# NATIVE FORB SEED PRODUCTION

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As more conservationists in prairie states attempt large-scale prairie restorations, the question has become "Where can I get native wildflower seed and how much does it cost?" Before an answer to that question becomes available, we must learn how to manage uniform stands of single species for seed production.

Over the past ten years, the Soil Conservation Service (SCS) has cooperated with state universities and agencies in investigating the potential of using wildflowers in conservation plantings. The work of the Manhattan Plant Materials Center (PMC) has been documented by Jacobson (1975), Dickerson and Hadle (1977), and Salac et al. (1978). To provide seed for evaluation and testing of Kansas ecotypes, small-scale seed production was started. We have now had experience in large-scale mechanical planting and harvesting seeds of *Petalostemum, Salvia, Echinacea, Ratibida, Liatris, Asclepias, Heliopsis, Helianthus, Lespedeza*, and *Desmanthus*. Small-scale harvests have been made of *Silphium, Penstemon,* and *Baptisia*. Other genera have been studied but are not beyond the single-row, hand-maintenance stage.

According to unpublished SCS records for Kansas, an average of 16,843 ha (41,600 acres) per year have been seeded with native grasses since 1946 (Soil Conservation Service, 1946-1977). Forb seeding amounting to 37,800 kilograms (assuming 2.28 bulk kilograms/ha or 2 lb/acre average rate) could have been included in the grass mixes. To provide this amount of forb seed, hit-and-miss field harvesting operations would not have sufficed.

Growing and harvesting forbs requires more attention than the native grasses because of different sizes of plants and wide range in growth requirements. Species such as purple prairie clover *(Petalostemum purpureum)* and butterfly milkweed *(Asclepias tuberosa)* are injured by damping-off and root rot fungi. Shell-leaf penstemon *(Penstemon grandiflorus)* and Illinois bundleflower *(Desmanthus illinoiensis)* are both short-lived in solid stands for reasons that are unknown. Harvesting of Maximilian sunflower *(Helianthus maximilianii)* requires height reduction to avoid seed loss by the combine. Many insects are associated with the life cycles of forbs as pollinators and predators. The wind-pollinated grasses do not have such extensive differences in management requirements. Though most species of forbs grown at Manhattan PMC require specific care during part of their life cycle, all share some common management practices. In discussing this management, we are reporting techniques used on our Haynie very fine sandy loam and Eudora silt loam soils (Jantz et al., 1975). Both are deep, well-drained soils suited to most crops.

## FIELD ESTABLISHMENT

Site preparation is more important with forbs than with grasses because we do not have a suitable herbicide for removing grasses from broadleaf plantings. These plantings should be made on a well prepared, weed-free seedbed. Fallowing for the two preceding growing seasons is highly desirable for weed control and the breakdown of herbicide residue. Perennial weeds, especially rhizomatous ones, are very difficult to control in a stand of forbs. Control before planting is far preferable for species such as bermudagrass *(Cynodon dactylon)*, yellow nutsedge *(Cyperus esculentus)*, and field bindweed *(Convolvulus arvensis)*.

Soil tests should be made to establish levels of available macronutrients, pH, and organic matter. Moderate levels of available phosphorus (28.5 kg/ha or 25 lb/acre) and potassium (171 kg/ha or 150 lb/acre) are desirable, while low levels of nitrogen (10 ppm or less of nitrate and ammonia) are advisable to reduce the potential for disease. Soil pH should be in the range of 6-7 to approximate the native condition. Damping-off may be reduced by maintaining a pH on the low end of this range. The organic matter content of the soil should be maintained by growing green manure crops during the years between forb crops. Reduction of the soil organic matter may occur because of the yearly removal of the forb crop residue. However, this removal is prudent to reduce insect and disease buildup. We have no experience to date with respect to micronutrient level requirements for forb seed production.

Optimum plant densities for maximum seed production have not been established. Future work may include such studies, but for now we are using 100 pure live seed/m (30 pure live seed/foot) as a target seeding rate. We suspect that very dense plant populations are conducive to disease and lower seed yield.

Whether spring- or fall-planted, all species may require irrigation to initiate timely germination if a dry winter and spring occur (Table 1). Almost all spring plantings are irrigated during the summer while fall-planted species must be irrigated only under very dry conditions. As implied earlier, soil moisture conditions are critical for prairie clovers during germination. Since damping-off organisms readily attack the new seedlings, irrigation should be avoided between the onset of germination and the 5- or 6-leaf stage. Morning watering is recommended and is practiced in tree nurseries where damping-off is a common problem (Williams and Hanks, 1976). Butterfly milkweed and Illinois bundleflower may also be vulnerable to overwatering. A 0.1 ha field of butterfly milkweed was lost to root rot during the third growing season, 1977, which was very wet. A 3-year-old stand of bundleflower failed to emerge during the spring of 1978. Sunflower heliopsis *(Heliopsis helianthoides)* wilts at the onset of dry weather but recovers well if promptly irrigated.

Slow seedling development prolongs the period of susceptibility to stress and greater injury is likely from insects, disease, water, wind, and cultivation. A correlation exists between seedling vigor and time until the first seed harvest is realized. Species with low seedling vigor such as butterfly milkweed, echinacea *(Echinacea* spp.), roundhead lespedeza *(Lespedeza capitata)*, Stueve's lespedeza *(L. stuevei)*, liatris (*Liatris* spp.), the prairie clovers (*Petalostemum* spp.), and grayhead prairieconeflower *(Ratibida pinnata)* do not produce seed during the establishment year (Table 1). In contrast, Illinois bundleflower, Maximilian sunflower, and pitcher sage *(Salvia pitcheri)* have good seedling vigor and often produce their best seed crops during the first year.

The mature size of most of the species in Table 1 precludes mechanical cultivation with standard farm equipment past the eighth week of the growing season during postestablishment years. The high cost of hand labor makes the use of selective preemergent herbicides attractive. At the present time no herbicides are registered for use in native forb seed production, but some are registered for use on broad-leaved herbaceous plants such as vegetables and soybeans. In a 4-year study (unpublished data) carried out at the Manhattan PMC in cooperation with Dr. Charles Long, assistant professor of ornamental horticulture, Kansas State University, three commonly used chemicals were determined to be compatible with selected native forb species at certain rates. When the forb crop is completely dormant, winter annuals such as henbit *(Lamium amplexicaule)* and evening primrose *(Oenothera biennis)* can be controlled with contact herbicides.

Fire is not useful for removing the forb residue because it is insufficient for burning. With some species a slow fire might carry through the stand, but a slow fire can result in damage by generating hotter soil temperatures. Anderson et al. (1970) related vegetative composition changes to timing of fire in the tallgrass prairie where late burns reduced the number of forbs. No work has been reported relating fire effects on single species stands. Mowing and baling of the crop residue in early spring reduces the number of harmful organisms that have overwintered in the stems and leaves. This method is preferred, but some species do not have sufficient residue for baling by spring; Stueve's lespedeza and butterfly milkweed are in this group. Spring baling is preferred because it allows the residue to remain as cover through the winter. In some years Maximilian sunflower residue is coarse enough to cause problems with baling. Shredding the stems with a rotory mower and rototilling the stubble in both fall and spring have been satisfactory at Manhattan PMC, but these techniques may not work in drier locations where decomposition would be slower.

## HARVESTING

Harvesting forb seed with a combine requires the same equipment and knowledge of the crop as grass seed. The range in seed sizes if not textures is greater for the forbs than for the grasses (Fig. 1). Combine settings that apply to Allis-Chalmers-72 and John Deere-45 combines[1] are listed in Table 2. We view these settings as a starting point, and each year's crop requires some fine tuning. Pickup guards are useful with most crops and necessary with those that lodge, such as gayfeather.

One of the most challenging aspects of harvesting native forbs is timing the harvest. Butterfly milkweed must be combined when the seed turns a uniform dark brown inside the pods which are still green. The seed pods dry and split within a few days after seed turns brown

[1]Trade names are used solely to provide specific information. Mention of a trade name does not constitute a guarantee of the product by the U.S. Department of Agriculture nor does it imply an endorsement by the Department over comparable products that are not named.

**Table 1.** Forb culture in solid stands.

| | Seeding Date | Planting Depth (mm) | Row Spacing (m) | Seedling Development | Size 1st Year (m) | Years To Maturity | Size 2nd Year (m) | Dormancy Period | Stand Longevity (years) |
|---|---|---|---|---|---|---|---|---|---|
| *Asclepias tuberosa* | May | 6 | 0.6-1.0 | Slow | 0.2-0.3 | 2 | 0.6-0.8 | Oct-May | 3 |
| *Desmanthus illinoensis* | May | 12 | 0.8-1.0 | Moderate | 1.3 | 1 | 1.3-1.5 | Oct-Apr | 3 |
| *Echinacea pallida/E. angustifolia* | Nov | 12 | 0.8-1.0 | Slow | 0.1-0.3 | 2-3 | 0.6-1.0 | None | 5+ |
| *Helianthus maximilianii* | May | 12 | 1.8-2.6 | Rapid | 2.0-2.6 | 1 | 2.6-3.9 | Nov-Apr | 5+ |
| *Heliopsis helianthoides* | Mar | 6 | 0.8-1.0 | Rapid | 1.3 | 1 | 1.3-1.5 | Oct-Apr | 5+ |
| *Lespedeza capitata* | May | 12 | 0.6-1.0 | Slow | 0.1-0.5 | 2 | 0.6-1.0 | Oct-May | 5+ |
| *L. stuevei* | Jun | 6 | 0.3-0.6 | Slow | 0.1-0.3 | 2 | 0.3-0.5 | Oct-May | 5+ |
| *Liatris pycnostachya* | Mar | 6 | 1.0-1.2 | Slow | 0.1-0.3 | 2 | 1.1-1.7 | Oct-Apr | 5+ |
| *Petalostemum purpureum* | Apr | 12 | 0.8-1.0 | Slow | 0.1-0.3 | 2 | 0.6-1.0 | Oct-Apr | 5+ |
| *Ratibida pinnata* | Apr | 12 | 0.8-1.0 | Moderate | 0.3-0.4 | 2 | 1.0-1.3 | Nov-Apr | 5+ |
| *Salvia pitcheri* | Apr | 12 | 0.8-1.0 | Rapid | 1.0-1.3 | 1 | 1.1-1.4 | Nov-Apr | 5+ |

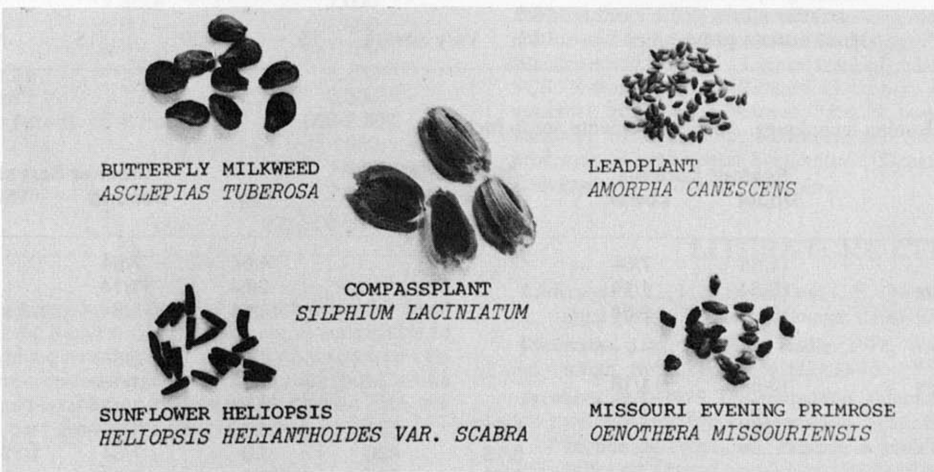


**Figure 1.** Range of seed sizes and shapes of selected forb species.

and the recoverable yield drops rapidly with time because the seed becomes airborne inside the machine and floats away. Maximilian sunflower maturity coincides with average first frost at Manhattan PMC. After frost, seed loss can occur rapidly because of wind shatter or large flocks of migrating birds. Failure to conduct a height-reducing mowing, about June 1, results in the sunflower becoming too tall and in excessive shatter loss during combining. Pitcher sage shatters immediately upon ripening if there is even a moderate breeze. Delay of a day will allow the crop to be lost, so very close observation is necessary.

Grayhead prairie coneflower and echinacea are examples of easily harvested forbs. Combining should be delayed until seed shatter begins, then rapidly executed. Failure to wait for seed shattering to begin allows a high percentage of the very hard seedheads to pass through the combine without being separated from the stems and knocked apart.

Drying the harvested crop requires artificial methods at Manhattan PMC. The seed is sacked in burlap bags and immediately placed on a drying apparatus that forces heated air (40°C) through the bags. Typical drying times are given in Table 2. Seed can also be dried by spreading it on a dry concrete floor and stirring two or more times a day, but this method takes longer.

## SEED CLEANING

Forb seed can be cleaned with a hammer mill and a two-screen fanning mill provided that a wide assortment of screen opening sizes and shapes are available. A general scalping operation is advisable before hammer milling. When harvesting is well-timed and the combine properly set, hammer milling is unnecessary for six of the eleven crops listed in Table 3. The screen sizes listed in Table 3 are to be used as a guide. Yearly fluctuations in seed size, trashiness, weed populations, and harvest precision will require changes in screen selection. The range of seed yield and quality of 11 forb species grown at Manhattan are listed in Table 4. These data were obtained under the rigorous cleanliness standards associated with foundation seed production. Some seed was sacrificed during the weeding, combining, and cleaning procedures that could have been retained at other levels of production.

## EQUIPMENT AND LABOR NEEDS

The basic equipment required for handling forb seed production is given in Table 5. The area that can be maintained in forb seed production with this equipment will vary with the crops grown and the

**Table 2.** Forb seed harvest techniques.

| | Harvest | Harvest Date | Shattering | Concave Clearance (mm) | Cylinder (rpm) | Air Intake Open (%) | Pickup Guards Needed | Forced Air Drying Time at 40°C (hr) |
|---|---|---|---|---|---|---|---|---|
| *Asclepias tuberosa* | Pods green & seed brown, firm | 8/25 | Severe | 12 | 900 | 0 | No | 24 |
| *Desmanthus illinoensis* | Legumes black & splitting | 8/15 | Trace | 10 | 1,000 | 50 | No | 24 |
| *Echinacea pallida/ E. angustifolia* | Head dry & seed shatter starts | 8-20 | Trace | 12 | 1,600 | 15 | Yes | 20 |
| *Helianthus maximilianii* | Head dry | 11/1 | Severe | 12-15 | 1,100 | 25 | No | 15 |
| *Heliopsis helianthoides* | Majority of heads brown | 8/19-9/7 | Severe | 12 | 1,100 | 15 | No | 24 |
| *Lespedeza capitata* | Head brown | 11/1 | Trace | 8 | 1,000 | 25 | Yes | 15 |
| *L. stuevei* | Legumes brown & seed firm | 10/18 | Moderate | 6 | 1,200 | 15 | No | 15 |
| *Liatris pycnostachya* | Spikes tan & seed firm | 10/5 | Severe | 15 | 800 | 0 | Yes | 10 |
| *Petalostemum purpureum* | Head gray & seed firm | 7/21-8/11 | Moderate | 18 | 450 | 15 | Yes | 15 |
| *Ratibida pinnata* | Heads gray & seed shatter starts | 9/1-10/8 | Trace | Closed | 1,100 | 15 | No | 10 |
| *Salvia pitcheri* | Most nutlets gray | 10/1 | Very severe | 15 | 800 | 15 | No | 15 |

**Table 3.** Forb seed cleaning techniques. All measurements are in inches.

| | Scalper Screens | | Hammer Mill Screen | | Cleaner Screens | | | |
|---|---|---|---|---|---|---|---|---|
| | Upper | Lower | Size | Rpm | Top | Second | Third | Fourth |
| *Asclepias tuberosa* | 14/64 | 7/64 | | | 14/64 | 7/64 | | |
| *Desmanthus illinoensis* | 10/64 | 1/14 | | | 9/64 | 1/14 | | |
| *Echinacea pallida/ E. angustifolia* | 10/64 | 9/64 | | | 10/64 | 9/64 | 1/2 x 1/16 | 1/2 x 1/2 |
| *Helianthus maximilianii* | | | | | 7/64 | 6/64 | 1/12 | 1/22 |
| *Heliopsis helianthoides* | 10/64 | 1/18 | | | 1/8 | 1/16 | | |
| *Lespedeza capitata* | 6/64 | 1/25 | | | 6/64 | 1/12 | | |
| *L. stuevei* | 6/64 | 1/20 | 1/8 | 800 | 1/12 | 1/20 | | |
| *Liatris pycnostachya* | | | 3/16 | 400 | 1/8 | 7/64 | 1/12 x 1/2 | 1/22 |
| *Petalostemum purpureum* | | | 3/32 | 900 | 10/64 | 6/64 | 1/14 | 1/25 |
| *Ratibida pinnata* | 8/64 | 1/20 | 1/2 | 1000 | 7/64 | 6/64 | 1/12 x 1/2 | 1/22 |
| *Salvia pitcheri* | Triangular 11/64 | 1/22 | 1/8 | 500 | 7/64 | 1/22 | | |

**Table 4.** Seed yield and quality.

| Species | Year | Yield (kg/ha) | Germination (%) | Hard Seed (%) | Purity (% by wt.) | Inert (% by wt.) | Other Crop & Weed Seed (% by wt.) | Notes |
|---|---|---|---|---|---|---|---|---|
| *Ascelpias tuberosa* | 76 | 81 | 57 | 0 | 86 | 14 | 0 | Stand destroyed by root rot. |
| *Desmanthus illinoensis* | 75 | 645 | 55 | 36 | 99 | 1 | 0 | |
| | 76 | 391 | 12 | 0 | 100 | 0 | 0 | |
| | 77 | 829 | 29 | 41 | 99 | 1 | 0 | |
| *Echinacea pallida/* | 76 | 242 | 0 | 0 | 96 | 4 | 0 | Seed testing procedure for germination not yet accurate. Field experience indicates higher actual germination rates. |
| *E. angustifolia* | 77 | 201 | 24 | 0 | 96 | 4 | 0 | |
| *Helianthus maximilianii* | 75 | 113 | 85 | 0 | 96 | 4 | 0 | |
| | 76 | 168 | 72 | 0 | 97 | 3 | 0 | |
| | 77 | 147 | 75 | 0 | 98 | 2 | 0 | |
| *Heliopsis helianthoides* | 75 | 155 | 30 | 0 | 98 | 2 | 0 | Germination test procedures inaccurate. |
| | 76 | 78 | 50 | 0 | 90 | 10 | 0 | |
| | 77 | 242 | 51 | 0 | 96 | 4 | 0 | |
| *Lespedeza capitata* | 75 | 59 | 37 | 50 | 97 | 3 | 0 | |
| | 76 | 96 | 55 | 36 | 100 | 0 | 0 | |
| *L. stuevei* | 75 | 93 | 18 | 59 | 97 | 3 | 0 | |
| | 76 | 161 | 24 | 23 | 100 | 0 | 0 | |
| | 77 | 60 | | | | | | Seed test not obtained. |
| *Liatris pycnostachya* | 75 | 31 | 83 | 0 | 98 | 2 | 0 | |
| | 76 | 200 | 63 | 0 | 89 | 11 | 0 | |
| | 77 | 149 | 60 | 0 | 94 | 6 | 0 | |
| *Petalostemum purpureum* | 75 | 14 | 27 | 60 | 99 | 1 | 0 | |
| | 76 | 333 | 53 | 42 | 100 | 0 | 0 | |
| | 77 | 190 | 37 | 50 | 99 | 1 | 0 | |
| *Ratibida pinnata* | 75 | 55 | 97 | 0 | 90 | 10 | 0 | |
| | 76 | 116 | 90 | 0 | 82 | 18 | 0 | |
| | 77 | 75 | 86 | 0 | 98 | 2 | 0 | |
| *Salvia pitcheri* | 76 | 296 | 31 | 0 | 99 | 1 | 0 | Germination test procedures inaccurate. Seed lost to wind shatter. |
| | 77 | 13 | 33 | 0 | 99 | 1 | 0 | |

**Table 5.** Equipment needs for wildflower seed production.

| | Size | Approximate Cost Retail (1978) |
|---|---|---|
| Tractor, with 3 pt. hitch | 40 hp | $10,500 |
| Disc, tandem | 10 ft | 1,300 |
| Harrow, spike tooth | 10 ft | 750 |
| Rototiller, p.t.o. | 2 row | 3,000 |
| Planter, unit (flex) | 2 row | 950 |
| Cultivator | 2 row | 1,000 |
| Sprayer, 3 pt. hitch | 100 gal | 1,000 |
| Pipe, irrigation | 1 acre | 1,000 |
| Spreader, fertilizer | 8 ft | 1,500 |
| Mower, sickle-bar | 6 ft | 1,700 |
| Baler, square, wire tie | | 5,400 |
| Hay rake, windrower | | 2,000 |
| Combine, pull-type (used) | 6 ft head | 1,000-2,000 |
| Bags, containers | | 500 |
| Hammer mill | | 1,000 |
| Fanning mill, 2-screen | | 2,000 |
| | Total | $33,600-$34,600 |

experience of the seed producer. Because requirements for hand labor are greatest during the year of establishment, it is desirable to establish only two or three new fields each year. Labor requirements will also depend on the crop and the grower's experience, but 12-16 ha (30-40 acres) of new and established plantings at Manhattan PMC will keep a crew of four busy from March to November.

## SUMMARY

The production of native forb seed is a new endeavor. Little or no previous work on large-scale production has been published. Solid stands of native forbs are inviting to insects and disease organisms. Large variations in growth and harvest requirements between species challenge the seed producer to adapt management schemes to individual species. Special attention to site preparation, weed control, water management, and the proper stage of maturity at harvest time will pay off with satisfactory yields. Equipment and manpower requirements are significant, however, and production costs for amateur growers may exceed purchase costs as commercial seed producers increase their output.

## ACKNOWLEDGEMENTS

The authors acknowledge the following individuals for their cooperation and technical input into Manhattan PMC activities: Jack W. Walstrom and Robert L. Lippert (retired), plant materials specialists, SCS, Salina, Kansas; Richard G. Jones, state resource conservationist, SCS, Salina, Kansas; Peter N. Jensen, state range conservationist, SCS, Lincoln, Nebraska; and Satero S. Salac, assistant professor of ornamental horticulture, Department of Horticulture, University of Nebraska, Lincoln.

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# SEED CONDITIONING AND GERMINATION OF NEW JERSEY TEA, *CEANOTHUS AMERICANUS* (RHAMNACEAE)


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With an increased effort to restore the plant diversity that once characterized the North American Prairie, it has become increasingly apparent that certain species are more difficult to establish than others, and more information is needed to determine the factors involved in seed conditioning, germination, and establishment of the more difficult prairie forbs. New Jersey tea, *Ceanothus americanus* L., has been one of these more difficult species. Widely distributed throughout the eastern tallgrass prairie region in dry to mesic prairie habitats and open woods, this low profile, woody shrub is a quality prairie plant. The plant exhibits a lustrous green foliage, very showy white flowers, and it provides important browse for deer and seeds for other wildlife species.

Western species of *Ceanothus* are important components of interior and coastal chaparral and are important deer browse on both summer and winter ranges (Leopold et al., 1951; Taylor, 1956). *Ceanothus americanus* is used in horticulture as a rootstock for grafting other *Ceanothus* species (Hartman and Kester, 1975). The genus *Ceanothus* contains some of the relatively few nonleguminous species which have nitrogen-fixing bacteria associated with their root systems (Delwiche et al., 1965).

Investigations on different species of *Ceanothus* of the western chaparral have been done by Quick (1935, 1961) and Hadley (1961). Radwan and Crouch (1977) have done a careful study on redstem ceanothus. In their study they determined that germination of *Ceanothus* seeds was usually restricted by a hard and impervious (to water) seed coat, which could be overcome by hot or boiling water treatments. Some species also required cold-damp conditioning to break dormancy and achieve maximum germination. In the present study a series of tests were conducted on *C. americanus* to determine the best method for achieving maximum germination of this species.

## MATERIALS AND METHODS

Twenty-one different treatment tests and one control test were conducted and compared. The tests were set up to examine the effects of fire, scarification, boiling water, hot water soak, cold-damp stratification, and gibberellic acid soak, in addition to several different durations and combinations of the various treatments. Also, concentrated sulfuric acid was used to treat some lots of seeds, yielding sporadic and very inconclusive results that are not presented in this paper.

Seeds were obtained in September from prairie remnants in Mercer County, Illinois. All seeds were collected by hand, air-dried, and hand-separated from seed pods and chaff. Seeds were stored dry at room temperature until they were used.

After preliminary testing, viability was determined using a cold water sink-float test. It was found that when *Ceanothus americanus* seeds were stirred into a container of water at room temperature, some of them sank to the bottom, while others floated on top. Germination tests were conducted on seeds which floated and seeds which sank. No germination was observed in the seeds which floated while germination did occur among the seeds which sank. This result provided an easy method of separating viable and nonviable seed for further testing. All final tests were conducted using seeds which sank when stirred in water.

Seeds to be exposed to fire were scattered on moist soil in wooden flats and covered with 2 cm of prairie grass straw. The straw was ignited, and allowed to burn until all combustible material was consumed. A thin layer of soil was then spread over the seeds and ashes. Scarification was accomplished by placing seeds on a sheet of sandpaper and gently scratching them with a sanding block.

Two methods of testing seeds with hot water were used in the study. In the hot water soak method, 1 liter of water was heated to selected temperatures, seeds were dropped into the water, and the water allowed to cool to room temperature. In the boiling water treatment, seeds were poured into vigorously boiling water. After various periods of boiling, the seeds were cooled quickly by pouring them into a container of cold water. Seeds were then removed from the water, drained, and planted.

Seeds to be cold-damp stratified were counted out in various lots, mixed with 50 ml of moist sterile sand, placed in small polyethylene bags, and refrigerated in an environmental chamber at 1-2° C for 10 weeks.

Seeds were treated with varying concentrations of gibberellic acid by placing the individual lots of seeds in test tubes, and covering them with 3-4 ml of gibberellic acid. All the gibberellic acid tests were previously treated by boiling in water for 1 minute. The seeds in the test tubes were placed in the dark and left to soak for 24-48 hours. Gibberellic acid concentrations of 50, 100, and 200 ppm were used.

With the exception of the fire test, all seed germination tests were carried out in plastic flats. The potting soil used was a commercial mixture called Redi Earth produced by Terra Lite. Each flat was filled with 3 cm of potting soil. The seeds were scattered on the soil, covered with 3 mm of soil, and gently watered. Flats were maintained in a greenhouse from November to March. Controls consisted of untreated seed planted in the same way as the treatment tests. The soil was kept moist throughout the study. Flats were checked daily and seedlings were recorded when they first came through the soil. Germination flats were observed up to 12 weeks although most of the germination occurred within 25-30 days with little change thereafter.