Ericaceae—Heath family

Vaccinium L.

blueberry, cranberry

Jason J. Griffin and Frank A. Blazich

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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.** *V. lamarckii* Camp *V. nigrum* (Wood) Britt. *V. angustifolium* var. *hypolasium* Fern. var. *laevifolium* House var. *nigrum* (Wood) Dole var. *brittonii* Porter ex Bickn.	**lowbush blueberry,** late sweet blueberry, low sweet blueberry	18 ± 9	Labrador & Newfoundland; W to Manitoba & Minnesota; S to Illinois, Delaware, & Pennsylvania; mtns of Virginia & West Virginia
***V. arboreum* Marsh.** *V. arboreum* var. *glaucescens* (Greene) Sarg. *Batodendron andrachniforme* Small *Batodendron arboreum* (Marsh.) Nutt.	**sparkleberry,** farkleberry	311 ± 102	Virginia to central Florida, W to E Texas, central Oklahoma & SE Mississippi
***V. corymbosum* L.** *V. constablaei* Gray *V. corymbosum* var. *albiflorum* (Hook.) Fern. *V. corymbosum* var. *glabrum* Gray *Cyanococcus corymbosus* (L.) Rydb. *Cyanococcus cuthbertii* Small	**highbush blueberry,** American blueberry, 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.** *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.** *V. angustifolium* var *myrtilloides* (Michx.) House *V. canadense* Kalm ex A. Rich. *Cyanococcus canadensis* (Kalm ex A. Rich) Rydb.	**Canadian blueberry,** velvet-leaf blueberry, velvetleaf huckleberry, sour-top blueberry	35 ± 14	Central Labrador to Vancouver Island, Northwest Territories SE to Appalachian Mtns
***V. ovatum* Pursh.**	**California huckleberry,** evergreen huckleberry, shot huckleberry	82 ± 42	Pacific Coast, British Columbia to California
***V. oxycoccos* L.** *V. palustre* Salisb. *Oxycoccus palustris* Pers. *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.** *V. virgatum* var. *ozarkense* Ashe *V. virgatum* var. *speciosum* Palmer *V. parviflorum* Gray; *V. amoenum* Ait. *V. ashei* Rehd.; *V. corymbosum* var. *amoenum* (Ait.) Gray *Cyanococcus virgatus* (Ait.) Small *Cyanococcus amoenus* (Ait.) Small	**rabbiteye blueberry,** 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**).

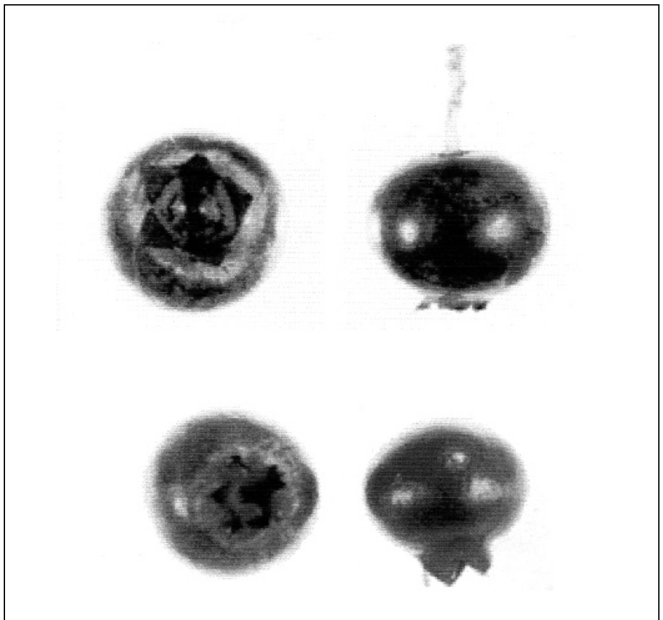


Table 3—*Vaccinium,* blueberry and cranberry: fruit and seed sizes of cultivated species

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

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 μm 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 μm 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**).

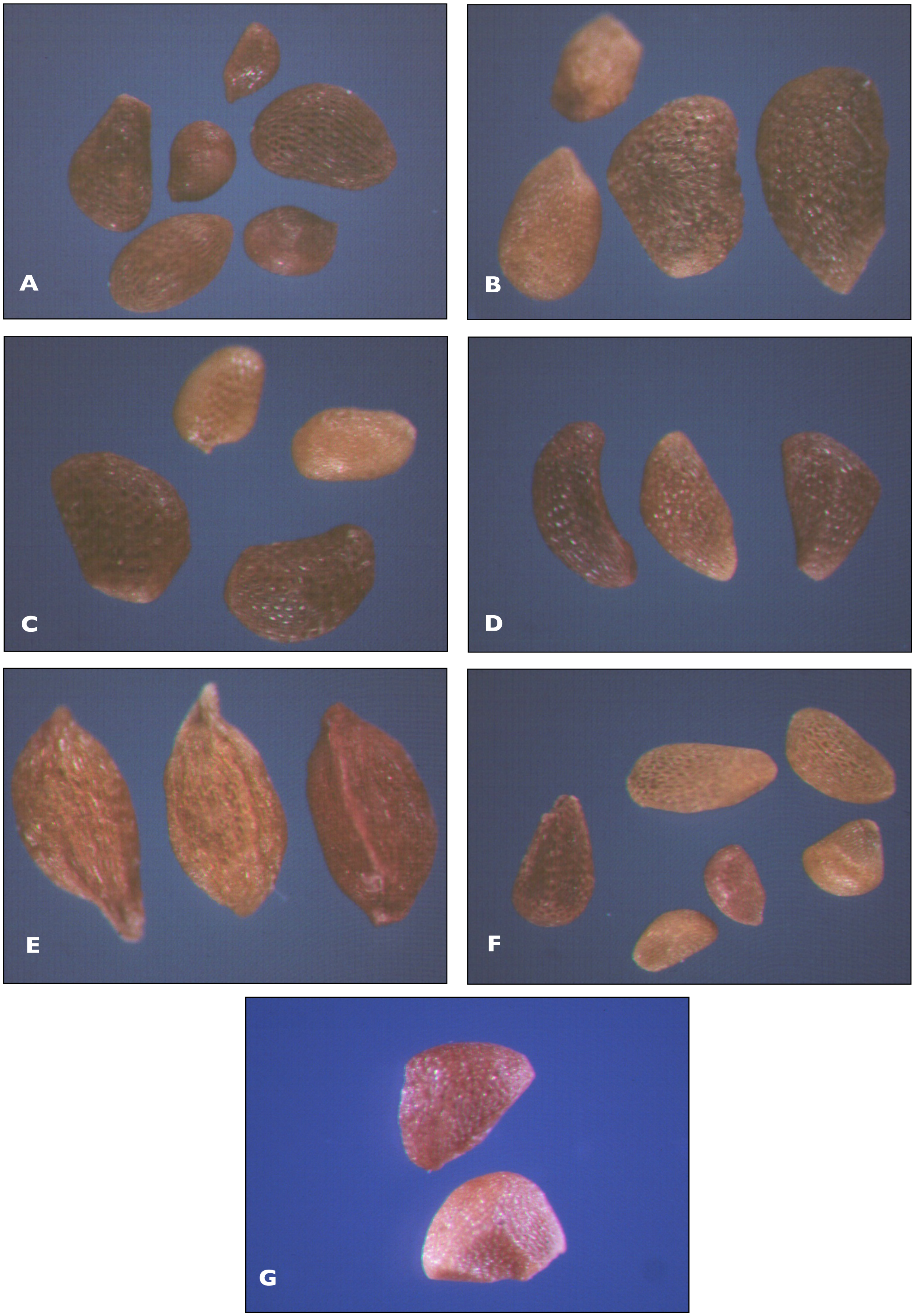
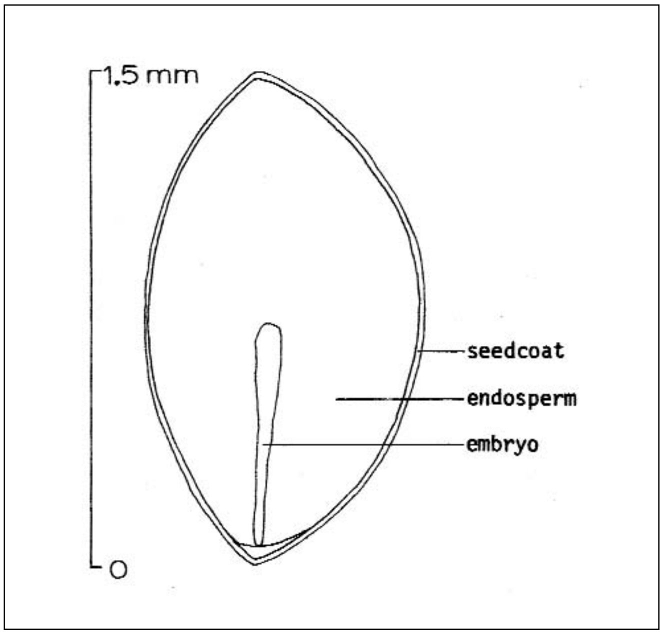


Figure 3—*Vaccinium corymbosum*, highbush blueberry: longitudial section of a seed.



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Euphorbiaceae—Spurge family

Vernicia fordii (Hemsl.) Airy-Shaw

tung-oil tree

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Synonyms. *Aleurites fordii* Hemsl.

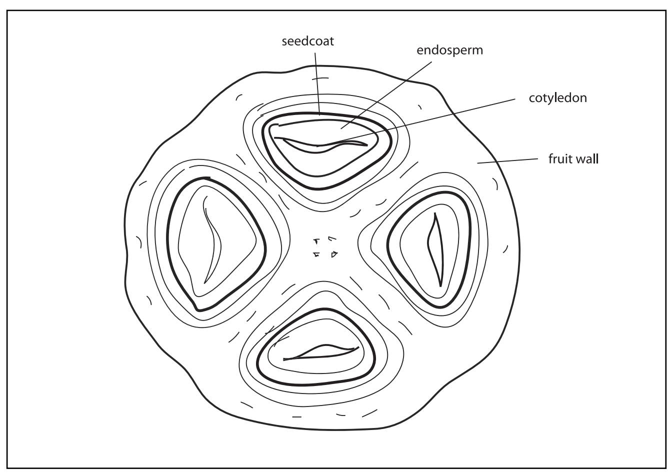
Occurrence and uses. Tung-oil tree—*Vernicia fordii* (Hemsl.) Airy-Shaw—is a native of central Asia. The species was introduced into the southern United States in 1905 as a source of tung oil (a component of paint, varnish, linoleum, oilcloth, and ink) that is extracted from the seeds. The use of this 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).

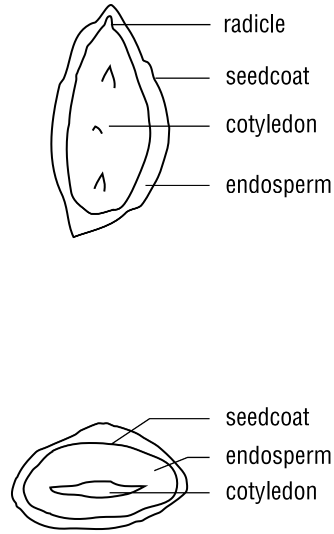
Figure 2—*Vernicia fordii*, tung-oil tree: cross-section of a fruit (adapted from McCann 1942).



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.** *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.** *V. alnifolium* Marsh. *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.** *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** *V. opulus* var. *amerieanum* Ait. *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** *V. affine* Bush ex Schneid. *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.

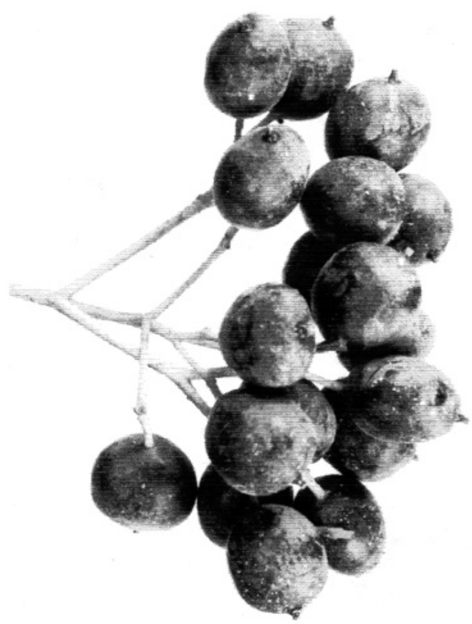


Table 2—*Viburnum,* viburnum: phenology of flowering and fruiting

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**).

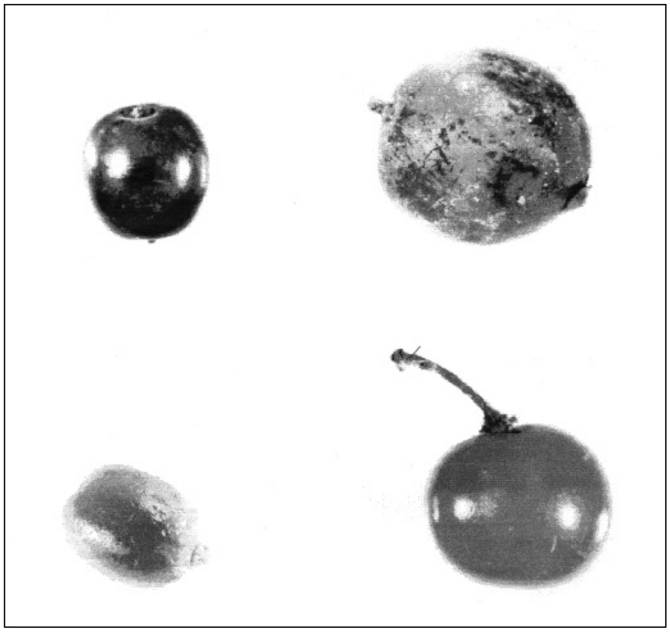


Figure 3—*Viburnum*, viburnum: cleaned seeds (stones) of (**top left to right**) *V. acerifolium*, mapleleaf viburnum; *V. lantanoides*, hobblebush; *V. nudum* var. *cassinoides*, witherod viburnum; *V. dentatum*, southern arrowwood; *V. lantana*, wayfaringtree; and (**bottom left to right**) *V. lentago*,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

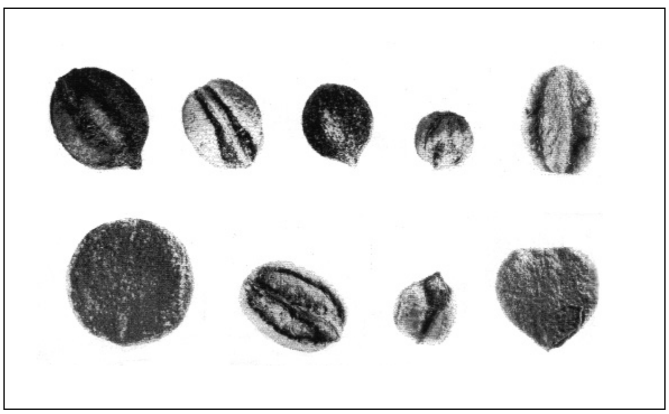
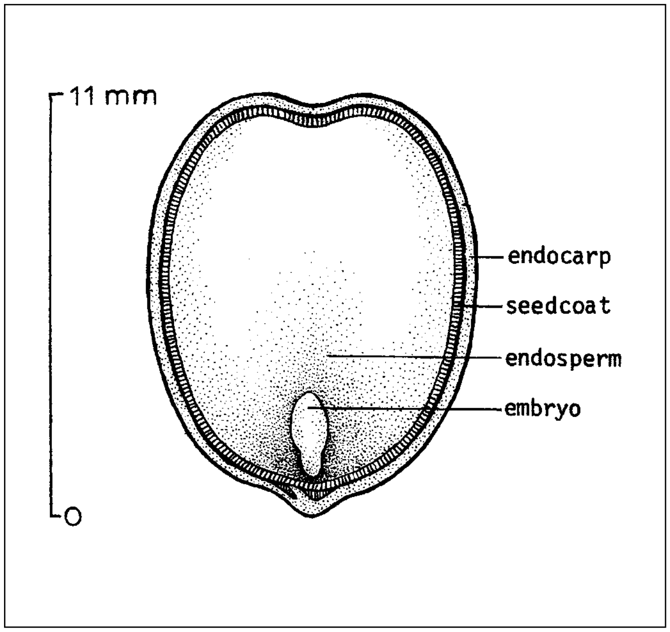


Figure 4—*Viburnum lentago*, nannyberry: longitudinal sections through a stone.



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 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).

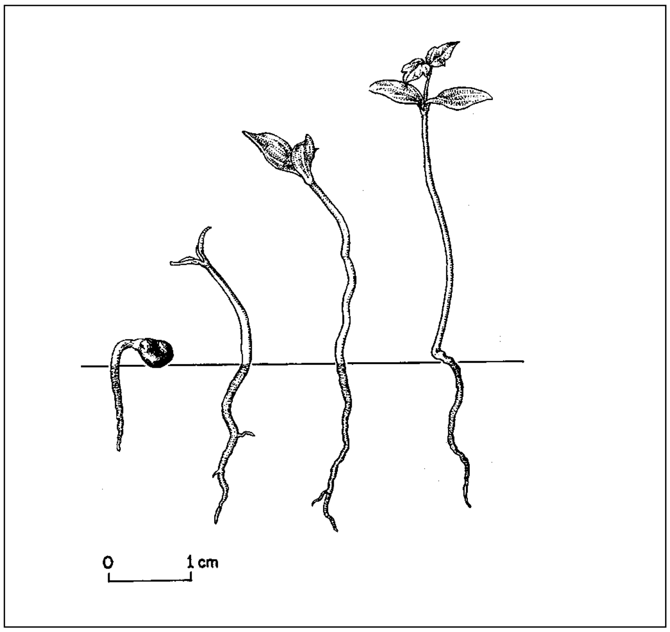
Nursery practice. The warm-cold stratification sequence (table 5) can be accomplished in nurserybeds. Seeds or intact drupes can be sown in the spring, to allow a full summer for root development (figure 6). The ensuing winter temperatures will provide the cold stratification needed to break epicotyl 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)	Cold period† (second stage)	Germination test duration‡	Germination percentage Avg (%)	Samples
V. acerifolium	180–510	60–120	60+	32	5
V. dentatum§	0	0	60	—	—
V. lantanoides	150	75	100	43	3
V. lentago	150–270	60–120	120	51	3
V. nudum var. *cassinoides*	60	90	120	67	2
V. opulus	60–90	30–60	60	60	3+
V. prunifolium	150–270	30–60	60+	75	2
V. rafinesquianum	360–510	60–120	—	—	—
V. recognitum	360–510	75	60+	69	2
V. rufidulum	180–360	0	—	—	—

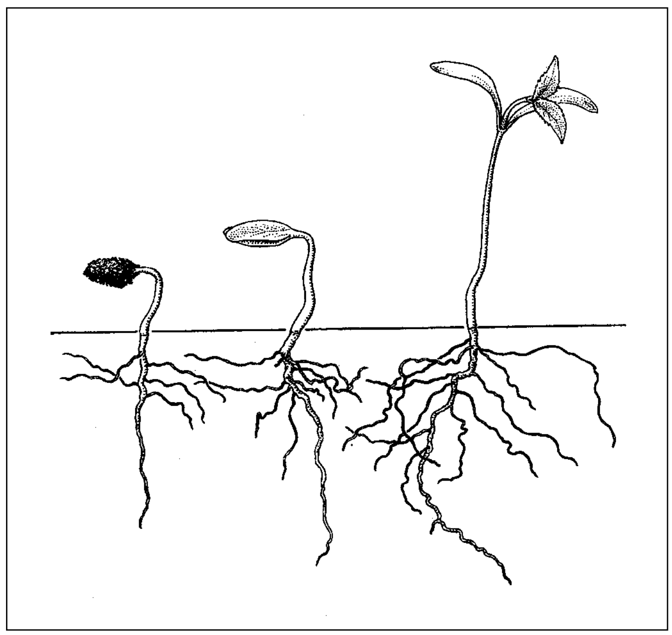
Sources: Gill and Pogge (1974), Vines (1960).
* Seeds in a moist medium were exposed to diurnally alternating temperatures of 30/20 °C or 30/10 °C, but a constant 20 °C was equally effective for most species (Barton 1958).
† Seeds and medium were exposed to constant temperature of 5 or 10 °C. Temperatures of 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/m^2 (20/ft^2) (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).

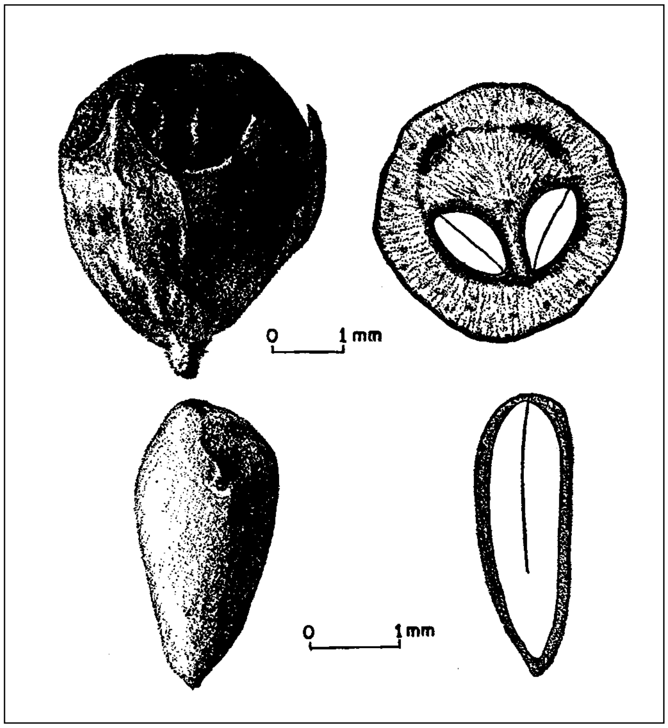
Varieties. Typical plants of the species have lavender flowers, but several other varieties have been cultivated in the United States (Rehder 1940; Dirr 1990). White chastetree, var. *alba* West., has white flowers. Hardy lilac chastetree, var. *latifolia* (Mill.) Loud., is characterized by broader leaflets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



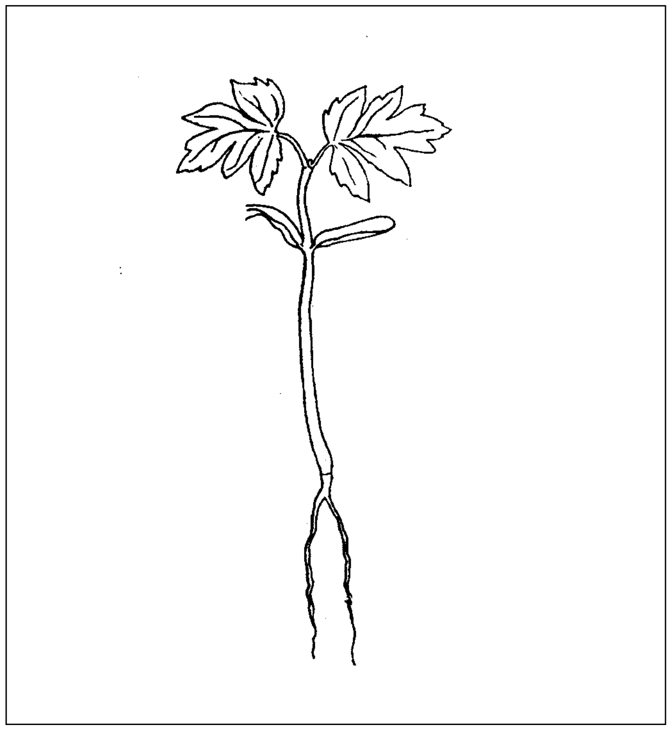
cleaned seed/45 kg of ripe fruit (75 lb/100 lb). Number of cleaned seeds varied from 74,800 to 130,000/kg (34,000 to 59,000/lb) in 4 samples (Schopmeyer 1974). Purity in 2 samples was 80%, and average soundness in 4 samples was 55%. In one test, seeds stored in moist sand and peat at 5 °C or 1 year showed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

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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.

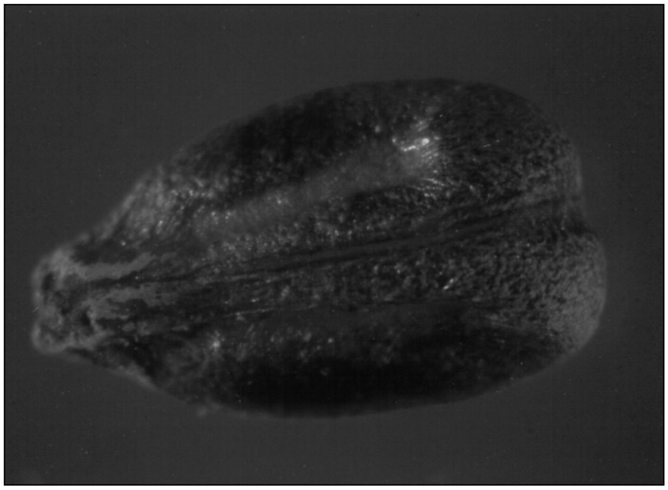
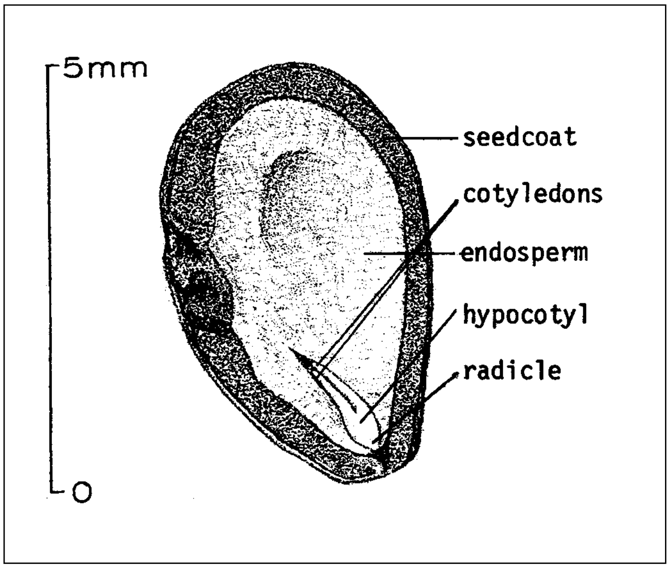


Figure 2 —*Vitis labrusca*, fox grape: longitudinal section through a seed.



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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