stony layer is up to 2 mm thick and is impermeable to water; and the embryo is partially dormant (Dehgan and Johnson 1983). Germination often takes 6 to 12 months. Removal of the fleshy seedcoat and scarification of the stony layer by cutting or cracking resulted in germination of 80 to 100% in 1 week (Smith 1978). Soaking seeds in sulfuric acid for 1 hour followed by 48 hours in gibberellic acid yielded a 92% germination in 6 weeks with intermittent mist (Dehgan 1996). Seeds average 340/kg (154/lb).

**Nursery practice and seedling care.** Cycads need well-drained soil with a pH of 6.5. The best growth occurs with a combination of slow-release fertilizer and monthly application of 300 ppm 20:20:20 N-P-K liquid fertilizer.

Seedlings should be provided with micronutrients applied once or twice per year or fertilizers that contain micronutrients should be used (Dehgan 1996). For prevention of root rot, the soil should not be allowed to remain wet longer than 1 to 2 days. The only major insect problems are with magnolia scale (*Neolecanium cornuparvum* (Thro)) and mealybugs (*Pseudococcus* spp.) (Dehgan 1996). Root-pruning helps to develop branched roots. The roots should be clipped where they join the stem, the cut surface dipped in indole butyric acid (IBA), and the plants misted for 2 weeks (Dehgan 1996).

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Rutaceae—Rue family

# *Zanthoxylum* L.

## prickly-ash

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**Growth habit and use.** Most of the prickly-ashes—*Zanthoxylum* spp.—are large shrubs or small trees. The 3 species considered here are listed in table 1. In some areas they provide food and cover for wildlife. Their deciduous foliage is very aromatic, and the bark and fruit were once used for medicinal purposes, both as home remedies and in the drug industry (Vines 1960). The wood of *espino rubial* is used for boxes, pallets, local construction, and some furniture (Francis 1991).

**Flowering and fruiting.** The greenish white dioecious flowers are borne in inconspicuous axillary cymes on common prickly-ash and in large terminal cymes 5 to 15 cm in length on Hercules-club and espino rubial (figure 1) (Sargent 1965; Francis 1991). Phenological data are summarized in table 2. Prickly-ash fruits are globose, single-seeded capsules 5 to 6 mm in diameter. During ripening, they turn from green to reddish brown. At maturity, the round, black, shiny seeds hang from the capsules (figures 1–3).

**Collection, extraction, and storage**. Seeds may be stripped from clusters of mature capsules by hand as the capsules open, or entire clusters of unopened capsules may be picked when they turn reddish brown. Unopened capsules will discharge their seeds with gentle flailing after several days of air-drying. Seeds can be separated from capsule fragments by screening or winnowing (table 3). There are no storage test data known for this genus, but the seeds are probably orthodox in storage behavior. They can be dried to 10% moisture content without loss of viability, and seeds of common prickly-ash showed practically no loss in germinability after 25 months of storage in sealed containers at 5 °C (Bonner 1974).

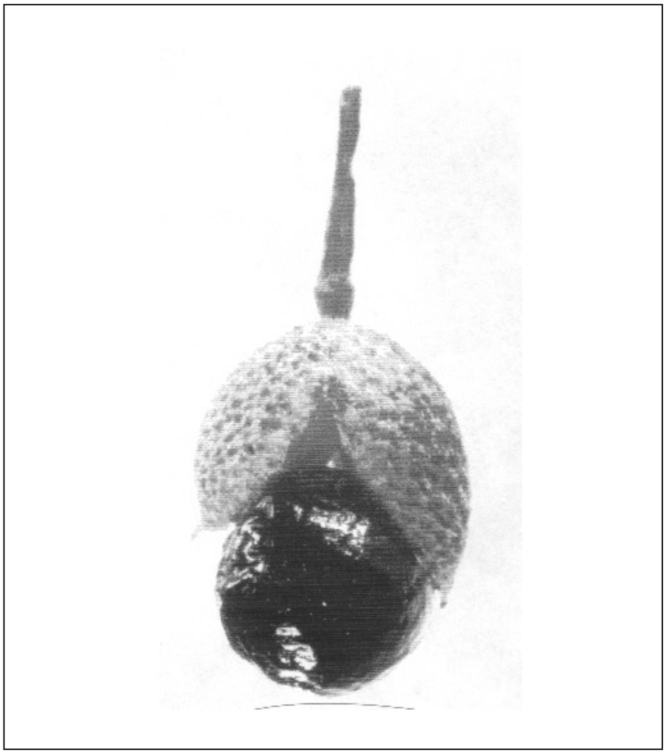
**Figure 1**—*Zanthoxylum clava-herculis*, Hercules-club: cluster of mature fruits.

**Table 1**—*Zanthoxylum,* prickly-ash: nomenclature, occurrence, and size

| Scientific name | Common name(s) | Occurrence | Height at maturity (m) |
|---|---|---|---|
| ***Z. americanum*** **Mill.** | **common prickly-ash,** toothache-tree, northern prickly-ash | Quebec to North Dakota, S to Oklahoma & Georgia | 8 |
| ***Z. clava-herculis*** **L.** | **Hercules-club,** toothache-tree, southern prickly-ash, tingle-tongue, pepperbark | Oklahoma & Virginia, S to Florida & Texas | 9–15 |
| ***Z. martinicense*** **(Lam.) DC.** | ***espino rubial,*** *pino macho, ayúa,* yellow hercules, *bosú* | Greater & Lesser Antilles, Trinidad & Tobago, E Venezuela | 20–25 |

**Sources:** Bailey (1949), Francis (1991), Little (1979), Sargent (1965).

**Figure 2**—*Zanthoxylum clava-herculis*, Hercules-club: single carpel and seed.



**Germination.** Seeds of common prickly-ash and Hercules-club exhibit strong dormancy, apparently imposed by the seedcoat. Scarification with concentrated sulfuric acid for 2 hours at about 21 °C has given fair results for Hercules-club, and stratification in moist sand for 120 days at 5 °C has helped germination of common prickly-ash (Bonner 1974). Germination of treated seeds of both species has been tested at diurnally alternating temperatures of 20 to 30 °C. (table 4). Seeds of espino rubial may have a similar dormancy, but there are no conclusive data. Untreated seeds sown in Puerto Rico produced only 5% germination (Francis 1991).

**Table 2**—*Zanthoxylum,* prickly-ash: phenology of flowering and fruiting

| *Species* | *Flowering* | *Fruit ripening* |
|---|---|---|
| *Z. americanum* | Apr–May | June–Aug |
| *Z. clava-herculis* | Apr–June | July–Sept |
| *Z. martinicense* | Apr–May* | Aug–Sept |

**Sources:** Vines (1960), Bonner (1974), Francis (1991).
* Primarily, but throughout the year in some areas.

**Figure 3**—*Zanthoxylum americanum*, common prickly-ash: longitudinal section of a seed (**left**) and seeds (**right**).

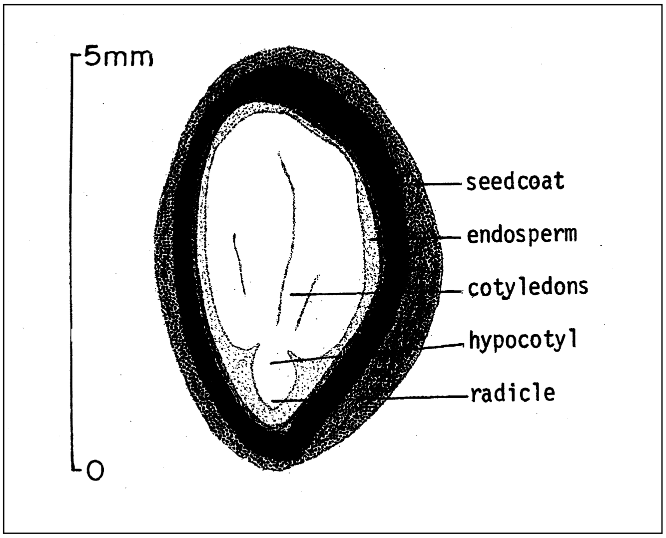



**Table 3**—*Zanthoxylum,* prickly-ash: seed data

| Species | Place collected | Seed moisture (%) | Cleaned seeds/weight Range /kg | Range /lb | Average /kg | Average /lb | Samples |
|---|---|---|---|---|---|---|---|
| *Z. americanum* | Minnesota | — | 48,100–72,590 | 21,800–32,900 | 56,490 | 25,600 | 3 |
| *Z. clava-herculis* | Mississippi | 10 | 33,100–37,050 | 15,000–16,800 | 35,000 | 15,900 | 2 |
| *Z. martinicense* | Puerto Rico | — | — | — | 75,000 | 34,020 | — |

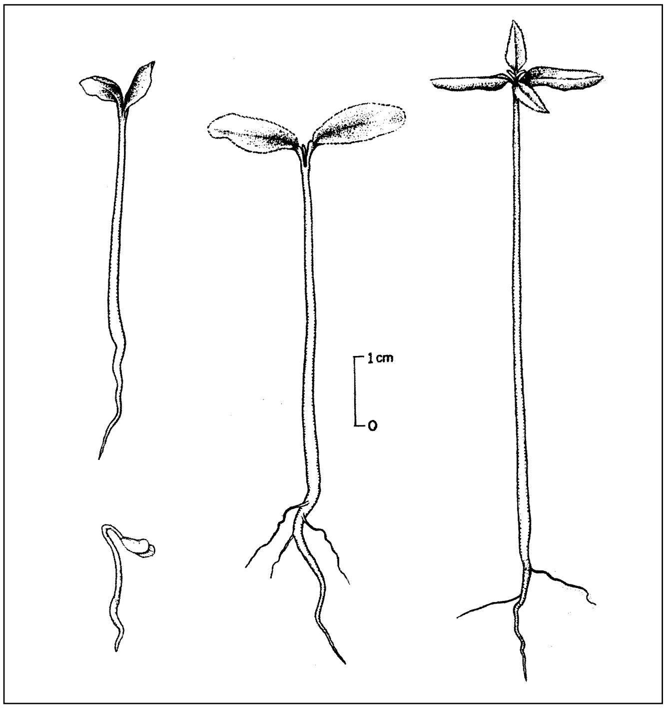
**Sources**: Bonner (1974), Francis (1991).

**Table 4**—*Zanthoxylum,* prickly-ash: germination test conditions and results

| | | Germination test conditions | | | | | Germination rate | | Germination % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pregerm-ination | Daily light | | Temp (°C) | | | Amt | | Avg | |
| Species | treatment | (hr) | Medium | Day | Night | Days | (%) | Days | (%) | Samples |
| *Z. americanum* | Stratified* | 24 | Sand | 30 | 20 | 60 | 20 | 20 | 24 | 1 |
| *Z. clava-herculis* | $H_2SO_4$ | 8 | Blotterpaper | 30 | 20 | 45 | 29 | 19 | 31 | 3 |

**Source:** Bonner (1974).
* In moist sand at 5 °C for 120 days.

**Figure 4**—*Zanthoxylum americanum*, common prickly-ash: seedling development at 1 (**left bottom**), 3 (**left top**), 13, and 18 days after




**Nursery practice.** Until more effective pregermination treatments are developed, fall sowing of untreated seed immediately after collection is recommended. Germination is epigeous (figure 4). Vegetative propagation from root cuttings and suckers is also possible (Dirr and Heuser 1987).

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Rhamnaceae—Buckthorn family

# *Ziziphus* P. Mill.

## jujube

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**Growth habit and occurrence.** There are about 100 species of this genus, which is composed of trees, shrubs, and lianas found chiefly in the tropical and subtropical regions of the world (Johnston 1963). There are 7 species native to the United States and Mexico, but none of them are of economic importance (Lyrene 1979). However, 2 exotic species, which are small deciduous trees, have been planted in this country for fruit production, wildlife food, and watershed protection (table 1). Common jujube—*Ziziphus jujuba* Mill.—the most commonly planted species, may grow to heights of 15 m at maturity (Vines 1960). This species has been cultivated for about 4,000 years in China and grown in this country for over 150 years (Bonner and Rudolf 1974; Lyrene 1979; Mowry and others 1953). Both common jujube and Christ-thorn—*Z. spina-christi* Willd.—are highly valued for fruit production and numerous agro-forestry uses in Africa and Asia (Von Carlowitz 1986), where there are many selected cultivars.

**Flowering and fruiting.** The perfect, yellow flowers of common jujube appear in March to May in the United States, and the reddish-brown fruits mature from July to November. The fruits are globose to slender, fleshy drupes, which turn from green to dark reddish brown at maturity. If left on the tree, the fruits will turn black (Bailey 1939; Vines 1960). Common jujube drupes are oblong and 2.5 to 5 cm in length. They contain a 2-celled and 2-seeded pointed stone that is deeply furrowed, reddish brown to deep gray, oblong, and 2 to 2.5 cm long (figure 1) (Bonner and Rudolf 1974; Mowry and others 1953). Trees bear fruit as early as 1 to 4 years after planting (Lyrene 1979). Good crops are borne annually, and although they are popular for human consumption in Asia and Europe, the fruits from trees grown in the United States have apparently not been as edible. The crisp flesh of common jujube is whitish in color and has a sweet to subacid taste (Mowry and others 1953; Goor 1955; Vines 1960).

**Collection, extraction, and storage.** Jujube drupes may be picked by hand or flailed onto canvas sheets in the fall. Stones can be depulped by running them through a macerator with water and floating off the pulp. The cleaned stones are used as seeds. Seed yields are as follows (Goor 1955; Bonner and Rudolf 1974):

| | Common jujube | Christ-thorn |
|---|---|---|
| **Cleaned seeds/weight of drupes—kg/45 kg (lb/100 lb)** | 12–16 (25–35) | — |
| **Cleaned seeds/weight—kg (lb)** | 1,650 (750) | 1,500 (680) |

No conclusive storage data are available for this genus, but dry storage at room temperature has been successful for Christ-thorn (Goor 1955). Because these seeds appear to be orthodox, storage at low moisture contents at 5 °C is suggested.

**Pregermination treatments.** Jujube seeds are moderately dormant and require treatment for prompt germination. Stratification recommendations for common jujube are 60 to 90 days in moist sand at 5 °C (Bonner and Rudolf 1974) or 3 months warm incubation, followed by 3 months cold stratification (Dirr and Heuser 1987). Some growers recommend scarification in sulfuric acid for 2 to 6 hours, followed by stratification at 5 °C for 60 to 90 days (Lyrene 1979). Very

**Table 1**—*Ziziphus*, jujube: nomenclature and occurrence

| Scientific name | Common name(s) | Occurrence |
|---|---|---|
| ***Z. jujuba*** **Mill.** | **common jujube,** jujube, Chinese date | Native to Asia, Africa, & SE Europe; planted in S US from Florida to California; naturalized along Gulf Coast from Alabama to Louisana |
| ***Z. spina-christi*** **Willd.** | **Christ-thorn** | Native to arid & semi-aridregions of Africa & W Asia; planted in SW US |

**Sources:** Bonner and Rudolf (1974), Vines (1960).

prompt germination was obtained for seeds of Christ-thorn in Israel by soaking them for 2 days in water at 21 to 38 °C. Shorter or longer periods were not as successful (Gindel 1947).

**Germination tests**. Germination tests with seeds treated as described above are summarized in table 2.

**Nursery practice.** Untreated stones of common jujube can be sown in drills in the fall; stones stratified for 90 days may be sown in the spring. They should be covered with 2.5 cm (1 in) of soil (Bonner and Rudolf 1974). In Israel, 2 days of water-soaking prior to sowing has been recommended for Christ-thorn (Gindel 1947). Intact drupes may also be sown in the nursery (Goor 1955). Germination is epigeal. Vegetative propagation is possible by root cuttings (Dirr and Heuser 1987).

**Figure 1**—*Ziziphus jujuba*, common jujube: longitudinal section through 2 seeds in a stone (**left**), exterior view of a seed after removal from a stone (**center**), exterior view of a seed (**right**).

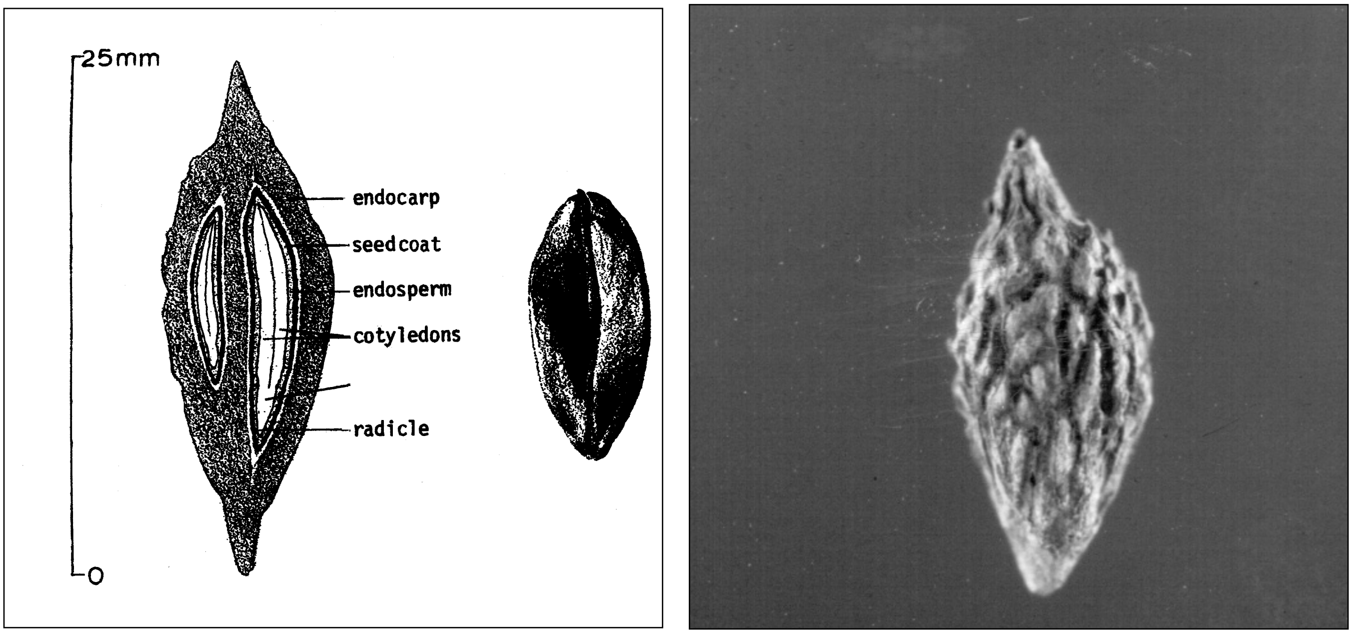


**Table 2**—*Ziziphus*, jujube: germination test conditions and results

| | Germination test conditions | | | | Germination rate | | Germination % | |
|---|---|---|---|---|---|---|---|---|
| | | Temp (°C) | | | Amt | | Avg | |
| Species | Medium | Day | Night | Days | (%) | Days | (%) | Samples |
| *Z. jujuba* | Sand | 30 | 21 | 50 | — | — | 31 | 2 |
| *Z. spina-christi* | — | 38 | 38 | 4 | 65 | 2 | 85 | 4 |

**Source:** Bonner and Rudolf (1974).

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Chenopodiaceae—Goosefoot family

# *Zuckia brandegei* (Gray) Welsh & Stutz ex Welsh

## siltbush

Nancy L. Shaw, Rosemary L. Pendleton, and Emerenciana G. Hurd

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**Other scientific names.** *Zuckia arizonica* Standley, *Atriplex brandegei* (Gray) Collotzi, *Grayia brandegei* (Gray).

**Other common names.** spineless hopsage, apple-bush, saltbush.

**Growth habit, occurrence, and use.** Siltbush is an autumn-deciduous shrub or sub-shrub ranging from 0.1 to 0.8 m in height (Goodrich and Neese 1986). Stems of the current year are thornless and erect or ascending, branching from a persistent, woody base. Leaves are gray-scurfy and entire to lobed. Overwintering leaf buds are prominent, axillary, and globose (Welsh and others 1987).

A narrowly distributed edaphic endemic, siltbush is largely restricted to the Colorado River drainage of central and eastern Utah and northeast Arizona, southwest Wyoming, western Colorado, and northwest New Mexico (Smith 1974; Stutz and others 1987; Welsh and others 1987). It grows in isolated monotypic populations on weathered, often saline or seleniferous, fine-textured to sandy substrates in desert shrub to lower juniper communities at elevations from 1,280 to 2,240 m (Goodrich and Neese 1986). Although a poor competitor, siltbush is a stress-tolerant species capable of surviving on sites unfavorable for establishment of other species and enduring long periods of adverse environmental conditions. It is a potential revegetation species for mined lands and other disturbed sites within its native range (Pendleton and others 1996).

**Geographic races and hybrids.** Type specimens of *Zuckia brandegei* were originally described as *Grayia brandegei* Gray (Gray 1876). Stutz and others (1987) later identified 2 chromosome races. Diploid populations (2X = 18) are small plants with narrow, linear leaves that are mostly restricted to south-central Utah and northeastern Arizona. Tetraploids (4X = 36) are larger plants with large ovate to lanceolate leaves that occur primarily as isolated populations in northeastern Utah, south-central Wyoming, eastern Colorado, and northwestern New Mexico. Based on distribution patterns and interpopulation differences, Stutz and others (1987) suggested that the larger plants may be autotetraploids of polyphyletic origin and designated them *G. brandegei* A. Gray var. *plummeri* Stutz and Sanderson var. nov. in honor of A. P. Plummer, pioneer shrub scientist.

Welsh (1984) and Welsh and others (1987) transferred *G. brandegei* to the genus *Zuckia*, renaming it *Z. b.* (Gray) Welsh & Stutz ex Welsh var. *brandegei* and reduced *Z. arizonica* Standley, the only species previously in the genus, to *Z. b.* Welsh & Stutz ex Welsh var. *arizonica* (Standley) Welsh. *Z. b.* var. *arizonica* is diploid (Sanderson 2000) and is found in scattered populations from northern Arizona to northeastern Utah (Goodrich and Neese 1986). Dorn (1988) later transferred *G. b.* var. *plummeri* to *Z. b.* var. *plummeri* (Stutz & Sanderson) Dorn. Transfers from *Grayia* to *Zuckia* were made on the basis of fruit morphology, branching pattern, and pubescence type. Goodrich and Neese (1986) concurred with these distinctions but with the reservation that *Grayia* "could logically be expanded to include *Zuckia*."

Naturally occurring hybrids of siltbush with shadscale (*Atriplex confertifolia* (Torr. And Frem.) Wats.) and Castle Valley clover (*A. gardneri* (Moq.) D. Dietr. var. *cuneata* (A. Nels.) Welsh) were reported by Drobnick and Plummer (1966). Blauer and others (1976) obtained viable seeds, but no seedlings, by artificially pollinating pistillate flowers of fourwing saltbush with tetraploid siltbush pollen.

**Flowering and fruiting.** All siltbush varieties are monoecious and heterodichogamous (Pendleton and others 1988). Plants are protogynous (producing pistillate, then staminate flowers) or protandrous (producing staminate, then pistillate flowers) in about equal numbers. Within each plant, temporal separation of pistillate and staminate phases is nearly complete, generally precluding self-fertilization.

Staminate flowers each consist of 4 or 5 stamens and a 4- or 5-lobed perianth. They develop in clusters of 2 to 5 in bract axils (Goodrich and Neese 1986; Welsh and others 1987). Pistillate flowers are 1 to several in bract axils with each enveloped by 2 united bracts. The bracts are either dorsiventrally flattened and unequally 6-keeled with the seed horizontal (*Z. b.* var. *arizonica*) (figures 1 and 2) or obcompressed and thin-margined with the seed vertical (*Z. b.* var. *bradegei* and *Z. b.* var. *plummeri*) (Goodrich and Neese 1986; Welsh and others 1987) (figures 1 and 2). Plants of all varieties flower in late spring or summer and fruits ripen in mid to late summer or fall (Blauer and others 1976; Pendleton and others 1988) (table 1).

Protogynous plants generally produce more seeds, but protandrous plants may be equally productive in wet years or in years with low seed predation (Pendleton and others 2000). Fruits are dispersed slowly, with some usually remaining dormant on the plant through winter (Blauer and others 1976). Seeds are light yellowish brown at maturity (Hurd and Pendleton 1999) (figure 3). The outer layer of the seedcoat is elastic when imbibed. The embryo is well developed, with pale yellow cotyledons and an elongate, inferior radicle encircling the perisperm (figure 3). Seedling development is epigeal (figure 4).

**Collection of fruits and seed extraction and cleaning.** Fruits are collected by hand- stripping or beating and air-dried. Coarse debris may be removed with an air-screen machine or a seed blower, or by screening. Careful rubbing to remove bracts prevents radicle damage. The final product may consist of debracted utricles (Meyer and Pendleton 1990; Pendleton and Meyer 1990) or seeds (figure 3). Weight of bracted utricles and seeds and seed fill data are provided in table 2.

**Figure 1**—*Zuckia brandegei*, siltbush: bracted utricles.

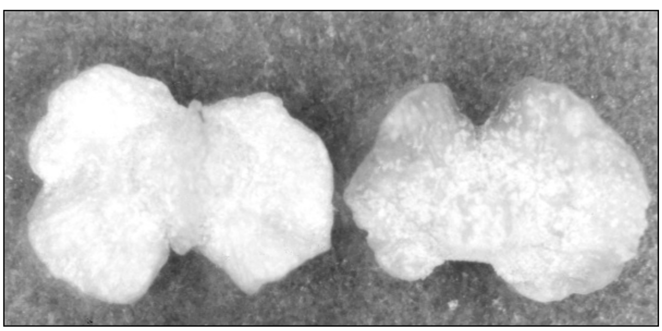
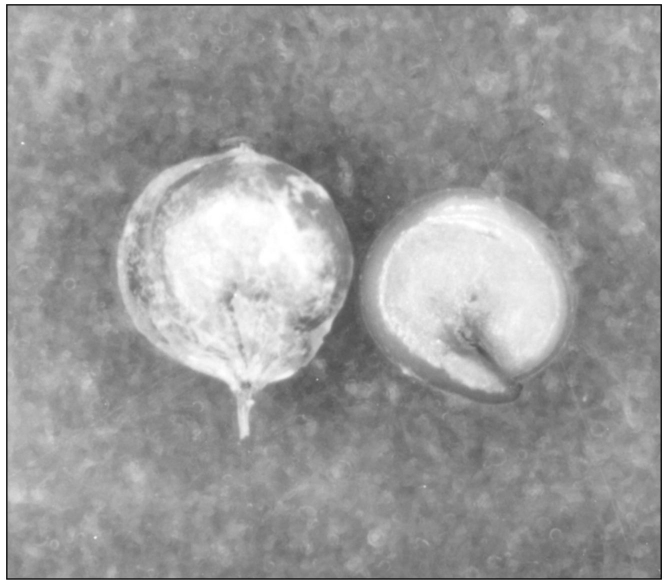


**Figure 2**—*Zuckia brandegei*, siltbush: utricle (**left**) and seed (**right**)



**Storage.** Germination of seeds incubated at 1 to 3 °C in constant darkness was 87% after 2 years of storage in cloth bags in a warehouse (Stevens and Jorgensen 1994; Stevens and others 1981). Germination from year 2 to year 4 was 88%, dropping to 57% by year 5, 13% by year 7, and 0% after 15 years. Viability of bracted utricles stored in paper bags at room temperature and debracted utricles from the same collection stored in a freezer at – 80 °C was 97% after 7 years as determined by tetrazolium chloride testing (Hurd and Pendleton 1994).

**Pregermination treatments**. Germination experiments have been conducted with seeds of *Z. b.* var. *brandegei* and *Z. b.* var. *plummeri*. Seeds of warm-winter populations may germinate opportunistically over a wide range of

**Table 1**—*Zuckia brandegei*, siltbush: phenology of flowering and fruiting

| Species | Location | Flowering | Fruit ripening | Seed dispersal |
|---|---|---|---|---|
| *Z. brandegei* | Central Utah | Mid-June–mid-Aug | Late Sept–early Oct | Jan or later |
| | Uinta Basin, Utah | May–June | Sept | — |
| | Sanpete Co., Utah | Mid-May–July | July–late Sept | — |
| | — | — | Sept 10–Dec 15 | — |

**Sources:** Blauer and others (1976), Goodrich and Neese (1986), Pendleton and others (1988), Plummer and others (1968).

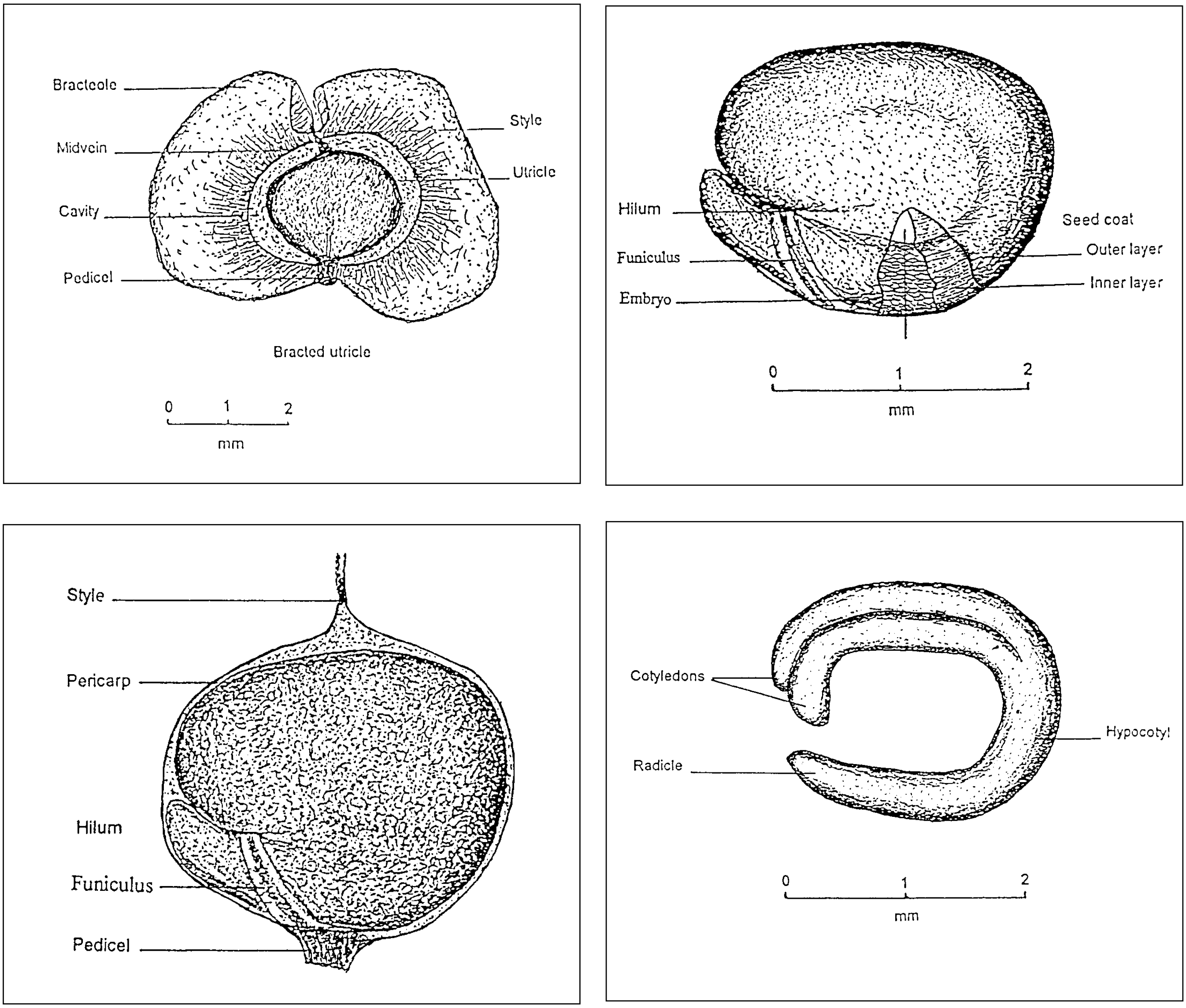



**Figure 3**—*Zuckia brandegei*, siltbush: bracted utricle (**top left**), seed (**top right**), utricle (**bottom left**), and embryo (**bottom right**).

constant temperatures (15 to 30 °C) when water is available (Meyer and Pendleton 1990). Seeds of cold-winter populations are dormant at fall and winter temperatures, germinating in early spring following exposure to overwinter chilling. Germination generally increased with duration of wet prechilling at 1 °C for up to 8 weeks, dry after-ripening for up to 14 months, or removal of bracts (Meyer and Pendleton 1990; Pendleton and Meyer 1990).

Techniques and criteria recommended for characterizing normal seedlings, excising embryos, and testing viability are as described for spiny hopsage (Shaw 1992):

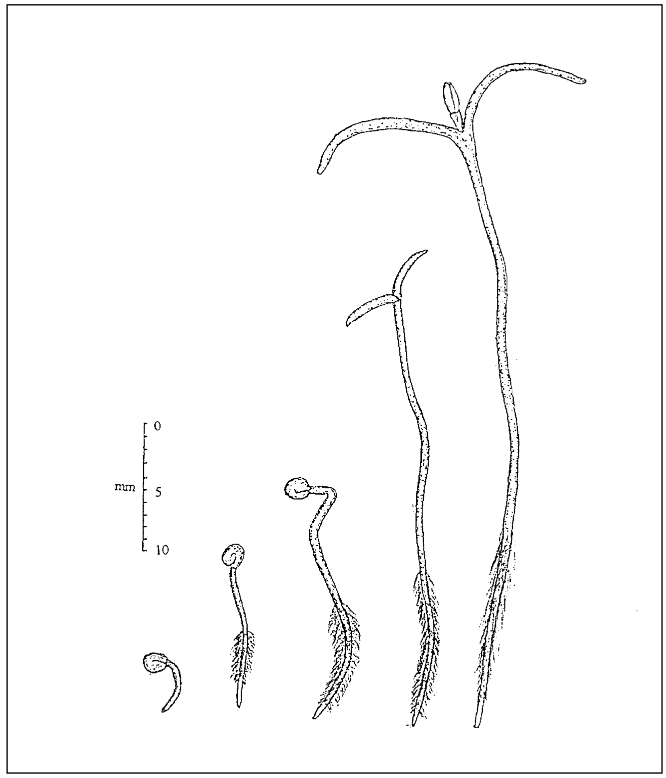
- Normal seedling—Epigeal, with thin, 10- to 15-mm-long hypocotyls; small, narrow cotyledons; short epicotyl; and well-developed root hairs (figure 4).
- Excised embryo—Seeds soaked in water at 28 °C for 12 hours and then drained can have their embryos excised with sharp needles; these embryos germinate rapidly at 15/5 or 15 °C and should be evaluated for presence of normal seedlings.
- Viability—Seeds soaked in water at 28 °C for 12 hours, and then drained can be pierced through the perisperm with a sharp probe or needle, then they are

**Table 2—*Zuckia brandegei*, siltbush: fruit and seed characteristics**

| Species | Bracted utricles (x1,000)/weight | | | | Seeds (x1,000)/weight | | | | Filled seed % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Average | | Range | | Average | | | |
| | /kg | /lb | /kg | /lb | /kg | /lb | /kg | /lb | Range | Average |
| *Z. brandegei* | 263–312 | 119–142 | 284 | 129 | 555–769 | 252–349 | — | — | 5–27 | 16 |
| *Z. brandegei* var. *arizonica* | 372–1,061 | 169–481 | 732 | 332 | 420–794 | 191–360 | 418–561 | 190 – 254 | 7–21 | 15 |

**Sources:** Pendleton and others (1988), Plummer and others (1968), Smith (1974).

**Figure 4**—*Zuckia brandegei*, siltbush: seedling development.




soaked in a 1% 2,3,5-triphenyl tetrazolium chloride solution for 4 to 8 hours at 28 °C; the seedcoat is translucent after soaking, making excision unnecessary for evaluation of staining.

**Nursery culture and direct seeding.** Because few data are available, recommendations for spiny hopsage (see Grayia, page 567) may be used as guidelines for establishing siltbush from seed. Based on studies conducted in south-central Utah, Monsen (1996) found that siltbush seedlings develop more rapidly than those of spiny hopsage. Root systems of bareroot stock are much more extensive after 1 growing season. Palatability is low to moderate (Monsen 1996; Stutz 1995). Plants may attract rodents, other small animals, and occasionally deer.

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