Ceratonia siliqua

L.

Fabaceae - Caesalpinioideae

locust bean, chocar, carob tree

LOCAL NAMES
Arabic (al-kharoubah,kharrub); Catalan (garrover,garrofer); English (St. John's bread,locust bean,carob tree,carob bean); French (caroubier); German (karubenßaum,johannisbrotßaum); Greek (charaoupi); Hindi (kharnub); Italian (carrubo); Malay (gelenggang); Mandarin (chiao-tou-shu); Portuguese (alfarrobeira); Spanish (garrover,algarrobo,garrofero); Thai (chum het tai); Trade name (carob tree,locust bean,chocar); Turkish (charnup)

BOTANIC DESCRIPTION
Ceratonia siliqua is an evergreen shrub or tree up to 10 m high, crown broad semi-spherical, thick trunk, brown rough bark and sturdy branches.

Leaves 10-20 cm long, alternate, pinnate, with or without a terminal leaflet. Leaflets 3-7 cm long, ovate to elliptic, 4-10 normally opposite pairs, coriaceous, dark green and shiny above, pale green beneath finely veined with margins slightly ondulate, tiny stipules.

Flowers green-tinted red, small, numerous, 6-12 mm long, spirally arranged along the inflorescence axis in catkin-like racemes borne on spurs from old wood and even on the trunk (cauliflory). Pentamerous symmetry with calyx but not corolla placed on a short pedicel. Calyx disc-shaped, reddish-green, bears nectaries. Females consist of a pistil (6-8.5 mm) on a disk and rudimentary stamens, 5 hairy sepals. Males consist of a nectarial disk, 5 stamens with delicate filaments hairy sepals. In the centre of the disk there is a rudimentary pistil. Hermaphrodite flowers a combination; containing a pistil and a complement of 5 stamens.

The fruit indehiscent pod, elongated, compressed, straight or curved, thickened at the sutures, 10-30 x 1.5-3.5 cm, about 1 cm thick with blunt or subacute apex. Pods brown, wrinkled surface, leathery when ripe. Seeds occur in the pod transversally, separated by mesocarp; very hard, numerous, compressed ovate-oblong, 8-10 x 7-8 mm, 3-5 mm thick; testa is hard, smooth, glossy brown, hilium minute.

The scientific name of the carob tree derives from the Greek 'keras', horn, and Latin 'siliqua', alluding to the hardness and shape of the pod. The common name originates from the Hebrew-'kharuv', from which other vernacular names are derived.

BIOLOGY
C. siliqua is a dioecious tree with some hermaphroditic forms; male, female and hermaphroditic flowers are generally borne on different trees. Unisexual and bisexual flowers are rare in the same inflorescence. The flowers are initially bisexual, but usually 1 sex is suppressed during the development of functionally male or female flowers.

C. siliqua is the only Mediterranean tree with the main flowering season in autumn (September-November). However, the time and the length of the flowering period depend on local climatic conditions, as with most fruit and nut trees. Carob bean size is a highly variable character, influenced by many environmental factors as well as level of pollination and fruit set.

Pollen dispersal is by insects, mainly bees, flies, wasps and night-flying moths. Flowers of all 3 types secrete nectar; the volume of nectar and its sugar content are higher in female flowers than in male. Male and hermaphroditic flowers emit a semen-like odour that attracts insects.

Harvesting is the major cost in carob production. Collecting operations depend on yield, size and shape of pod, and orchard density.

Dead branches are the result of feeding by rats. (William M. Ciesla, Forest Health Management International, www.forestryimages.org)

C. siliqua is widely cultivated in traditional Olive-Apricot-Fig-pasture agroforestry systems throughout the Mediterranean. Typical old tree of C. siliqua in the Algarve, Portugal. (Colin E. Hughes)

Unripe pods of C. siliqua. (Colin E. Hughes)

ECOLOGY
A long-lived evergreen and thermophilic tree thriving in habitats with mild Mediterranean climates. It grows well in warm temperate and subtropical areas, tolerates hot and humid coastal areas. It is a xerophytic species, well adapted to the ecological conditions of the Mediterranean region. C. siliqua, together with Olea europea var. sylvestris, forms one of the most characteristic associations of the lowest Mediterranean vegetation zone and is thus considered a climax community (Olea-Ceratonion). Areas suitable for C. siliqua should have a subtropical Mediterranean climate with cool, not cold, winters, mild to warm springs, and warm to hot, dry summers.

Cannot withstand waterlogging although the root system is usually deep. The tree's extensive root system penetrates the soil deeply; roots develop under stressful conditions to explore deeper layers where water may be available; it can thus survive long periods of drought. In addition the leaves can maintain turgor under situations of drought, using different strategies according to the season.

Sensitivity to frost is a serious problem in this crop. The extent of frost damage depends on the temperature within the orchard and the physiological state of the trees. Noted for its drought resistance, the plant is especially useful where irrigation is impractical or rainfall unreliable. However, unless irrigated, the fruits are dry and shrivelled, having little commercial value, and the yields are very low. Although drought-resistant, C. siliqua trees do not bear commercial crops unless they receive at least 500-550 mm/year, but 350 mm of annual rainfall is considered enough for fruit set.

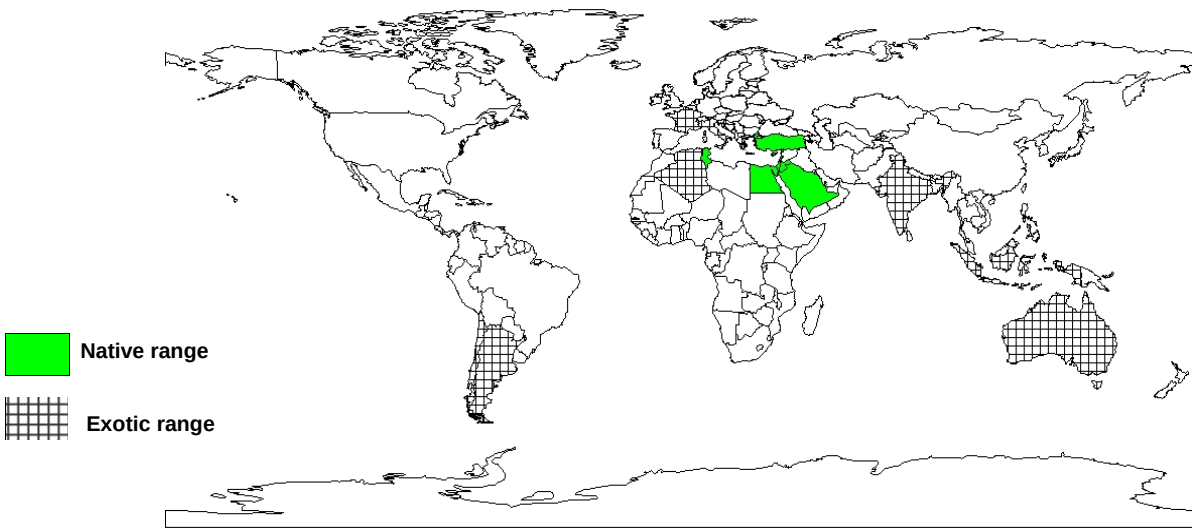
BIOPHYSICAL LIMITS
Altitude: 0-500 m, Mean annual temperature: -4 to 40 deg. C, Mean annual rainfall: 250-550 mm

Soil type: Adaptable to a wide range of soils; poor sandy soils, rocky hillsides, deep soils. Prefers sandy well-drained loams; calcareous soils with high lime content also suitable. Appears to tolerate salinity well.

DOCUMENTED SPECIES DISTRIBUTION

Native: Cyprus, Egypt, Israel, Jordan, Lebanon, Libyan Arab Jamahiriya, Saudi Arabia, Syrian Arab Republic, Tunisia, Turkey

Exotic: Algeria, Argentina, Australia, Chile, Croatia, France, Greece, India, Indonesia, Italy, Malta, Mexico, Morocco, Pakistan, Portugal, South Africa, Spain, US, Venezuela, Yugoslavia (Former)



The map above shows countries where the species has been planted. It does neither suggest that the species can be planted in every ecological zone within that country, nor that the species can not be planted in other countries than those depicted. Since some tree species are invasive, you need to follow biosafety procedures that apply to

your planting site.

PRODUCTS
Food: Carob pulp is high in total sugar content (48-56%). In addition, it contains about 18% cellulose and hemicellulose. Mineral composition consists of potassium, calcium, magnesium, sodium, iron, copper, iron, manganese and zinc.

In some countries, Egypt for example, carob syrup is a popular drink, obtained from carob kibbles with water. Unicellular organisms convert carob pulp into a high-protein feed; sugar solutions extracted from carob pods are an excellent substrate for culturing fungi such as Aspergillus niger and Fusarium monoliforme, and the dried mycelium is a palatable and nutritious feed, containing up to 38% crude protein by weight. The carob product most widely used, especially in the food industry, is carob bean gum (CBG), or locust bean gum (LBG). This gum comes from the seed endosperm and chemically is a polysaccharide, a galactomnnan. 100 kg of seeds yield 20 kg on average of pure dry gum.

The mucilaginous gum, known as ‘tragasol’, is used in a wide range of commercial products as a thickener, stabilizer, binder and gelling or dispersal agent. The food industry uses CBG for the production of a large number of different commodities: ice cream, soups, sauces, cheese, fruit pies, canned meats, confectionery, bakery products and pet foods. Technical applications of CBG include cosmetics, pharmaceuticals, film emulsions, paints, polishes, ceramics and adhesives.

Pulp extracted and purified produces sugar and molasses. Powdered pulp is used as a food ingredient and cacao substitute and for preparing dietary products. Carob powder consists of 46% sugar, 7% protein and small amounts of numerous minerals and vitamins and is thus quite nutritious. Carob ‘cocoa’ has an advantage over chocolate in that it has fewer calories and neither caffeine nor theobromine. Ground seed embryo and endosperm can be used for human consumption; the latter, containing CBG and E-410, is a food additive and a dietary fibre.

Fodder: C. siliqua pods provide fodder for ruminants and non-ruminants. Endosperm and embryo of the seed can be ground and used for pet food. The fodder is now being used in zero-grazing in Mediterranean countries.

Fuel: The wood produces a slow-burning charcoal and can also be used for firewood.

Timber: C. siliqua timber is hard and close-grained and has been used to make utensils.

Gum or resin: Currently, the main use of the seed is gum extraction.

Tannin or dyestuff: Ripe carob pods contain large amounts of condensed tannins (16-20% of dry weight).

Alcohol: A high sugar content and its relatively low cost have made carob pulp among the earliest horticultural crops used for the production of industrial alcohol by fermentation in several Mediterranean countries.

Medicine: Tannins extracted from the pulp act as an anti-diarrhoetic. Ground pulp and seed endosperm are used in the preparation of pharmaceutical products.

Other products: Technical applications of CBG (carob bean gum) include cosmetics, pharmaceuticals, film emulsions, paints, polishes, ceramics and adhesives.

SERVICES
Shade or shelter: Widely planted as a shade tree, also recommended as a windbreak around orchards.

Reclamation: Since it requires little if any cultivation, tolerates poor soils and is long lived, C. siliqua is often recommended for reforestation of degraded coastal zones threatened by soil erosion and desertification.

Ornamental: A popular ornamental in California, Australia and elsewhere; male trees are preferred as they do not provide litter from pod fall. However, the value of C. siliqua as a drought-tolerant, air-pollution tolerant, low maintenance tree for street landscape planting could be limited by its large size when mature and its strong, invasive roots.

Intercropping: Frequently planted with species such as olive, grapevines or almond. Young C. siliqua orchards are intercropped with early-bearing species such as peach, almond or even vegetables; an annual perennial crop between the rows may give early returns to the investment.

Pollution: Could help buffer noise from factories, roads and railways because of its dense foliage.

TREE MANAGEMENT
Seedling rootstocks, before or after budding, are usually planted from pots directly into the orchard. Trees with well-developed roots should be used for transplanting, and proper care during and after planting is essential.

For dryland orchards on poor soils on the Mediterranean coast, tree densities between 100 and 175 trees/ha are recommended, that is, spacing from 9 x 9 m to 7 x 8 m. When C. siliqua is to be planted in fertile soils, high-density planting and tree thinning later may be considered. Little pruning is necessary due to the tree's specific growth and fruiting habits.

If male and hermaphroditic trees are planted as pollinators they must be interspersed around and within the orchard in a regular pattern. It is important to use different types of male or hermaphroditic pollinators to overlap with female cultivar bloom, as main cultivars often display a long blooming season of 3-4 months. Since male trees have a shorter flowering period than hermaphrodites, the latter usually show better overlapping.

GERMPLASM MANAGEMENT
Orthodox seed storage behaviour; viability can be maintained for 5 years in air-dry storage at 5 deg. C without loss in viability. Although carob seeds have remained viable for as long as 5 years stored at low temperatures in sealed containers, it is advisable to use seeds from the current season. Seeds are presumably viable after passing through an animal's digestive tract. There are about 500 seeds/kg.

PESTS AND DISEASES
C. siliqua is normally free from severe insect and disease troubles and traditionally is a crop that is not sprayed. In Spain, the most damaging insect is the polyphagous larva of the leopard moth (Zeuzera pyrina), which attacks the wood of trunk and branches, causing severe damage to younger trees. Pods of many cultivars may become infested with the small and polyphagous larva of the carob moth (Myelois ceratoniae) while maturing or before harvest is complete. In Cyprus, carob midge (Asphondylia spp.) attacks on pods at an early stage have caused stunting. Black aphids attack mainly the terminal shoots of young trees. The mildew disease caused by Odium ceratoniae attacks pods, leaves and twigs in different periods of the year. Other pests that occasionally cause severe damage to the carob orchards are small rodents like gophers (Pitymys spp.) and rats (Rattus spp.). Gophers can severely damage the root system of young trees. Rats can strip the bark not only of young shoots but also of older shoots and even limbs; and by girdling a limb or branch can kill the plant.

FURTHER READNG

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SUGGESTED CITATION

Orwa C, Mutua A , Kindt R , Jamnadass R, Simons A. 2009. Agroforestree Database:a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/af/treedb/)