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.

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

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

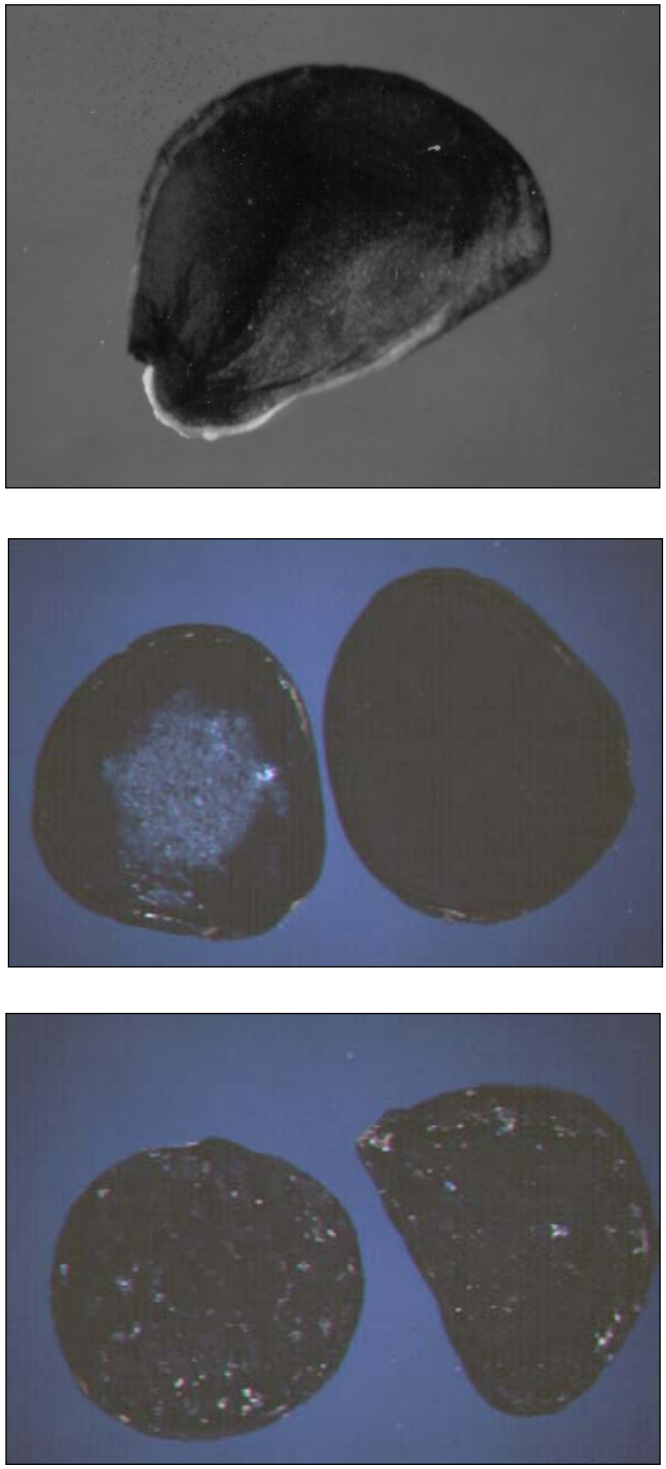
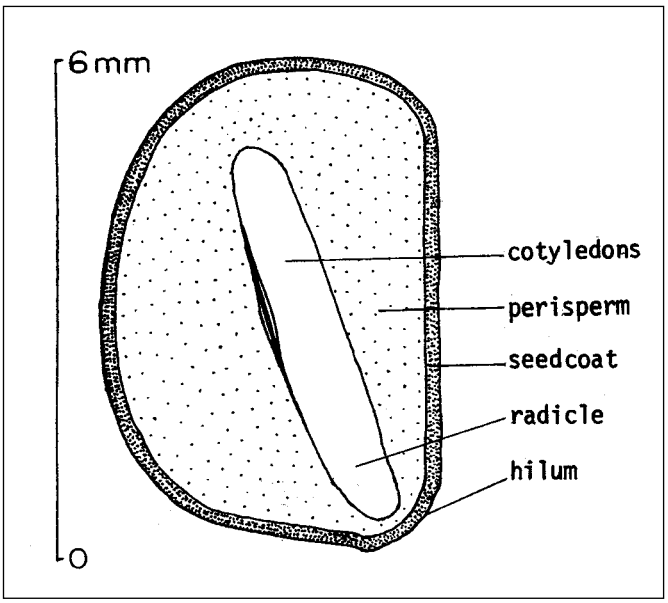


Table 2—*Yucca,* yucca: phenology of flowering and fruiting

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

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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).

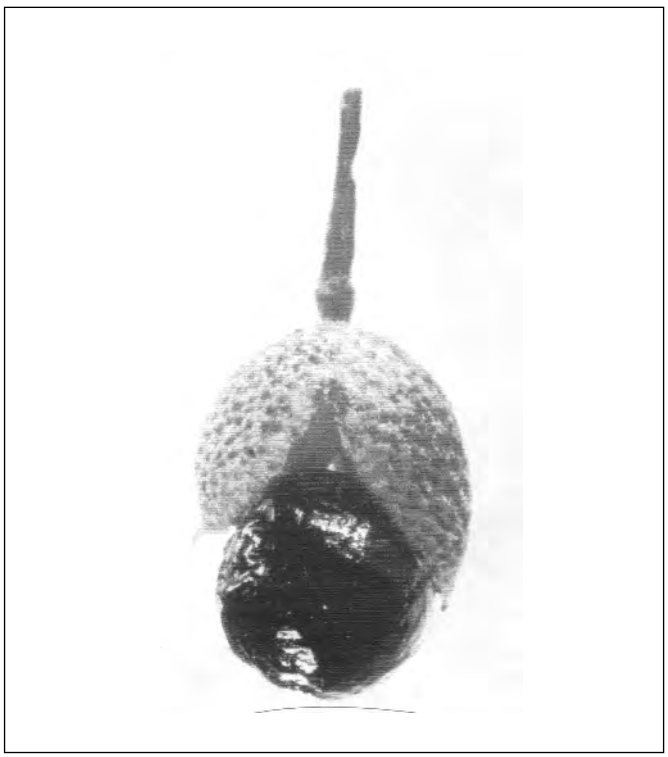
Figure 1—*Zanthoxylum clava-herculis*, Hercules-club: cluster of mature fruits.

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.



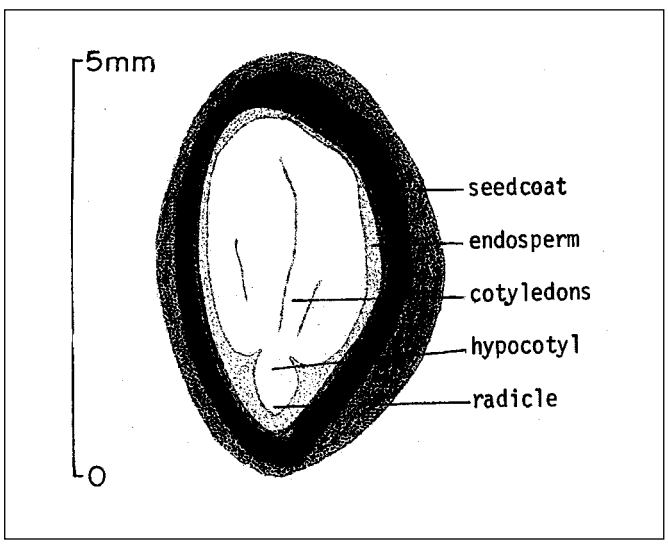
Germination. Seeds of common prickly-ash and Hercules-club exhibit strong dormancy, apparently imposed by the seedcoat. Scarification with concentrated sulfuric acid for 2 hours at about 21 °C has given fair results for Hercules-club, and stratification in moist sand for 120 days at 5 °C has helped germination 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**).



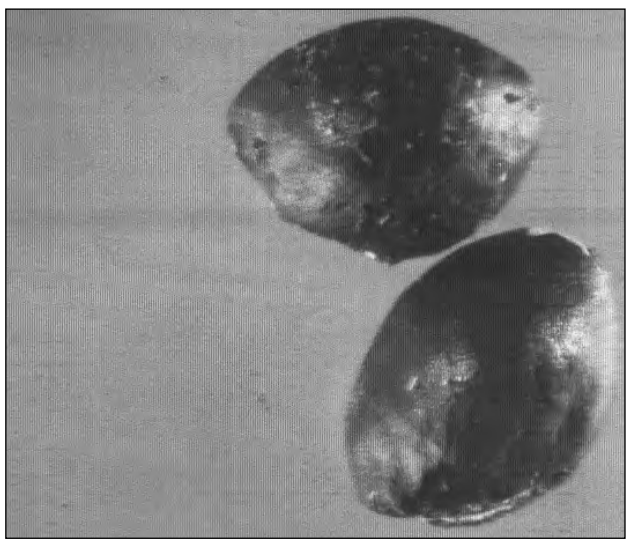


Table 3—*Zanthoxylum,* prickly-ash: seed data

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).

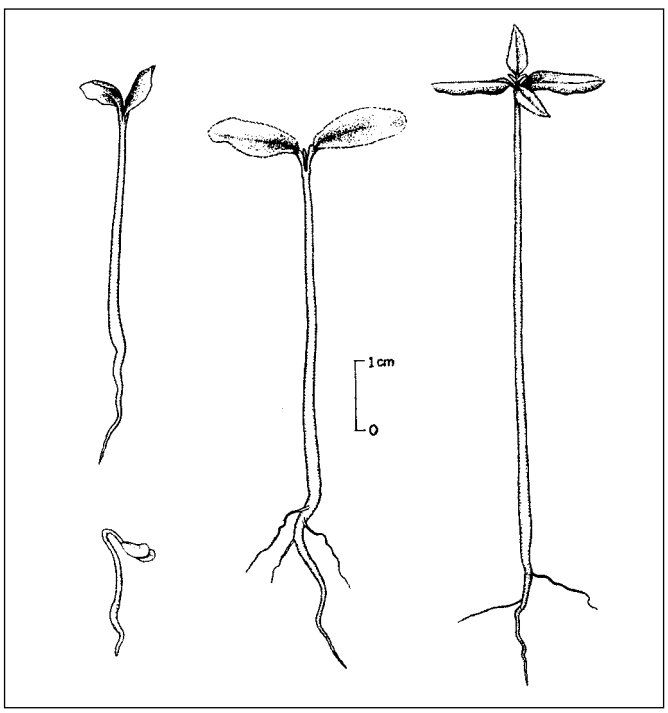
Table 4—*Zanthoxylum,* prickly-ash: germination test conditions and results

Species	Pregermination treatment	Germination test conditions: Daily light (hr)	Medium	Temp (°C): Day	Temp (°C): Night	Days	Germination rate: Amt (%)	Germination rate: Days	Germination %: Avg (%)	Germination %: 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 agroforestry 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**).

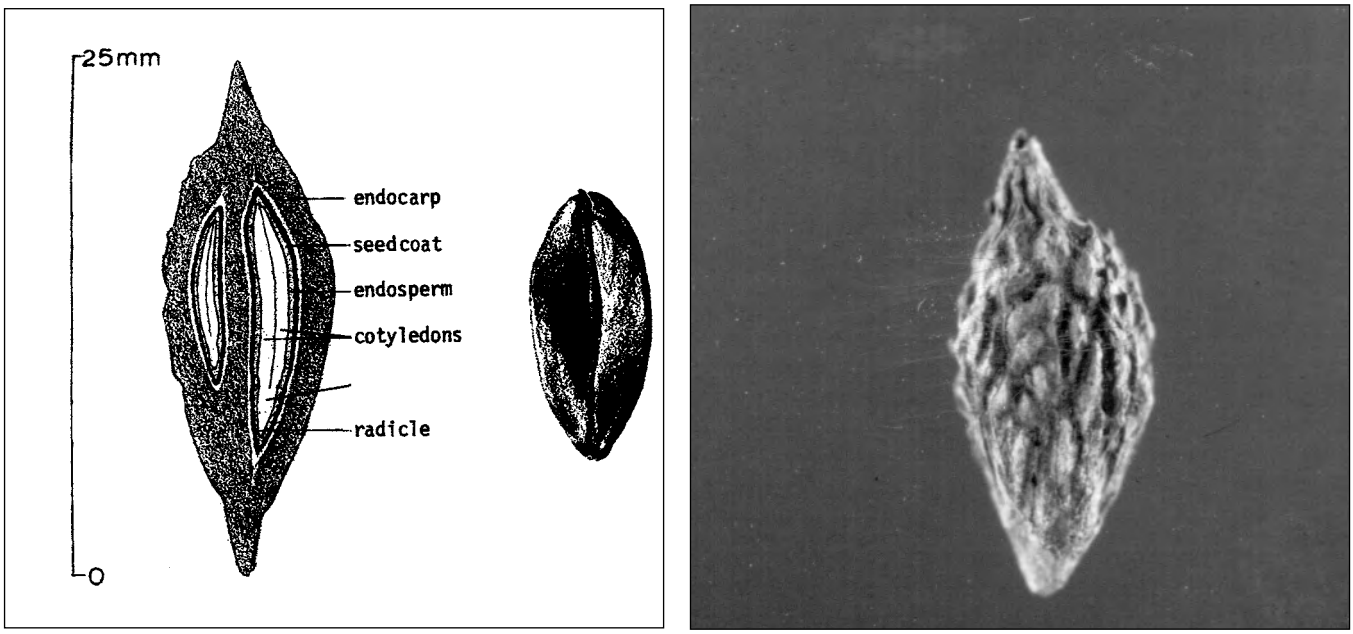

Table 2—*Ziziphus*, jujube: germination test conditions and results

	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

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

Other common names. spineless hopsage, applebush, 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.