Pinaceae—Pine family

Cedrus Trew

cedar

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Growth habit, occurrence, and use. The genus of true cedars—*Cedrus*—consists of 4 (or fewer) closely related species of tall, oleoresin-rich, monoecious, coniferous, evergreen trees, with geographically separated distributions (Arbez and others 1978; Bariteau and Ferrandes 1992; Farjon 1990; Hillier 1991; LHBH 1976; Maheshwari and Biswas 1970; Tewari 1994; Vidakovié 1991). The cedars are restricted to the montane or high montane zones of mountains situated roughly between 15°W and 80°E and 30 to 40°N (Farjon 1990). This discontinuous range is composed of 3 widely separated regions in North Africa and Asia (Farjon 1990): the Atlas Mountains of North Africa in northern Morocco and northern Algeria; Turkey, the mountains on Cyprus, and along the eastern border of the Mediterranean Sea in Syria and Lebanon; the Hindu Kush, Karakoram, and Indian Himalayas. The 4 species of cedars (table 1) are so closely related that habitual characteristics help differentiate the species (Farjon 1990). Isozyme analysis of cedar diploid tissue raises questions about the separation of Atlas cedar and cedar of Lebanon into 2 distinct species, because no distinguishing gene marker was detected (Panetsos and others 1992). There is disagreement as to the exact taxonomic status of the various cedars, with some authors suggesting that they be reduced to only 2 species: deodar cedar and cedar of Lebanon. In this writing, we will examine all 4 species.

The cedars are both valuable timber trees and quite striking specimen plants in the landscape. The wood of cedar of Lebanon is fragrant, durable, and decay resistant; and on a historical note, the ancient Egyptians employed cedar sawdust (cedar resin) in mummification (Chaney 1993; Demetci 1986; Maheshwari and Biswas 1970). Upon distillation of cedar wood, an aromatic oil is obtained that is used for a variety of purposes, from scenting soap to medicinal practices (Adams 1991; Chalchat and others 1994; Maheshwari and Biswas 1970; Tewari 1994).

Atlas cedar is a large tree that grows rapidly when young and is closely related to cedar of Lebanon. The Atlas cedar is distinguished by a taller crown, less densely arranged branchlets, bluish green leaves (needles) that vary from light green to silvery blue, smaller cones, and smaller

Table 1—*Cedrus,* cedar: nomenclature, occurrence, height at maturity, and date first cultivated

Scientific name	Common name	Occurrence	Height at maturity (m)	Year first cultivated
***C. atlantica* (Endl.) G. Manetti ex Carriere**	**Atlas cedar**	In Algeria on Mts. Babor & Tababort & in Hodna Mtns; in Morocco in Rif Mtns (at 1,370–2,200 m); planted in US	9–40	Before 1840
***C. breviifolia* (Hook. f.) A. Henry**	**Cyprian cedar**	Two separate locations on Mt Paphos in western Cyprus (at 900–1,525 m)	8–24	1879
***C. deodara* (Roxb. ex D. Don) G. Don F.**	**deodar cedar**	E Afghanistan (Hindu Kush), NW Pakistan (Karakoram), NW India (Kashmir & Gharwal Himalaya), rare in Nepal (1,700–3,000 m in western range & 1,300–3,300 m in eastern range); planted in US	15–50	1831
***C. libani* A. Rich.**	**cedar of Lebanon**	In S Turkey (Taurus Mtns), also Syria (Djebel el Ansiriya) & Lebanon (Djebel Loubnan); disjunct relict population in N Turkey near Black Sea (at 1,300–3,000 m); planted in US	15–40	Pre-1650

Sources: Dirr (1990), Farjon (1990), Hillier (1991).

seeds (table 2) (Dirr 1990; Farjon 1990; Hillier 1991; Loureiro 1990, 1994). Young trees appear stiff, with an erect leader and a pyramidal overall shape; with maturity this species assumes a flat-topped habit with horizontally spreading branches (Dirr 1990). Atlas cedar is hardy in USDA zones 6 to 9, with several beautiful cultivars that differ in color and characteristic habit (Dirr 1990; Hillier 1991; Vidakovié 1991). Of special note is '*Glauca*' (f. *glauca*), with very blue to silvery blue leaves, which is a spectacular specimen tree (Dirr 1990; Hillier 1991).

Cyprian cedar is a rare species that grows slowly but eventually develops into a medium-sized tree. This species is distinguished from cedar of Lebanon only by its habitual form and shorter leaves (table 2) and the broad and umbrella-shaped crown on older specimens (Farjon 1990; Hillier 1991; Vidakovié 1991).

Deodar cedar is an excellent specimen tree. The deodar cedar is broadly pyramidal when young, with gracefully pendulous branches (Dirr 1990; Tewari 1994). It is distinguished from the other species by its drooping leader and longer leaves (table 2) (Hillier 1991). Multi-stemmed crowns occasionally evolve from the higher branches turned erect, but the crown seldom becomes flat-topped, remaining conical or pyramidal (Farjon 1990). Deodar cedar is hardy in USDA zones 7 to 8, but young trees are prone to injury from frosts and cold wind (Dirr 1990). There are many cultivars of deodar cedar, but 2 worth mentioning are 'Kashmir' and 'Shalimar'. The former is winter-hardy—it tolerates cold winters to –30 °C—with silvery blue-green foliage (Dirr 1990; Vidakovié1991). The latter displays good blue-green leaf color and is the hardiest cultivar planted in the United States (Dirr 1990; Koller 1982).

Cedar of Lebanon is a majestic tree with innumerable historical and biblical references. It has a thick, massive trunk and wide-spreading branches; it is pyramidal when young but develops a flat-topped crown and horizontally tiered branches when mature (Chaney 1993; Dirr 1990; Farjon 1990; Hillier 1991). The dark green foliage, stiff habit, and rigidly upright cones (table 2) give this tree its splendor for landscape specimen planting. The morphological differences between cedar of Lebanon and Atlas cedar are small and not entirely constant (Farjon 1990; Maheshwari and Biswas 1970). Cedar of Lebanon is hardy in USDA Zones 5 to 7 (Dirr 1990; Dirr and others 1993). A geographical form—*C. libani* ssp. *stenocoma* (Schwarz) Davis—differs from the typical Lebanon cedar in having a broadly columnar habit and needle and cone characteristics that are intermediate between Atlas cedar and cedar of Lebanon; it is also more cold-hardy (Hillier 1991; Vidakovié 1991). There are also several dwarf cultivars of cedar of Lebanon that are of interest for use in the landscape (Hillier 1991; Vidakovié 1991).

Flowering and fruiting. The male flowers of cedar are erect catkins, up to 5 cm in length, whereas the female flowers are erect, cone-like inflorescences, 1 to 1.5 cm long, surrounded by needles at the base (Vidakovié 1991). Male and female strobili of the true cedars are borne (usually) on the same tree, but on separate branches (Farjon 1990; Maheshwari and Biswas 1970; Rudolf 1974). The male cones are solitary, grow more or less erect from the short shoots, and bear abundant yellow pollen (Farjon 1990; Maheshwari and Biswas 1970). Depending upon the altitude, locality, and weather, the pollen is shed late in the year (September through November), relating to the late development of the female strobilus (Farjon 1990; Maheshwari and Biswas 1970). The female cones are borne singly at the tips of the dwarf shoots, stand erect, and are less abundant than the male cones (Farjon 1990; Maheshwari and Biswas 1970). Although pollination takes place in the fall, the cones do not mature until the second year, requiring about 17 to 18 months for full development (Farjon 1990; Maheshwari and Biswas 1970; Rudolf 1974).

The mature, barrel-shaped cones (figure 1) are resinous and characterized by numerous closely appressed, very broad scales, each containing 2 seeds (table 2) (Rudolf 1974). The scales are attached to the persistent rachis with a narrowed, petiolate base and dismember from it by abscission at maturity, as in fir (*Abies*) (Farjon 1990; Rudolf 1974). The irregularly triangular mature seed is rather soft and oily, with resin vesicles present on each side of the seed,

Table 2—*Cedrus,* cedar: cone, seed, and leaf (needle) characteristics

	Cone characteristics			Seed size		Leaf characteristics	
Species	Ripe color	Length (cm)	Width (cm)	Length (mm)	Width (mm)	Length (cm)	No. in whorls
C. atlantica	Light brown	5–8	3–5	8–13	4–6	1–2.5	20–45
C. brevifolia	Light brown	5–10	3–6	8–14	5–6	0.5–1.6	15–20
C. deodara	Reddish brown	7–13	5–9	10–15	5–7	2–6.0	20–30
C. libani	Grayish brown	8–12	3–6	10–14	4–6	1–3.5	20–40

Sources: Farjon (1990), Rudolf (1974), Vidakovie (1991).

and it has a membranous, broad wing that is several times larger than the seed (figures 2 and 3) (Farjon 1990; Rudolf 1974). Seeding habits of the various species are given in table 3. Commercial seed bearing of deodar cedar begins from 30 to 45 years of age, and good seedcrops are borne every 3 years, with light crops in the intervening years (Doty 1982; Maheshwari and Biswas 1970; Rudolf 1974; Tewari 1994; Toth 1979).

Collection of fruits; extraction, cleaning, and storage of seeds. Cones should be collected directly from the trees, before the cones turn brown, or cone-bearing twigs may be cut from standing or felled trees just before ripening is complete (Dirr and Heuser 1987; Rudolf 1974; Singh and others 1992). One cubic meter (28.38 bu) of cones weighs from 12.2 to 15.9 kg (27 to 35 lb) and yields about 1.4 kg (3 lb) of cleaned seeds (Rudolf 1974). Cones should be allowed to dry until the scales loosen and the seeds can be removed (Dirr and Heuser 1987; Macdonald 1986; Toth 1980a). It is important to avoid any more drying than is absolutely necessary, because the seeds may be killed. Cones of cedar may be soaked in warm water for 48 hours to encourage them to disintegrate (Rudolf 1974; Macdonald 1986). Freezing moist cones (as a last resort) will also force the scales to open up (Macdonald 1986). After the cone scales are dry, they can be placed in a cone shaker to remove the seeds (Rudolf 1974), and seeds can be separated from the debris by fanning or sieving (Macdonald 1986). Seeds are de-winged by simply rubbing them in a dry cloth (Macdonald 1986), for resin from the resin pockets in the wings can make de-winging with bare hands difficult (Macdonald 1986). Purity of commercially cleaned seed has been 85 to 90% (table 4).

Even though cedar seeds are orthodox in storage behavior, they are very oily and do not keep well under many storage conditions (Allen 1995; Rudolf 1974). If cedar seeds are dried below a critical level, they will not imbibe water in a way that will allow the food reserves to be used by the embryo (Macdonald 1986). Cedar seeds have retained viability for 3 to 6 years when dried to a moisture content of less than 10%, placed in sealed containers, and held at temperatures of –1 to –5 °C (Erkuloglu 1995; Rudolf 1974).

Pregermination treatments. Cedar seeds exhibit little or no dormancy and will germinate without pretreatment. However, variable degrees of dormancy may be observed within a single lot of seeds (Dirr and Heuser 1987). Seeds should be stratified at 3 to 5 °C for 2 weeks (6.5 weeks for Cyprian cedar) to give more uniform germination (Allen 1995; Rudolf 1974). Thapliyal and Gupta (1980) found that 9 °C was a better temperature for stratification than 3 °C. Deodar cedar and cedar of Lebanon seeds are prone to damping-off disease and thus should be treated with an appropriate fungicide (Mittal 1983).

Germination tests. The AOSA (1993) prescribes germination tests of stratified seeds (14 days) on top of blotters for 3 weeks at 20 °C for all cedars (see also Toth 1980a). ISTA (1993) rules, however, specify diurnally alternating

Figure 1—*Cedrus libani*, cedar of Lebanon: mature cone.

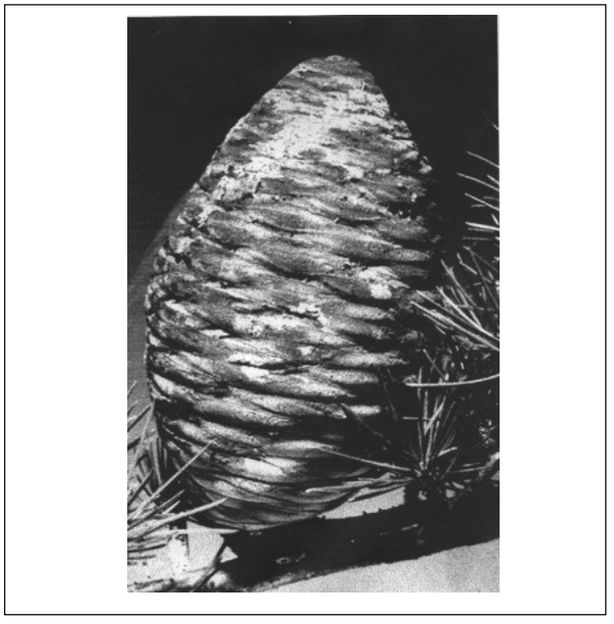
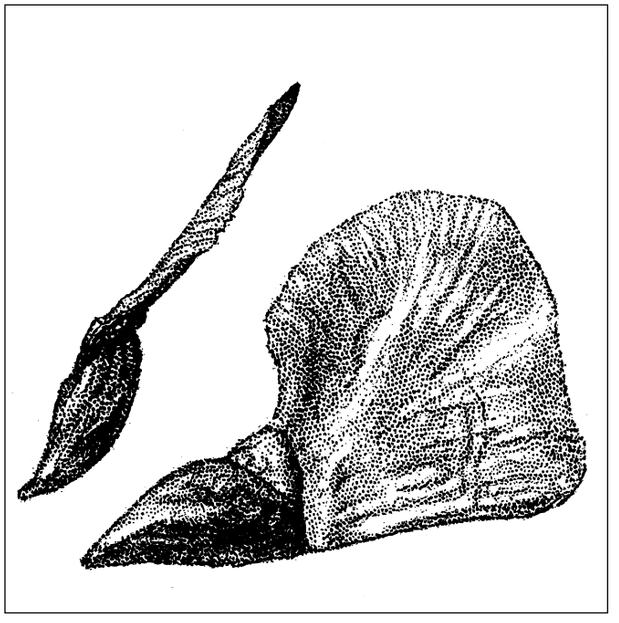


Figure 2—*Cedrus libani*, cedar of Lebanon: seeds with membranous wing attached.

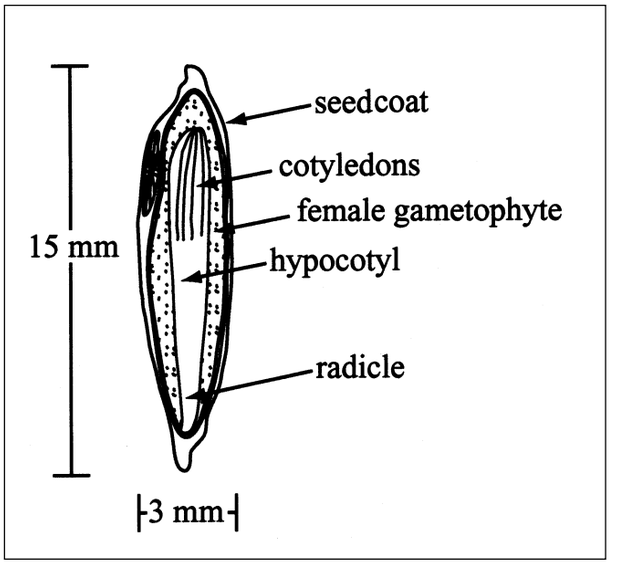


temperatures of 20 °C (night) and 30 °C (day) for a period of 4 weeks. Tests may also be made in sand flats (Rudolf 1974). Deodar cedar seeds stratified at 4 °C in moist sand for 30 days showed 45% germination versus 11% without stratification (Dirr and Heuser 1987). Thapliyal and Gupta (1980) also found that the percentage of germination without stratification to vary from 16 to 69%. Singh and others (1992) found that seeds from larger cones exhibited higher germination (66%) in Himalayan cedar. Singh and others (1997) also found that there were significant differences between tree-diameter classes in fresh and dry weight of seeds and also in germination in the laboratory and in the nursery. Germination of cedar seed is epigeal (figure 4).

Nursery practice and seedling care. Deodar cedar seeds should be sown in the fall (or in spring) at a rate of 200 to 250 seeds/m^2 (19 to 23/ft^2), in drills 10 to 15 cm (4 to 6 in) apart for lining-out stock and for root stocks (Macdonald 1986; Rudolf 1974). Chandra and Ram (1980) recommend sowing deodar seeds at a depth of 1 cm (0.4 in); further increase in depth results in decreased germination. Al-Ashoo and Al-Khaffaf (1997) reported that the best treatment for germination of cedar of Lebanon seeds was a 1.5-cm (0.6-in) sowing depth, with a covering medium of clay or alluvial soil. In northern areas, fall-sown beds should be mulched over winter, the mulch removed early in the spring, and the bed racks covered with burlap on critical spring nights to prevent freezing (Heit 1968). Cedar seeds can be sown in containers in the fall, transplanted into other containers during the winter, and kept in shaded beds in the summer to produce $^1/_2$- to 1 $^1/_2$-year-old planting stock (Rudolf 1974). The size of the propagation container, growth media, transplanting date, and handling of seedlings is important in container or field grown stock (Appleton and Whitcomb 1983; Burger and others 1992; Doty 1982; Guehl and others 1989; Puxeddu and Alias 1991; Toth 1980b).

Deodar cedar 'Shalimar' can be propagated by collecting cuttings in late fall to early winter; 67% of such cuttings given a quick dip in 5 g/liter (5,000 ppm) indole-3-butyric acid (IBA) solution and placed in a sand–perlite medium with bottom heat (Nicholson 1984) rooted. Shamet and Bhardwaj (1995) reported 69% rooting of deodar cedar cut-

Figure 3—*Cedrus brevifolia*, Cyprian cedar: longitudinal section through a seed (**top**) and exterior view of a de-winged seed (**bottom**).



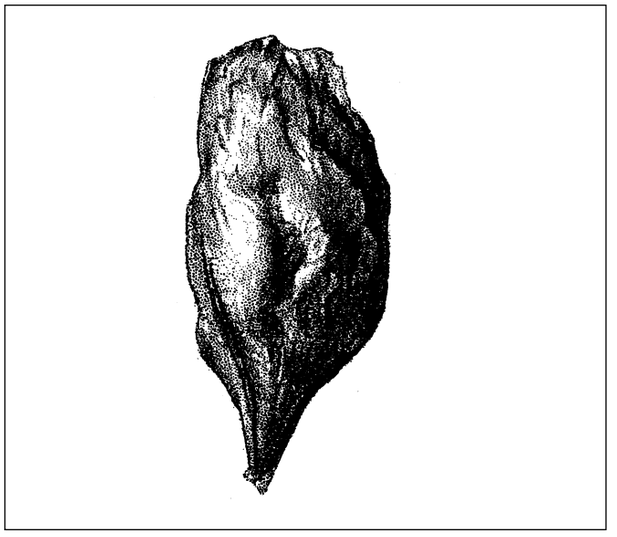


Table 3—*Cedrus*, cedar: phenology of flowering and fruiting

Species	Flowering	Cone ripening	Seed dispersal
C. atlantica	June–Sept	Sept–Oct	Fall–spring
C. deodara	Sept–Oct	Sept–Nov	Sept–Dec
C. libani	June–Sept	Aug–Oct	Fall–spring

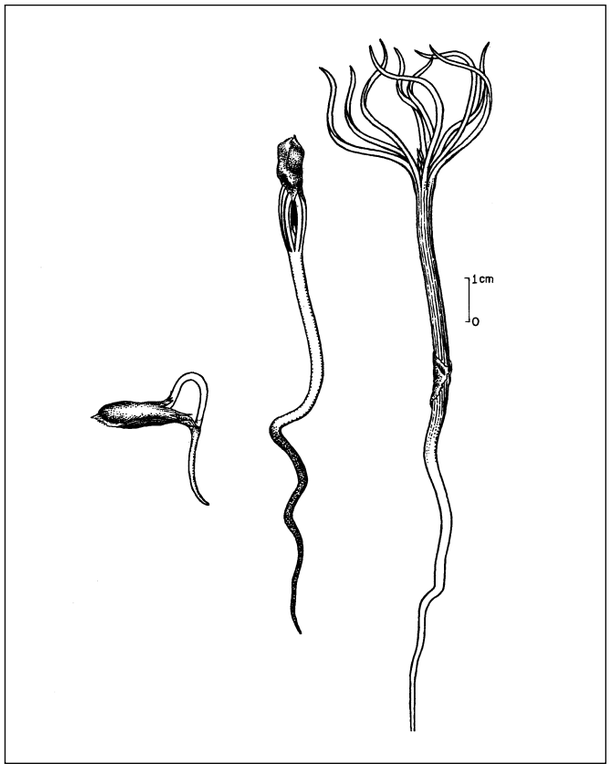
Sources: Rudolf (1974), Vidakovic (1991).

Table 4—*Cedrus*, cedar: seed data

Species	Avg no. cleaned seeds /kg	Avg no. cleaned seeds /lb	Commercial seed purity (%)
C. atlantica	13,900	6,300	89
C. brevifolia	13,000	5,890	—
C. deodara	8,150	3,700	85
C. libani	11,700	5,300	87
C. libani ssp. *stenocoma*	17,600	8,000	—

Sources: Allen (1995), Rudolf (1974).

Figure 4—*Cedrus libani*, cedar of Lebanon: seedling development at 1, 4, and 8 days after germination.



tings treated with 0.5% indole-3-acetic acid–talc or 1% naphthaleneacetic acid–activated charcoal, both supplemented with 10% captan and 10% sucrose. However, cuttings taken from Atlas cedar and cedar of Lebanon are difficult to root, although some rooting may occur on cuttings taken in late winter and treated with 8 g/liter (8,000 ppm) IBA–talc (Dirr and Heuser 1987). Cultivars of cedar species are more routinely propagated by grafting (Blomme and Vanwezer 1986; Dirr and Heuser 1987; Hartmann and others 1990; Lyon 1984; Macdonald 1986; Richards 1972). Two reports have been published on the *in vitro* culture of deodar cedar (Bhatnagar and others 1983; Liu 1990). A method for *in vitro* propagation of cedar of Lebanon through axillary bud production, a study of bed dormancy *in vitro*, and detection of genetic variation of *in vitro*–propagated clones has also been described (Piola and Rohr 1996; Piola and others 1998, 1999).

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