Cercis L.

redbud

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Growth habit, occurrence, and uses. The genus *Cercis*CredbudCincludes 8 species of trees and shrubs; 2 are indigenous to North America, 5 to China, and 1 to an area from southern Europe eastward to Afghanistan (Little 1979; Robertson and Lee 1976). Eastern redbud is widely distributed from southernmost Canada to central Mexico, spans about 24 degrees of longitude and 23 degrees of latitude, and has at least 1 well-defined variety, Texas redbud (table 1). This species shows clinal variation and substantial differences in morphological, dormancy, and hardiness characteristics associated with climatic and geographic conditions (Donselman 1976; Donselman and Flint 1982; Raulston 1990). California redbud also has variable characteristics (Smith 1986) within its much more restricted range in the southwestern United States. About 15 cultivars of eastern redbud have been developed and cultivars of other redbuds also are propagated (Raulston 1990).

Redbuds are deciduous, small- to medium-sized trees or shrubs with unarmed slender branchlets that lack terminal buds. Eastern redbud typically is a straight-trunked tree up to 12 m tall (table 2); the tallest one on record is 13.4 m (AFA 1996). Although they also reach tree size, California and Texas redbuds are more commonly described as multiple-stemmed shrubs. California redbud grows from 2 to 6 m tall; the tallest one on record is 8.8 m and the tallest Texas redbud is about the same (AFA 1996). Eastern redbud occurs on many soils in moist open woodlands, flood plains, river thickets, and borders of small streams, whereas the variety, Texas redbud, often inhabits drier locations, primarily paleozoic limestone formations such as xeric pastures, hills, outcrops, and bluffs (Hopkins 1942). California redbud is unevenly distributed at elevations of 70 to 1524 m along foothill streams, flats, draws, low slopes and canyons and on dry gravelly and rocky soils (Chamlee 1983; Jepson 1936; Sudworth 1908).

Redbuds are valued particularly for their showy buds and flowers that appear before the leaves (Clark and Bachtell 1992; McMinn and Maino 1937). They exhibit caulifloryCflowering directly along older branches and trunksCwhich is rare among temperate species (Owens and Ewers 1991) and contributes greatly to flowering showiness. Flowers typically are a deep reddish purple (magenta) but vary among localities (Coe 1993; Smith 1986) and species (table 3); some white ones occur naturally, and cultivars have been developed for particular colors (Raulston 1990). Ornamental uses are extensive within each species= indigenous range and several species have proven hardy more extensively (McMinn and Maino 1937; Robertson 1976). Where redbuds are numerous, they provide valued bee pasture in early spring (Magers 1970). The buds, flowers, and legumes (pods) of redbuds are edible and have been used in salads or batter (Coe 1993). Native Californians used the roots and bark of California redbud in basketry (Coe 1993; Jepson 1936); remedies for diarrhea and dysentery were also made from the astringent bark (Balls 1962).

Redbuds also are used for borders, erosion control, windbreaks, and wildlife plantings. Eastern redbud is browsed by white-tail deer (*Odocoileus virginiana*)and the seeds are eaten by birds, including bobwhite (*Colinus virginianus*) (Van Dersal 1938). California redbud is moderately important as fall and spring browse for deer, but has been rated fair to poor for goats and poor or useless for other livestock (Sampson and Jespersen 1963).

Two fungal diseases affect the flowering and attractiveness of eastern redbudCverticillium wilt (*Verticillium* sp.) and botryosphaeria canker (*Botryosphaeria dothidea* (Moug.:Fr.) Ces. & De Not.)Cby causing die-back of branches. The canker has become more common and destructive in the eastern United States, appearing to attack trees that are under stress (Geneve 1991a; Raulston 1990; Vining 1986).

Flowering and fruiting. Flowering occurs from February to May, varying somewhat by species and location (table 3). The bisexual redbud flowers are brilliant pink to reddish purple and develop on older wood from dormant axillary buds laid down 1 to several years earlier (Owens and Ewers 1991). The flowers are borne sessile or on short, thin pedicels in umbel-like clusters densely covering the branches and trunk. Flowers of California redbud are somewhat larger than those of eastern redbud (Hopkins 1942; Robertson 1976). Eastern redbud begins flowering in 3 to 4 years from seed when 1.5 to 2 m tall, and trees in open or semi-open locations flower most abundantly (Clark and Bachtell 1992; Raulston 1990). Pollination is usually done by long- and short-tongued bees (Robertson 1976). Crops of legumes are produced abundantly by both eastern and California redbud but seed set is more variable (Hopkins 1942; Jepson 1936).

Redbud fruits are pendulous, flattened legumes (figure 1) 4 to 10 cm long (table 2). The generic name *Cercis* (Greek *kerkis*, weaver=s shuttle) apparently alludes to the shape of the pod (Robertson and Lee 1976). The legumes of California redbud are somewhat wider and shorter than those of eastern redbud. Legumes of eastern redbud contain 4 to 10 seeds each; those of California redbud only a few (Hopkins 1942; Robertson 1976). Pod color varies from lustrous reddish brown to dull red and turns tan or brown as the fruits mature and dry in July or later. Some legumes open and release seeds in autumn, but many remain closed for most of the winter. Seeds may be released from legumes on the tree or on the ground by opening of pod sutures or decay of the walls (Robertson 1976). They are dispersed by wind, birds, and animals; the proportion by each can vary greatly by location.

Redbud seeds are somewhat flattened, oval to rounded, and hard (figures 1 and 2). Those of eastern redbud are 4 to 5 mm in diameter; those of California redbud are slightly smaller (table 2). The light tan to dark brown seedcoats are thin but made up of thick-walled cells impermeable to water (Afanasiev 1944). At maturity the embryo is straight, well-developed, and surrounded by endosperm (figure 2).

Collection, extraction, and storage. Legumes can be collected any time after they turn tan or brown. Although legumes remain closed on trees for lengthy periods, prompt collection is prudent to minimize the substantial seed losses that might occur from insects or other factors (Afanasiev 1944). Legumes can be picked by hand or loosened by flailing or shaking the branches and caught on ground cloths. Collected legumes are temporarily stored and transported in loosely woven sacks.

If legumes are not fully dry when collected, they should be spread thinly and dried until brittle in the sun, under shelter, or in a kiln at 38 to 41 °C. The legumes can be threshed manually or in a variable speed, modified seed macerator (such as a Dybvig cleaner), hammermill, or grinder. Seeds are separated from the chaff by screening and fanning. Nearly 100% purity is readily obtainable in cleaning the smooth redbud seeds (Lippitt 1996).

After thorough air-drying, seeds can be stored in cloth bags or in closed glass, metal, or fiberboard containers. Because of their impermeable seedcoat, redbud seeds should store dry reasonably well at room temperature or in cool or cold storage, but little storage experience has been reported. Zins (1978) obtained substantial germination from an eastern redbud seed lot stored for 13 years in a glass jar at -25 °C. Seeds of California redbud have been stored satisfactorily for 12 years or more under the same conditions as many conifers at a moisture content of 5 to 9% and temperature of -18 °C (Lippitt 1996).

Seeds of California redbud average about half again as heavy as those of eastern redbud but seed weight varies widely among lots for both species (table 4).

Pregermination treatments and germination tests. Redbud seeds generally require pregermination treatment to overcome dormancy attributable both to a hard, impermeable seedcoat and to some demonstrated (but not fully identified) embryo dormancy (Afanasiev 1944; Geneve 1991b; Hamilton and Carpenter 1975; Heit 1967a,b; Jones and Geneve 1995; Profumo and others 1979; Rascio and others 1998; Riggio-Bevilacqua and others 1985; Tipton 1992; Zins 1978). Test results indicate that the level of dormancy varies by species, seed source, seed lot, age of seed, and perhaps other factors. Given such variable dormancy, pretreatment might involve using the one demonstrated to be most broadly applicable, or determining sufficiently the nature of dormancy in local lots and applying a customized pretreatment.

Three pretreatments have proven satisfactory for overcoming redbud=s seedcoat impermeabilityCmechanical scarification, immersion in sulfuric acid, or in hot water (table 5). In comparison tests, the acid treatment has generally produced more consistent or slightly better results (Afanasiev 1944; Liu and others 1981), but good imbibition of water has resulted after all 3 treatments. Acid treatment involves immersing redbud seeds in concentrated sulfuric acid for 15 to 90 minutes at room temperature followed by thorough washing in water (Afanasiev 1944; Frett and Dirr 1979; Liu and others 1981). Length of treatment required can be determined on a small sample; if immersion is too short, seedcoats remain impermeable, if too long, the seeds are damaged. Well-rinsed, acid-scarified seeds can be placed immediately in stratification or surface dried and stored several months until sown by hand or seeder (Heit 1967a).

Abrading, clipping, or piercing the seedcoat to expose the endosperm and allow ready entry of water (Hamilton and Carpenter 1975; Riggio-Bevilacqua and others 1985; Zins 1978) can be done easily for small test lots but not as readily in quantity. Immersing small or large quantities of seed in hot or boiling water can be done easily, but results have been more variable than for acid treatmentCsometimes reasonably good (Fordham 1967; Mirov and Kraebel 1939), other times poor to mediocre (Afanasiev 1944; Liu and others 1981). Hot water treatment clearly makes redbud seedcoats permeable but may cause internal damage. Better calibration of timeBtemperature effects appears neededCwhether to dip the seeds for 15 or more seconds in boiling water or immerse them overnight in 60 to 88 °C water that cools gradually. Application of dry heat also appears to have promise (Williams 1949).

After scarification, cold stratification is generally required to overcome some degree of embryo dormancy and maximize seed germination. Germination differences between unstratified and cold-stratified seeds range from none (Hamilton and Carpenter 1975), to fractional differences in the response of excised embryos (Geneve 1991b), up to major differences for intact seeds (Afanasiev 1944; Fordham 1967; Frett and Dirr 1979; Geneve 1991b). Stratification of eastern redbud for 28 to 60 days at 1 to 7 ˚C has proven satisfactory (table 5) and 90 days for California redbud (Heit 1967a; Van Dersal 1938). Up to a point, seed response improves with longer stratification, and extended stratification generally does no harm. Seeds should be sown promptly after stratification; drying out for more than 6 days at room temperature reduced germination of eastern redbud seeds (Afanasiev 1944).

A pretreatment and germination test protocol has not yet been specified for redbud seeds due perhaps to extensive variability in seed lot characteristics, length of time required, and low demand for a standard test. Pretreated seeds of eastern redbud will germinate at temperatures of 1 to 38 ˚C; Afanasiev (1944) concluded 8 days at 21 ˚C was most satisfactory. Texas redbud seeds germinate at 24 to 31 ˚C; 28 ˚C was optimum (Tipton 1992). Germination test methods currently used for many speciesC14 to 28 days at alternating temperatures of 20 and 30 ˚CCseem to nicely bracket conditions that yielded high germination from pretreated redbud seeds (table 5).

Viability of redbud seeds is most easily and rapidly determined by a tetrazolium (TZ) test or a growth test of excised embryos. The TZ test is the only method prescribed by the International Seed Testing Association; preparation and evaluation procedures to use are listed in a published handbook (Moore 1985). In brief, the seeds are cut at the distal end of the cotyledons either dry or after overnight soaking in water at room temperature. Soaking in a 1% TZ solution follows for 6 to 24 hours at 35 ˚C. The embryos are then cut longitudinally, and the staining pattern of cotyledons, hypocotyl, and radicle evaluated. A growth test of excised embryos requires making the seedcoats permeable with acid, hot water, or mechanical scarification; soaking the seeds overnight, excising the embryos, and incubating them for 4 to 6 days on moist filter paper at 20 ˚C (Flemion 1941; Geneve 1991b). Viability determined by tetrazolium or excised embryo test reveals the seeds' maximum potential and generally is higher than indicated by a germination test (Flemion 1941; Hamilton and Carpenter 1975; USDA FS 1996).

Nursery practice. Redbuds are propagated most readily from seeds sown either in the fall or spring. Fall-sown seeds may or may not be scarified, and stratification occurs naturally in the seedbeds (Lippitt 1996; Raulston 1990). In one reported instance, immature seeds of eastern redbud collected, extracted, and sown before the seedcoats hardened yielded 90% germination the following spring (Titus 1940). When seeds are scarified for either fall or spring sowing, acid treatment for 15 to 60 minutes, rinsing, and a 24-hour soak in water; a boiling water dip for 15 seconds or more followed by a 24-hour soak in cooler water; or immersion overnight in 88 ˚C hot water that gradually cools; is generally used to overcome seedcoat dormancy (Frett and Dirr 1979; Heit 1967b; Lippitt 1996; Raulston 1990; Robertson 1976; Smith 1986). After scarified seeds have imbibed water, they may need to be sorted to separate those not swollen and still impermeable for further treatment. When necessary, seeds are stratified at 1 to 5 ˚C for 30 to 90 days. Stratification requirements are uncertain for 2 reasons: Variability among seed lots, and the unknown stratification effect produced by low temperature storage of the seeds.

Surface-dried seeds are drill or broadcast sown and covered 0.6 to 2.5 cm (3 to 1 in) deep with soil, sand, sawdust, or bark. Some nurseries fumigate, then reinoculate before sowing seedbeds. Presence of an endomycorrhizal fungus is important; inoculation with *Glomus fasciculatum* (Thaxter)

Gerdemann and Trappe has increased first-season growth of eastern redbud as much as 72% (Maronek and Hendrix 1978). Mulching of fall-sown beds can be beneficial but the mulch must be removed when germination starts. Germination is epigeal (figure 3).

Seedling return from nursery sowings is very variable. An average of 1,100 usable eastern redbud seedlings (range 280 to 3,200) were produced per pound of seed (Roy 1974). Germination is fairly consistent year to year for California redbud, averaging 54 to 60% (Lippitt 1996). Under favorable conditions, seedling height growth of eastern redbud can be rapid: about 0.5 m (20 in) in reinoculated soil (Maronek and Hendrix 1978), 1 m (40 in) or more under an intensive nitrogen fertilizer schedule, and about 2 m (80 in) if started in January in a greenhouse under long-day conditions and transplanted outdoors after the danger from frost is over (Raulston 1990).

Redbud seedlings are also produced in pots and tube containers in both greenhouses and shadehouses where production practices and growth conditions can be closely controlled. To gain the benefits of natural stratification, containers may be sown in the fall and overwintered in shadehouses. Treatments to prevent botrytis are necessary soon after late February germination of California redbud (Lippitt 1996). Seedlings suitable for outplantingC15 to 30 cm (6 to 12 in)Ccan be produced readily in one season (Clark and Bachtell 1992; Lippitt 1996).

Redbuds are relatively difficult to propagate vegetatively, but that must be done to produce the desired cultivars. Redbud cultivars are generally budded or grafted. Field-grown stock is easier to bud then container-grown stock, and summer budding is much more successful then winter budding (Raulston 1990). Much effort and some progress has been reported on reproducing redbud from stem cuttings (Tipton 1990) and tissue cultures (Bennett 1987; Geneve 1991a; Mackay and others 1995).

Literature cited

Abrams L. 1944. Illustrated flora of the Pacific States. Volume 2, Polygonaceae to Krameriaceae. Stanford, CA: Stanford University Press. 635 p.

Afanasiev M. 1944. A study of dormancy and germination of seeds of *Cercis canadensis.* Journal of Agricultural Research 69(10): 405B420.

AFA [American Forestry Association]. 1996. 1996B97 National register of big trees. American Forests 102(1): 20B51.

Balls EK. 1962. Early uses of California plants. Berkeley: University of California Press. 103 p.

Bennett L. 1987. Tissue culturing redbud. American Nurseryman 166(7): 85B91.

Chamlee H. 1983. The redbud in southern California. Fremontia 10(4): 27.

Clark R, Bachtell KR. 1992. Eastern redbud (*Cercis canadensis* L.). Morton Arboretum Quarterly 28(1): 6B10.

Coe FW. 1993. Redbuds and Judas trees. Pacific Horticulture 54(2): 37B41.

Donselman HM. 1976. Variation in native populations of eastern redbud (*Cercis canadensis* L.) as influenced by geographic location. Proceedings of the Florida State Horticultural Society 89: 370B373.

Donselman HM, Flint HL. 1982. Genecology of eastern redbud (*Cercis canadensis).* Ecology 63(4): 962B971.

Fernald ML. 1950. Gray=s manual of botany. 8th ed. New York: American Book Company. 1632 p.

Flemion F. 1941. Further studies on the rapid determination of the germinative capacity of seeds.

Contributions from Boyce Thompson Institute 11: 455B464.
Fordham AJ. 1967. Hastening germination of some woody plant seeds with impermeable seed coats. Combined Proceedings of the International Plant Propagators= Society 17: 223B230.
Frett JL, Dirr MA. 1979. Scarification and stratification requirements for seeds of *Cercis canadensis* L., (redbud), *Cladrastis lutea* (Michx. F.) C. Koch (yellowwood), and *Gymnocladus dioicus* (L.) C. Koch (Kentucky coffee tree). Plant Propagator 25(2): 4B6.
Geneve RL. 1991a. Eastern redbud (*Cercis canadensis* L.) and Judas tree (*Cercis siliquastrum* L.). Biotechnology in Agriculture and Forestry 16: 142B151.
Geneve RL. 1991b. Seed dormancy in eastern redbud (*Cercis canadensis*). Journal of the American Society for Horticultural Science 116(1): 85B88.
Hamilton DF, Carpenter PL. 1975. Regulation of seed dormancy in *Cercis canadensis* L. Journal of the American Society for Horticultural Science 100(6): 653B656.
Heit CE. 1967a. Propagation from seed: 6. Hardseededness: a critical factor. American Nurseryman 125(10): 10B12, 88B96.
Heit CE. 1967b. Propagation from seed: 8. Fall planting of fruit and hardwood seeds. American Nurseryman 126(4): 12B13, 85B90.
Hopkins M. 1942. *Cercis* in North America. Rhodora 44: 193B211.
Hosie RC. 1969. Native trees of Canada. 6th ed. Ottawa: Canadian Forestry Service, Department of Fisheries and Forestry. 380 p.
Jepson WL. 1936. A flora of California. Volume 2, Capparidaceae to Cornaceae. Berkeley: University of California. 684 p.
Jones RO, Geneve RL. 1995. Seedcoat structure related to germination in eastern redbud (*Cercis canadensis*). Journal of the American Society for Horticultural Science 120(1): 123B127.
Lippitt L. 1996. Personal communication. Davis, CA: California Department of Forestry and Fire Protection, Lewis A. Moran Reforestation Center.
Little EL Jr. 1979. Checklist of United States trees, native and naturalized. Agric. Handbk. 541. Washington, DC: USDA Forest Service. 375 p.
Liu NY, Khatamian H, Fretz TA. 1981. Seed coat structure of three woody legume species after chemical and physical treatments to increase seed germination. Journal of the American Society for Horticultural Science 106(5): 691B694.
Mackay WA, Tipton JL, Thompson GA. 1995. Micropropagation of Mexican redbud, *Cercis canadensis* var. *mexicana*. Plant Cell, Tissue and Organ Culture 43: 295B297.
Magers AW. 1970. Honey plants of the Missouri Valley. American Bee Journal 110(1): 94.
Maronek DM, Hendrix JW. 1978. Mycorrhizal fungi in relation to some aspects of plant propagation. Combined Proceedings of the International Plant Propagators= Society 28: 506B514.
McMinn HE. 1939. An illustrated manual of California shrubs [1970 printing]. Berkeley: University of California Press. 663 p.
McMinn HE, Maino E. 1937. An illustrated manual of Pacific Coast trees. Berkeley: University of California Press. 409 p.
Mirov NT, Kraebel CJ. 1939. Collecting and handling seeds of wild plants. Forestry Publ. 5. Washington, DC: USDA Forest Service, Civilian Conservation Corps. 42 p.
Moore RP, ed. 1985. Handbook on tetrazolium testing. Zurich: International Seed Testing Association. 99 p.

Munz PA, Keck DD. 1959. A California flora. Berkeley: University of California Press. 1681 p. [with 1968 supplement, 224 p].

Owens SA, Ewers FW. 1991. The development of cauliflory in redbud, *Cercis canadensis (Fabaceae*). Canadian Journal of Botany 69: 1956B1963.

Profumo P, Gastaldo P, Martinucci R. 1979. On the inhibitory action of endosperm on germination of *Cercis siliquastrum* seeds. Experientia 35(11): 1452B1453.

Rascio N, Mariani P, Dalla Vecchia F, La Roccha N, Profumo P, Gastaldo P. 1998. Effects of seed chilling or GA_3 supply on dormancy breaking and plantlet growth in *Cercum siliquastrum* L. Plant Growth Regulation 25(1): 53-61.

Raulston JC. 1990. Redbud. American Nurseryman 171(5): 39B51.

Riggio-Bevilacqua L, Roti-Michelozzi G, Serrato-Valenti G. 1985. Barriers to water penetration in *Cercis siliquastrum* seeds. Seed Science and Technology 13: 175B182.

Robertson KR. 1976. *Cercis*: the redbuds. Arnoldia 36(2): 37B49.

Robertson KR, Lee YT. 1976. The genera of Caesalpinioideae (Leguminosae) in the southeastern United States: 8. *Cercis Linnaeus*. Journal of the Arnold Arboretum 57: 48B53.

Roy DF. 1974. *Cercis* L., redbud. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 305B308.

Sampson AW, Jespersen BS. 1963. California range brushlands and browse plants. Publ. 4010. Oakland: University of California, Division of Agriculture and Natural Resources. 162 p.

Sargent CS. 1933. Manual of the trees of North America (exclusive of Mexico). 2nd ed. Cambridge, MA: Riverside Press. 910 p.

Smith N. 1986. Growing natives: more from the chaparral. Fremontia 14(3): 34B35.

Sudworth GB. 1908. Forest trees of the Pacific slope. Washington, DC: USDA Forest Service. 441 p.

Tipton JL. 1990. Vegetative propagation of Mexican redbud, larchleaf goldenweed, littleleaf ash, and evergreen sumac. HortScience 25(2): 196B198.

Tipton JL. 1992. Requirements for seed germination of Mexican redbud, evergreen sumac, and mealy sage. Hortscience 27(4): 313B316.

Titus GR. 1940. So-called 2-year seeds germinated first year. American Nurseryman 72(11, Dec.1): 22.

USDA FS [USDA Forest Service]. 1996. Unpublished data. Dry Branch, GA: USDA Forest Service, National Tree Seed Laboratory.

Van Dersal WR. 1938. Native woody plants of the United States: their erosion-control and wildlife values. Misc. Publ. 303. Washington, DC: U.S. Department of Agriculture. 362 p.

Vining D. 1986. Redbud. Horticulture 64(4): 26B29.

Williams M. 1949. Germination of redbud seeds. Journal of the California Horticultural Society 10(2): 70B72.

Zins ME. 1978. A study of seed viability and imbibition in eastern redbud (*Cercis canadensis* L.). Plant Propagator 24(2): 4B6.

Table 1C *Cercis,* redbud: nomenclature and occurrence

Scientific name & synonym	Common name	Occurrence
C. canadensis **L.**	**eastern redbud**, redbud, Judas-tree E to Florida	Connecticut W to S Ontario, Michigan, Iowa, & E Nebraska; S to Texas & central Mexico;
C. canadensis **var.** ***texensis*** **(S. Wats.) M. Hopkins**	**Texas redbud,** Mexican redbud	Southern Oklahoma to SE New Mexico, S to Texas & east-central Mexico
C. occidentalis **Torr. ex Gray** *C. orbiculata* Greene	**California redbud**, Arizona redbud, western redbud	Utah, Nevada, California, & Arizona

Sources: Clark and Bachtell (1992), Hopkins (1942), Hosie (1969), Little (1979), Robertson and Lee (1976), Sargent (1933).

Table 2C *Cercis,* redbud: growth habit, height, legume color, and size

Species	Growth habit	Height at maturity (m)	Legume color	Legume size Length (cm)	Width (mm)	Seed diam. (mm)
C. canadensis	Tree or shrub	7B12	Reddish brown	5B10	8B18	4B5
C. canadensis var. *texensis*	Shrub or tree	4B10	Reddish brown	6B10	8B25	4B5
C. occidentalis	Shrub or tree	2B6	Reddish purple, dull red, to reddish brown	4B9	13B25	3B4

Sources: Fernald (1950), Hopkins (1942), Hosie (1969), Jepson (1936), McMinn (1939), Munz and Keck (1959), Sargent (1933).

Table 3C*Cercis,* redbud: phenology of flowering and fruiting

Species	Flowering	Flower color	Fruit ripening
C. canadensis	MarBMay	MagentaBpurplish pink	JulyBearly autumn
C. canadensis var. *texensis*	MarBApr	Magenta pink	AugBSept
C. occidentalis	FebBMay	Magenta pinkBreddish purple	JulyBSept

Sources: Abrahms (1944), Clark and Bachtell (1992), Fernald (1950), Hopkins (1942), Jepson (1936), Mirov and Kraebel (1939), Van Dersal (1938).

Table 4C*Cercis,* redbud: seed yield data

	Seeds/100 wt	Seed wt/legume vol		Average cleaned seeds/wt		
Species	of legumes	kg/hl	lb/bu	/kg	/lb	Samples
C. canadensis	20B35	C	C	39,570	17,950*	18
C. occidentalis	44	2.10	1.64	27,460	12,455H	24

Sources: Lippitt (1996), Roy (1974), USDA FS (1996).
* Range = 30,870B55,100/kg, 14,000B25,000/lb.
H Range = 20,950B40,100/kg, 9,500B18,169/lb.

Table 5C *Cercis,* redbud: scarification, stratification, germination test conditions, and test results*

	Scarification		Stratification		Germination test conditions				
Species	Treat.	Time (min)	Days	Temp (°C)	Medium	Temp (°C)	Days	Germination (%)	Samples
C. canadensis	H_2SO_4	45	Var.	5	Peat	C	48	77	2
	H_2SO_4	45	Var.	5	Peat	C	107	78	2
	H_2SO_4	30	42	5	Cotton	21	8	97	2
	H_2SO_4	25B30	35B91	3-7	Cotton	C	C	88B100	7H
	H_2SO_4	30	60	5	Sand	20B30	30	80	2
	Mech.	C	60	5	PeatBperlite	25	24	90	5
	H_2SO_4	30	60	5	PeatBperlite	25	24	88	5
	Mech.	C	C	C	PeatBperlite	25	24	82	5
	H_2SO_4	30	C	C	PeatBperlite	25	24	91	5
	H_2SO_4	15B60	60	5	Vermiculite	18B21	42	87	3
	H_2SO_4	30B90	60	5	Soil	20B27	14	67B72	12
	C	C	0	1	Paper	20B30	28	43	1
	C	C	28	1	Paper	20B30	28	83	1
C. canadensis	H_2SO_4	62	35	5	Paper	21	14	95	25I
var. *texensis*	H_2SO_4	62	35	5	Paper	28	14	100	81I
C. occidentalis	Heat'	Overnight	C	C	Vermiculite	C	118	38	1
	Heat|	9	C	C	Vermiculite	C	118	52	1
	H_2SO_4	60	90	2B4	Cotton	C	10	84	1

Sources: Afanasiev (1944), Flemion (1941), Frett and Dirr (1979), Hamilton and Carpenter (1975), Heit (1967a), Liu and others (1981), Roy (1974), Tipton (1992), USDA FS (1996), Williams (1949).

* Only the better results for each test series are listed. In several studies, only full seeds were tested.
H Best results from a set of tests on each of 7 seed lots.
I Test combinations used to develop a response surface.
' Moist heat applied by immersing seeds in 82 °C water that cooled gradually.
| Dry heat applied in oven at 121 °C.

Figure 1C*Cercis canadensis*, eastern redbud: 4 to 10 seeds (A, × 10) are in each legume (B, × 1).

Figure 2C*Cercis canadensis*, eastern redbud: the flattened seed in transverse section (above) and longitudinal section (below), × 10.

Figure 3 C*Cercis occidentalis*, California redbud: young seedlings grow rapidly, first leaf stage (left), about 1 month old (right).