

Cactaceae—Cactus family

Carnegiea gigantea (Engelm.) Britton & Rose

saguaro or giant cactus

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Growth habit, occurrence, and use. Saguaro has the northernmost distribution of any of the large, columnar cacti of the tropical and subtropical Americas. Formerly regarded as a member of the genus *Cereus*, it is now considered the single species of its own genus, *Carnegiea gigantea* (Engelm.) Britt. and Rose. It is a principal indicator species of the Sonoran Desert and is found at elevations below 1,200 m from extreme southeastern California east to south central Arizona and south into northern Sonora (Kearney and Peebles 1960; Munz 1964). Saguaro is an arborescent, sometimes branched, stem succulent that reaches 10 m in height. It is found primarily in desert upland communities with coarse, gravelly, well-drained soils.

Saguaro is an important component of the communities where it occurs, providing food and shelter to a host of desert animals. Its wood has been used for fence and hogan construction by indigenous people of the area, and its fruits provided one of their most reliable wild food sources. The sweet, fleshy fruit pulp can be eaten raw or used to make confections or jams. The nectar is reported to be a source of excellent honey (Alcorn and Martin 1974). In addition, saguaro is one of the most well-known and beloved plants in the country, recognizable at a glance by most Americans.

Flowering and fruiting. Saguaro plants normally produce fruit on a yearly basis, even if the winter has been dry (Steenbergh and Lowe 1977). They have sufficient water and energy reserves in their succulent stems to buffer fruit production from the yearly vagaries of water availability. Even plants that have been severed at the base are capable of fruit production for 2 subsequent years. Plants in the wild reach reproductive maturity at a height of about 2 m and an age of about 40 years (Steenbergh and Lowe 1983). Flowering occurs from March through May, depending on latitude and elevation, with later flowering on cooler sites. The fruit crop may be damaged or destroyed by frost during flowering. The large, fragrant, epigynous flowers are borne at the stem apices. They open in the evening, and each lasts only until midday the following day. The flowers produce copious pollen and nectar and are pollinated primarily by nectar-feeding bats, although many other visitors take advantage of the rich resource (Hevly 1979; Steenbergh and Lowe 1977).

Fruits ripen from June through August. A single fruit contains 2,000 to 2,500 seeds. The succulent fruits usually split open while still attached to the plant, exposing the tiny seeds to removal by rain, but the fruits eventually fall to the ground. Many animals utilize the fruits and seeds. Larger mammals such as coyotes (*Canis latrans*) may act as dispersers, but most users, especially harvester ants (*Pogonomyrmex* spp.) and doves (*Zenaida* spp.), are consumers only. Most of the seeds are consumed before the beginning of summer rains, especially in years when fruits ripen early or

initiation of the summer rainy season is delayed (Steenbergh and Lowe 1977).

Seed collection, cleaning and storage. Ripe fruits turn from green to purple and can be collected by cutting with long-handled knives prior to dehiscence on the plant. The seeds can be removed from the fruits using standard procedures for fleshy fruited species, such as maceration in a Dybvig macerator or by forcing through an appropriately sized sieve, removal of the pulp by flotation, drying of the seeds, and cleaning in a fanning mill or aspirator. Extra care must be taken because of the small seed size. The average number of seeds per weight is 990/g (450,000/lb) (Alcorn and Martin 1974). The seeds are usually of high quality (>95% germination). Seeds apparently may be stored at room temperature for a few years without much loss of viability; even after 10 years, germination values as high as 51% have been recorded (Alcorn and Martin 1974).

Germination. Saguaro seeds are readily germinable when fruits are ripe. Their germination is suppressed by the fruit pulp, but once they are washed free of the pulp they germinate freely, as long as temperatures are high (25 °C is optimum) and the seeds are exposed to light (Alcorn and Martin 1974; Steenburgh and Lowe 1977). Official testing calls for germination on moist blotter paper for 20 days at alternating temperatures of 20/30 °C, with light during the 8 hours at the higher temperature; no pretreatment is needed (AOSA 1993). In the field, seeds germinate soon after dispersal in response to adequate summer storms. Time to 50% germination of initially air-dried seeds is about 72 hours. If the seeds are first exposed to high-humidity air (without condensation) for 24 hours, they can reach 50% germination in 48 hours, an apparent adaptation for speeding germination during closely spaced summer storms (Steenbergh and Lowe 1977). Saguaro seeds do not form persistent seed banks; all viable seeds germinate soon after dispersal.

Because of apparently poor recruitment in natural stands, factors affecting survival of saguaro seedlings and young plants have been studied in some detail (Despain 1974; Nobel 1980; Steenbergh and Lowe 1969, 1976, 1977, 1983). New seedlings are highly susceptible to drought and herbivore damage, whereas young plants are at risk both of overheating in summer and freezing in winter. Nurse plants and other sheltering objects such as rocks greatly decrease these risks.

Nursery practice. Cleaned saguaro seeds may be surface-sown on coarse potting medium. The seedlings are highly susceptible to fungal pathogens, and care must be taken to provide good drainage and avoid overwatering (Alcorn and Martin 1974). They must be protected from freezing and also from full sunlight. Shade is probably beneficial for plants up to a meter in height. The seedlings grow very slowly at first, only a few millimeters a year for the first several years.

Literature cited

- Alcorn SL, Martin SC. 1974. *Cereus giganteus* Engelm., saguaro. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 313B314.
- AOSA [Association of Official Seed Analysts]. 1993. Rules for testing seeds. Journal of Seed Technology 16(3): 1B113.
- Despain DG. 1974. The survival of saguaro (*Carnegiea gigantea*) seedlings on soils of differing albedo and cover. Journal of the Arizona Academy of Science 9: 102B107.
- Hevly RH. 1979. Dietary habits of two nectar and pollen feeding bats in southern Arizona and northern Mexico. Journal of the ArizonaNevada Academy of Science 14: 13B18.

- Kearney TH, Peebles RH. 1960. Arizona flora. Berkeley: University of California Press. 1085 p.
- Munz PA. 1974. A flora of southern California. Berkeley: University of California Press. 1086 p.
- Nobel PS. 1980. Morphology, nurse plants, and minimum apical temperatures for young *Carnegieia gigantea*. Botanical Gazette 141: 188B191.
- Steenbergh WF, Lowe CH. 1969. Critical factors during the first years of life of the saguaro (*Cereus giganteus*) at Saguaro National Monument, Arizona. Ecology 50: 825B834.
- Steenbergh WF, Lowe CH. 1976. Ecology of the saguaro: 1. The role of freezing weather in a warm desert population. In: Research in the parks. Symp. Ser. 1. Washington DC: USDI National Park Service: 49B92.
- Steenbergh WF, Lowe CH. 1977. Ecology of the saguaro: 2. Reproduction, germination, establishment, growth, and survival of the young plant. Sci. Monogr. Ser. 8. Washington, DC: USDI National Park Service. 248 p.
- Steenbergh WF, Lowe CH. 1983. Ecology of the saguaro: 3. Growth and demography. Sci. Monogr. Ser. 17. Washington, DC: USDI National Park Service: 228 p.

Figure 1C *Carnegieia giganteus*, saguaro: seed, $\times 8$.

Figure 2C *Carnegieia giganteus*, saguaro: longitudinal section through a seed, $\times 20$.