Simmondsiaceae—Jojoba family

Simmondsia chinensis (Link) Schneid.

jojoba

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Other common names. goatnut.

Growth habit, occurrence, and use. The Simmondsiaceae *(*jojoba family), has only 1 genus, *Simmondsia,* which consists of only 1 species, jojoba—*S. chinensis* (Link) Schneid. Once considered an isolated member of the box family (Buxaceae), jojoba is now regarded as sufficiently distinct to be placed in its own family. Jojoba is found from coastal and cis-montane southern California east to central Arizona and south to Sonora and Baja California (Munz 1974; Yermanos 1974). It is a characteristic plant of upland shrub communities in the Sonoran and Colorado Deserts and is also quite common as a component of chaparral.

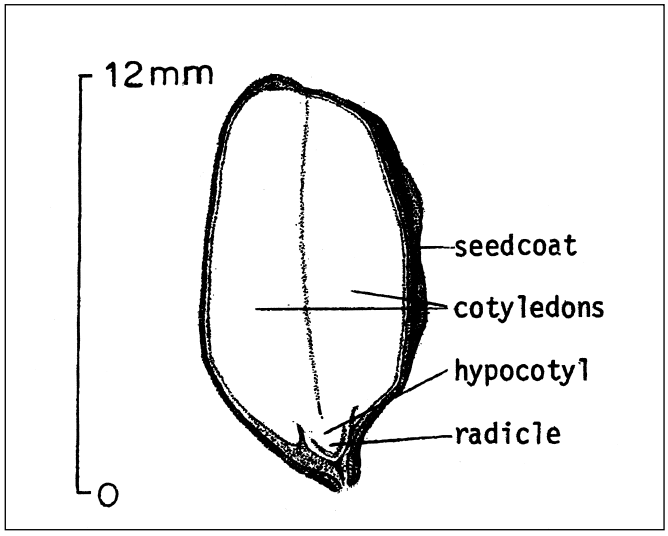
Jojoba is a sparsely branched, decumbent to erect shrub that grows to 2 or rarely 3 m in height. Its large (2- to 4-cm-long), opposite, entire leaves are evergreen, leathery, and dull gray. Plants are extremely tolerant of drought (Al-Ani and others 1972) and their foliage is a source of nutritious forage for sheep, goats, and cattle, as well as for wild ungulates and smaller browsers such as rabbits. The large seeds have been used locally as a food source by indigenous people (Brooks 1978).

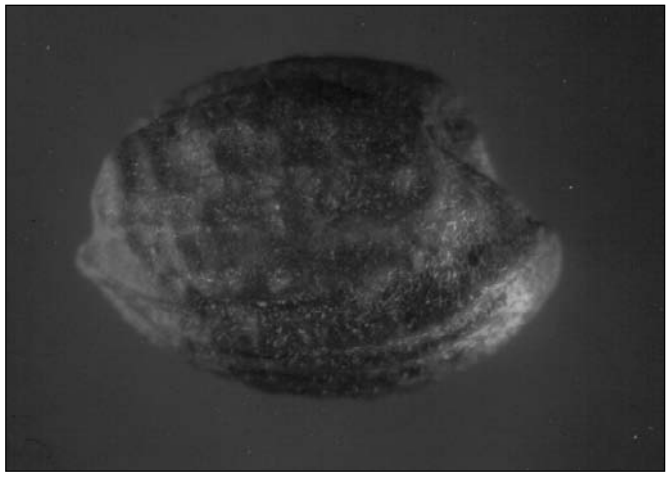
The most noteworthy feature of jojoba from a human perspective is the unusual liquid wax that makes up the storage reserve of its seeds. This substance, a fatty acid ester of a long-chain alcohol, is unique in the plant kingdom. It has chemical and rheological properties similar to those of sperm whale oil, which make it useful in a host of applications (Brooks 1978). Interest in commercial production of jojoba seed was greatly increased in the mid-1970s, when import of sperm whale oil into the United States was banned. First efforts were focused on harvesting seeds from wildland stands, but it was soon realized that for cost-effective production, cultivation in an agronomic setting would be necessary (Foster 1980; Yermanos 1979). Since that time, jojoba has been successfully cultivated in many semi-arid regions of the world (Ismail 1988; Kumari and others 1991; Milthorpe 1989; Muthana 1981; Nimir and Ali-Dinar 1991), where it has the advantage of low water requirements and the ability to grow on agriculturally marginal land. Selection on natural variability and breeding have given rise to improved cultivars (Dunstone 1990, 1991; Palzkill and others 1989).

Flowering and fruiting. Jojoba is dioecious and relies on wind for successful pollination (Niklas and Buchmann 1985). The flowers, which are greenish yellow, inconspicuous, and without petals, are borne in the axils of the leaves. The male flowers are clustered at the nodes, and the female flowers are usually borne singly. Flowering occurs in March through May in response to winter rains. Plants of most populations appear to have a short (2-week) vernalization requirement for induction of flowering (Nord and Kadish 1974). Under plantation conditions, jojoba usually begins producing seeds the second or third year after planting (Nord and Kadish 1974; Yermanos 1974). Seeds ripen during the summer. The endosperm is absent (figure 1), and the cotyledons (which function as the storage organs) contain about half of their weight as wax (Brooks 1978). Good seedcrops are produced at intervals of 2 to several years (Brooks 1978; Castellanos and Molina 1990). Some individuals appear to be genetically predisposed to be more productive than others, making selection for higher yield possible (Nord and Kadish 1974; Yermanos 1974).

The 1 to 3 large seeds are borne in a capsule that superficially resembles an acorn. This splits open apically and down the sides to release the seeds. As is the case with many large-seeded North American desert species, jojoba seeds are dispersed by scatter-hoarding rodents that are also their principal consumers (Castellanos and Molina 1990). Sherbrooke (1976) reported that only 1 heteromyid species in southern Arizona—Bailey's pocket mouse (*Peragnathus baileyi*)—was able to utilize jojoba seeds. The seeds contain a unique toxic cyanogenic glucoside (simmondsin). He concluded that Bailey's pocket mouse had evolved a detoxifica-

Figure 1—*Simmondsia chinensis*, jojoba: longitudinal section through a seed (**top**) and exterior view of a seed (**bottom**).





tion mechanism, enabling it to eat the seeds without harm. The seeds are, however, not particularly toxic to humans.

Jojoba seedlings emerge in response to autumn, winter, or spring rains (Castellanos and Molina 1990; Sherbrooke 1977). Germination is hypogeal. Wildland stands are often strongly male-biased—sometimes as many as 4 males to 1 female—but in cultivation the sex ratio is more equal (Brooks 1978). Male plants are thought to be more stress-tolerant as seedlings and thus to have higher survival rates under natural conditions. Seedling survival depends principally on weather patterns (Castellanos and Molina 1990) but may be higher in the protection of nurse plants or other sheltering objects (Sherbrooke 1977).

Seed collection, cleaning, and storage. Seeds of jojoba are most readily collected by raking or vacuuming after they have fallen to the ground, but where rodents are active, seeds do not remain on the ground for long (Castellanos and Molina 1990). Also, the growth form may or may not be conducive to this activity, a problem that is solved in cultivation by bottom-pruning (Yermanos 1974). For small lots, seeds can be collected by beating the branches over a hopper or by hand-stripping them when still slightly green, the "hard-dough" stage (Nord and Kadish 1974). Seeds picked green should be allowed to dry in a shady, well-ventilated area. A pneumatic device has been developed for commercial harvest (Coates and Yacizi 1991). If collected intact, the capsules may be broken up using a barley de-bearder or hammermill. The seeds can then be cleaned of debris and unfilled seeds in a conventional fanning mill or air-screen cleaner. The purity and viability of cleaned seedlots are usually high (Nord and Kadish 1974).

Jojoba seeds are quite variable in size, both within and among seedlots (Yermanos 1979). Nord and Kadish (1974) report an among-lot mean seed weight range of 660 to 3,300/kg (300 to 1,500/lb). Ismail (1988) sorted seeds of a single lot into 3 size classes with the following mean values:

	Seeds/weight		Length	
	/kg	/lb	cm	in
small	2,300	1,045	0.93	1/3
medium	1,300	590	1.38	1/2
large	1,060	480	1.84	3/4

Castellanos and Molina (1990) reported an even wider spread in the size of viable seeds, 670 to 20,000/kg (305 to 900/lb). Jojoba seeds lose viability relatively rapidly in laboratory storage at room temperature (from 100% to <60% after 2 years), but they are apparently still orthodox in storage behavior. When stored at low moisture content and temperature (3 °C), seedlots have retained high viability for 10 to 12 years (Nord and Kadish 1974). Under natural conditions, jojoba seeds do not form a persistent seedbank; all seeds either germinate, lose viability, or are consumed within a year of production (Castellanos and Molina 1990).

Germination. Jojoba seeds require no pretreatment and are usually readily germinable immediately after harvest (Nord and Kadish 1974; Rao and Iyengar 1982). They are protected from premature summer germination by a requirement for relatively cool temperatures—an optimum 15 to 23 °C (Nord and Kadish 1974), with no germination at 30/40 °C (Ismail 1988)—and slow germination rates. It takes 3 days for the first emergence of the radicle at 20/30 °C and 7 days at 10/20 °C) (Ismail 1988). Seedlots of large seeds germinated more quicky and to higher percentages than did lots of small seeds, suggesting that seed size is associated with germination polymorphism (Ismail 1988). This may function to reduce germination risk under field conditions by spreading out germination across rain events

(Castellanos and Molina 1990). Dormancy could be removed in most seeds by breaking the testa at the radicular end. Nord and Kadish (1974) reported that jojoba seeds could germinate at 5 to 10 °C but only after an 8-hour pretreatment at 20 °C. Germination is hypogeal (figure 2).

Nursery practice and field seeding. Jojoba may be direct-seeded if the plots are protected from seed predation and seedling grazing by rodents. The seeds should be planted in spring, when daytime soil temperatures are above 60 °C, at a depth of 2.5 to 5 cm (1 to 2 in) (Nord and Kadish 1974). Although mature plants can tolerate some freezing, the seedlings do not, perishing at temperatures below –2 °C.

Seedlings may also be readily be produced as container stock (Yermanos 1974). Seedlings emerge in 7 to 12 days at 60 to 75 °C. The plants may be held in 3.8-liter (1-gal) pots outdoors for 8 to 24 months. With the longer period, flowering takes place in the pots, making it possible to optimize sex ratios in plantation plantings. Another alternative is to establish plants from cuttings of known sex. Jojoba can be propagated from softwood stem cuttings taken in the spring or summer (Nord and Kadish 1974).

Figure 2—*Simmondsia chinensis*, jojoba: seedling development at 3, 7, and 14 days after germination.

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