

Salvia L.

sage

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Growth habit, occurrence, and use. The sage genus—*Salvia*—contains about 700 species of annual and perennial herbs and shrubs and is worldwide in distribution. There are perhaps 20 woody species in the United States, principally in the Southwest and California (table 1) (Correll and Johnson 1970; Munz and Keck 1959). They are intricately branched, rounded or sprawling shrubs or subshrubs with often leathery, opposite leaves. The foliage is usually strongly aromatic. Members of the sage genus are used medicinally and as culinary herbs; many of the native species have been locally adopted for these uses. Native sages are often fast-growing and freely reseed themselves onto disturbed lands (Keeley and Keeley 1984). They could be useful in the stabilization of disturbed land. Several California species are dominant components of coastal sage scrub communities and are also significant in chaparral. They also head the list of wild California bee plants for honey production (Jepson 1951). In addition, sages are showy in flower and have interesting foliage, giving them great potential as ornamentals for low-water-use landscaping (ANPS 1990). Most are native to warm winter areas, but Dorr sage occurs throughout the Great Basin and is quite cold hardy.

Flowering and fruiting. Sages tend to flower after the principal rainy season. Thus California and Mojave Desert species are spring-flowering, whereas Sonoran and Chihuahuan Desert species are usually late summer-flowering. The flowers are often large and showy, borne in interrupted spikes or terminal heads, and attractive to many native bees and other pollinators. The corollas are strongly 2-lipped and range from white through red, blue, or violet in color, depending on the species. The superior ovary is deeply 4-lobed, and after fertilization it develops into 4 easily separable nutlets that ripen within the papery calyx cup. Fruits toward the base of each inflorescence ripen first, perhaps 2 to 3 weeks earlier than those at the upper end (Nord and Gunter 1974). The nutlets usually ripen about 6 weeks after full flower. Each nutlet contains a single seed. The ripened nutlets are shaken from the plant by wind or raindrops. Once on the ground they may be eaten by ants, rodents, or birds. They have no special mode of dispersal.

Seed collection, cleaning, and storage. The procedures of Nord and Gunter (1974) for the harvest, cleaning, and storage of Sonoma sage could probably be applied to most shrubby species. The seeds are harvested by clipping, hand-stripping, or beating into containers as soon as nutlets can be dislodged from the lower parts of the inflorescences. These early seeds are apparently larger and of better quality than those produced later in the season. If harvesting is delayed, most of the crop could be “stormed-off” and lost. The harvested material should be thoroughly dried and passed through a hammermill or barley de-bearder. Small lots may be

hand-rubbed. The seeds may then be cleaned-out by screening or with a fanning mill. For creeping sage, a #1 (1-mm) screen retained a high proportion of filled nutlets while allowing most unfilled nutlets to pass through. The optimal screen size for this purpose will depend on species and possibly on the seedlot (table 2). Fill percentage can be increased by blowing or screening out smaller nutlets, so that this value is somewhat an artifact of the cleaning procedure. The importance of high fill depends on the intended use of the seedlot. The reported weights for individual nutlets of different species vary from 0.8 to 2.4 mg, and number of seeds per weight varies from 416,750 to 1,250,230/kg (189,000 to 567,000/lb) (table 2).

Sage species may form persistent seedbanks in the field (Keeley and Keeley 1984; Malanson and O'Leary 1982), so it is likely that they remain viable for considerable periods in dry storage (orthodox behavior). Kay and others (1988) reported that seeds of Dorr and white sages showed little loss of viability during 5 to 7 years of sealed warehouse or 4 EC storage, whereas in unsealed warehouse storage (where moisture levels were allowed to fluctuate) some loss of viability was observed. Nord and Gunter (1974) reported no loss of viability for seeds of creeping sage stored at 4 EC for over 2 years.

Germination and seed testing. Seeds of shrubby sage species are generally relatively easy to germinate (table 3). Seed collections of cis-montane California and desert species generally contain a readily germinable fraction (Kay and others 1988; Keeley 1986, 1987)), whereas seeds of other species, such as creeping sage, may have a chilling requirement (Nord and Gunter 1974). A desert population of black sage showed increased germination in the light in response to heat shock treatments (1 or 5 hours at 70 EC or 5 minutes at 115 EC) that may have simulated summer soil heating (Keeley 1986). Seeds of desert populations of the related annual species chia—*S. columbariae* Benth.—are known to have an after-ripening requirement that is met more quickly at high temperatures (Capon and others 1978). White sage is also reported to respond positively to heat shock (Keeley 1987, 1991). Coastal sage scrub and chaparral populations of black sage germinated well in light without pretreatment but required a charate stimulus (a leachate made from charred wood) to germinate in the dark (Keeley 1986). This response is apparently an adaptation that permits seedlings to germinate and establish from persistent seedbanks after wildfire (Keeley 1986). Chilling and alternating temperature regimes sometimes increased germination percentages for black sage, but the results were inconsistent (Keeley 1986). Kay and others (1988) reported that a seedlot of Dorr sage germinated to 28% at 15 EC in the dark after a summer of warehouse storage and that its germination increased to 53% after 5 years in storage, suggesting that seeds of this species also have a dry after-ripening requirement. They obtained a similar increase (from 19% to 43%) for seeds of white sage during a single year of warehouse storage. Sage seed dormancy that is overcome in nature by either dry after-ripening or chilling may be circumvented through a 1-hour soak in gibberellic acid (GA)—100 to 500 ppm (Nord and Gunter 1974) and 400 ppm (Emery 1988). The seeds may be dried for sowing following the GA treatment.

For recently harvested seedlots of sage species, a cut test is a good indicator of viability. Tetrazolium (TZ) staining may also be used, either to evaluate the viability of ungerminated seeds at the end of a germination test or in lieu of a germination test. Belcher (1985) recommends the following procedure for the herbaceous blue sage, *S. azurea* Michx. ex Lam.: soak seeds overnight in water, clip at cotyledon end, place in 1% TZ solution for 6 hours and then slice them lengthwise for evaluation. The embryo in sage seeds is well-developed and fills

the seed cavity, but the endosperm is rudimentary or absent. Until more specific recommendations can be made, a generic germination test for shrubby sage species (as recommended for blue sage) is incubation at 15/25 EC or 20/30 EC in the light, with first count at 7 days and last count at 21 days and with post-test viability evaluation as described above.

Field seeding and nursery practice. Shrubby sage species can be direct-seeded in early to late fall in winter rainfall areas such as cis-montane and coastal California (Emery 1988). Sonoran and Chihuahuan Desert species would probably best be seeded before summer rains. Sages are often early seral species adapted to disturbance and establish more readily if seeded in the absence of heavy herbaceous competition (Nord and Gunter 1974). Spring-seeding of chilled or GA-treated seeds was recommended for creeping sage, on the argument that rodent predation would be decreased and that field chilling conditions were unreliable (Nord and Gunter 1974).

Shrubby sages are readily produced from seed as container stock in a nursery setting. In California, seeds are sown outdoors in flats in early fall (Emery 1988). More dormant seedlots may be treated with GA or subjected to a chilling treatment before sowing. Seedlings are then transplanted to larger containers when at the 6- to 8-leaf stage. Sages may also be direct-seeded or planted as germlings in tube containers such as those used for conifer seedling production.

References

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Figure 1—*Salvia sonomensis*, creeping sage: nutlet, H 12.

Figure 2—*Salvia sonomensis*, creeping sage: longitudinal section through a seed, H 20.

Table 1—*Salvia*, sage: nomenclature, habit, habitat, and geographic distribution

Scientific name	Common name(s)	Habit	Habitat	Geographic distribution
<i>S. apiana</i> Jepson	white sage	Subshrub	Coastal sage scrub, chaparral, ponderosa pine forest, warm desert shrub margins	Coastal & cis-montane S California S to Baja California
<i>S. dorrii</i> (Kellogg) Abrams	Dorr sage, purple sage	Shrub	Warm & cold desert shrub communities, piñon–juniper woodland	W Washington to SE California, Arizona, Utah, & Idaho
<i>S. mellifera</i> Greene	black sage	Subshrub	Coastal sage scrub, chaparral, warm desert shrub margins	Coastal & cis-montane central California S to Baja California
<i>S. sonomensis</i> Greene	creeping sage	Mat-forming suffrutescent	Chaparral, oak woodland, ponderosa pine forest	Coastal & cis-montane California, mostly in N

Source: Munz and Keck (1959).

Table 2—*Salvia*, sage: Seed weights and maximum germination percentages

Species	Seed weight		Seeds/weight		Maximum germination %
	mg	oz	/kg	/lb	
<i>S. apiana</i>	1.4	.05	714,420	324,000	42
<i>S. apiana</i>	1.9	.07	511,560	233,000	43
<i>S. dorrii</i>	2.4	.08	416,750	189,000	53
<i>S. mellifera</i>	1.1	.04	910,660	413,000	69
<i>S. sonomensis</i>	1.5	.05	685,750	311,000	90
<i>S. sonomensis</i>	0.8	.03	1,212,750	550,000	70

Sources: Kay and others (1988), Keeley (1986, 1987), Nord and Gunter (1974).

Table 3—*Salvia*, sage: seed germination responses to pretreatments and incubation conditions

Species	<u>Germination pretreatment or condition</u>						GA
	Light	Alternating temp	Chilling	Heat shock	Dry storage	Charate	
<i>S. apiana</i>	+	+	+	+	+	nd	+
<i>S. dorrii</i>	nd	nd	nd	nd	+	nd	nd
<i>S. mellifera</i>	+	+	+	+	nd	+	+
<i>S. sonomensis</i>	nd	nd	+	nd	nd	nd	+

Sources: Emery (1988), Kay and others (1988), Keeley (1986, 1987), Nord and Gunter (1974).
nd = no data; see text for details.