

Ceratonia siliqua L.

carob

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Growth habit. *Ceratonia siliqua* L. Carob, St. John's bread, or locust is a small to medium-sized broadleaf, evergreen tree that may grow to 20 m in height under ideal climatic conditions (Catarino 1993) but usually reaches heights of 8 to 15 m (Goor and Barney 1968). Carob is thought to be a tropical plant that has adapted well to Mediterranean climates by utilizing its deep rooting habit and xerophilous leaves to avoid water stress (Catarino 1993). The deep taproot's penetration into moist regions of the soil profile effectively lengthens the active growth period for carob leaves during the Mediterranean dry season (Rhizopoulou and Davies 1991).

Occurrence. Carob is native to the eastern Mediterranean from the southern coast of Asia Minor to Syria (Goor and Barney 1968; Griffiths 1952; Karschon 1960). It has been cultivated for thousands of years as a forage crop on a wide variety of soils in Asian, European, and North African countries along the coast of the Mediterranean Sea (Bailey 1947; Catarino 1993). Carob's sensitivity to low temperatures limits its area of distribution (Catarino 1993). Since its introduction to the United States in 1854, carob has done well only in the warm subtropical climates (southern Florida, the Gulf States, New Mexico, Arizona, and southern California) where annual rainfall is not below 30 to 35 cm (Bailey 1947; Coit 1951, 1962).

Use. Carob legumes (the fruits, also known as pods) are commonly used as animal feed or ground into flour and mixed with other cereals for human consumption. The legumes are rich in protein and sugar and are a highly nutritious livestock feed, comparable to barley and superior to oats (Bailey 1947; Coit 1962). However, the high sugar content (< 50%) is offset by a high tannin content (16 to 20%) that inhibits protein assimilation (Catarino 1993). Techniques are currently being developed to enzymatically separate and extract the phenolic tannin compounds to increase utilization (Catarino 1993). Legumes are also used in making health foods (as a chocolate substitute), carob syrup, and medicines such as laxatives and diuretics (Binder and others 1959; Coit 1951, 1962). In addition, they can be used as a cheap carbohydrate source for ethanol production, yielding 160 g of ethanol/kg of dry legumes (Roukas 1994). The annual production of carob legumes is 340,000 to 400,000 metric tons (374,800 to 441,000 tons), with Greece, Spain, Italy, and Portugal being primary producers (Roukas 1994; Catarino 1993).

Carob seeds are extremely hard, but the endosperm contains 30 to 40% by weight of galactomanane polysaccharides collectively known as carob-, or locust-bean gum (Catarino 1993). The compound is a valuable stabilizing and thickening additive used in the food processing,

pharmaceutical, textile, paper, and petroleum industries.

The adaptability, ease of cultivation, and aesthetic appeal of carob also make it a desirable landscape plant (Catarino 1993). It is chiefly valuable in the United States as an ornamental evergreen but has been used to some extent in environmental plantings (Toth 1965).

Flowering and fruiting. The flowers, borne in small, lateral, red racemes, are polygamotrioecious (Loock 1940). Nearly all cultivated species are dioecious, although flowers of both sexes may possess vestigial components of the other sex. Rarely, plants will possess both male and female flowers on the same stalk or completely hermaphroditic flowers (Catarino 1993). Flowers bloom from September to December in California, depending on the variety and the weather (Bailey 1947; Coit 1951).

The fruit is a coriaceous, indehiscent legume 10 to 30 cm long, 6 to 20 mm thick, filled with a sweet, pulpy substance bearing 5 to 15 obovate, transverse, brown, bony seeds about 6 mm wide (figures 1 and 2) (Bailey 1947; Coit 1951). Legumes ripen, turn dark brown, and begin to fall from September to November (California), depending on the variety and the weather (Bailey 1947; Coit 1951, 1962). Natural seedlings appear in Greece in November even though temperatures do not favor shoot growth (Rhizopoulou and Davies 1991). Plants begin to bear fruit when 6 to 8 years old, and crops are abundant every second year (Bailey 1947). Average annual yield per tree at maturity is about 90 to 113 kg (200 to 250 lbs) of fruit (Coit 1951, 1962).

Collection of fruits. Fruits may be collected on the ground, or the ripe legumes may be shaken from the trees onto canvas sheets (Coit 1951). Legumes shaken from the tree should be allowed to remain on the ground for 2 to 3 days until completely dry (Coit 1962). Because of their high sugar content, legumes are likely to become moldy and quickly infested with a small scavenger worm *Paramycolius transitella* Walker. If wet weather occurs during the harvesting season (Coit 1951, 1961, 1962). Because the worms infect the legumes while they are still attached to the tree, it is advisable to limit collections to dry years.

Extraction and storage of seed. Seeds are easily extracted after the legumes have been air-dried for a few days (Coit 1951; Goor and Barney 1968). If the legumes are to be stored for a time before extracting the seeds, they should be fumigated with an acceptable substitute for methyl bromide, which was recommended by Coit (1962) but is scheduled to be removed from use in the future. One kilogram (2.2 lb) of legumes yields about 50 to 140 g (1.8 to 4.9 oz) of cleaned seeds (Binder and others 1959). Cleaned seeds average 4,400 to 5,500 seeds/kg (2,000 to 2,500 seeds/lb) (Alexander and Shepperd 1974; Goor and Barney 1968). Soundness appears to be relatively high (<80% for 2 samples) (Alexander and Shepperd 1974). Seeds have remained viable for as long as 5 years when stored dry at low temperatures in sealed containers (Goor and Barney 1968).

Pregermination treatments. Seeds sown from recently ripened legumes germinate well without pretreatment (Rhizopoulou and Davies 1991), but if the seeds dry out they become very hard and do not readily imbibe water (Coit 1951). The best treatments to overcome seedcoat impermeability are soaking in concentrated sulfuric acid (H_2SO_4) for 1 hour and then in water for 24 hours, or alternatively, soaking for 24 hours in water that has first been brought to a boil and then allowed to cool (Goor and Barney 1968; Karschon 1960). Mechanical scarification is also effective in increasing the rate of water absorption with small lots of seeds (Coit 1951).

Germination tests. Germination tests have been run in moist vermiculite for 34 days at 21 °C. The germination rate was 66% for 16 days and the percentage germination was 80% (Alexander

and Shepperd 1974).

Nursery practice. Seeds should be scarified by acid or hot water treatment and sown immediately afterwards in sterile soil or vermiculite under partial shade (Coit 1962; Karschon 1960). Seeds can be sown in either the spring or fall (Goor and Barney 1968). Seedlings have also been grown at 14 to 17 °C greenhouse temperatures with a 12-hour photoperiod of natural light supplemented with 250-W metal halide lamps (Rhizopoulou and Davies 1991). Seedlings develop a single deep taproot with a few small lateral roots less than 1.0 cm in length (Rhizopoulou and Davies 1991). Because the long taproot is easily injured, seeds should be sown in flats, pots, or containers so that seedlings can be outplanted with the original rooting medium intact (Coit 1951; Looock 1940). An alternate practice is to soak the legumes in water for 2 to 3 days and then plant without removing the seeds, but the germination rate is usually low (Coit 1951).

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Figure 1 *Ceratonia siliqua*, carob: seed, $\times 2$.

Figure 2 *Ceratonia siliqua*, carob: longitudinal section through a seed, $\times 3$.